Aspects of the ecology and conservation status of selected wildlife in and around Tembe Elephant Park, KwaZulu-Natal, South Africa

by

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Submitted in partial fulfilment of the requirements for the degree

MAGISTER SCIENTIAE (WILDLIFE MANAGEMENT)

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ABSTRACT

The present study compared Sand Forest bird assemblages found in a communal land area with that of the Tembe Elephant Park, and determined the habitat preference and status of selected herbivore species within the park. The study forms part of the Maputaland Conservation-based and Integrated Rural Development Programme of the Centre for Wildlife Management from the University of Pretoria and is linked to the activities of the Lubombo Transfrontier Conservation Area (LTFCA). The main purpose of the study was to compare Sand Forest bird assemblages found in the Tshanini Community Conservation Area, which is characterised by low levels of human utilisation, with that of the Tembe Elephant Park, which is characterised by wildlife utilisation. This approach was used to determine the biological importance of this communal land area in contributing towards the conservation of the rare Sand Forest habitat. Visual and auditory bird surveys revealed that the communal land area contains unique Sand Forest bird assemblages, which demonstrated the biological importance of the communal land for Sand Forest conservation, especially from an avian perspective. The second purpose of the study was to identify possible competition between selected herbivore species within the Tembe Elephant Park and/or a decrease in numbers of rare species. Herbivores that might be adversely affected by the destruction of the Sand Forest, or who may themselves have a destructive effect on the Sand Forest were also identified. Target herbivores included the nyala *Tragelaphus angasii*, impala *Aepyceros melampus*, Burchell's zebra *Equus burchellii*, greater kudu *Tragelaphus strepsiceros*, red duiker *Cephalophus natalensis* and suni *Neotragus moschatus*. Road transects were used to record the spatial distribution of the target herbivores, and the vegetation types that were used more or less often than expected were subsequently determined. None of the target herbivores showed a preference for the Sand Forest or appeared to have a destructive effect on the Sand Forest. The suni, however, reached its highest density within the Sand Forest and the destruction of this habitat will therefore negatively affect the suni population. In several parks and reserves that aim to conserve a variety of species, it has been necessary to control the populations of highly competitive species. Both the nyala and the impala are highly competitive and occur in relatively high numbers within the Tembe Elephant Park, and consequently their population numbers should be kept sufficiently low in order not to have a negative influence on the vegetation or the survival of less competitive ungulates. Total aerial counts and transect distance sampling counts indicated an increase in the numbers of all the target herbivores. It is important to protect a viable portion of the preferred habitat of every target species within a reserve, and to keep competition with rare species to a minimum for the long-term survival of the regional biodiversity. Key aspects of wildlife and their habitat should be monitored so that trends are noted in time, and management adjustments can be made accordingly.

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WELCOME TO
TEMBE
ELEPHANT PARK

CHAPTER 1

INTRODUCTION

Human activity has been changing ecosystems for thousands of years. The pace and extent of change, however, increased rapidly with the more recent period of agricultural and industrial development. Economic and industrial development has always been seen as the answer to the development of countries and no real attention was given to the environment and the renewable natural resource base (Hugo *et al*. 1997). As a result, vast numbers of species have become extinct prematurely, natural cycles have been disrupted, billions of tons of topsoil have been lost, genetic diversity has eroded, and the very climate of the planet may have been disrupted (Meffe & Carroll 1997). In addition to habitat loss and degradation, the overexploitation of certain species, the introduction of exotic species, and the pollution of the soil, water and atmosphere have had major effects on terrestrial, freshwater and marine biodiversity. The establishment of conservation areas is a widely used technique for reducing such human induced threats on the environment (Margules & Pressey 2000).

In South Africa, existing conservation areas were predominantly proclaimed on an *ad hoc* basis on land considered marginal for agriculture or undesirable for human settlement (Lombard 1995; Wynberg 2002). New reserves were often placed in areas that did not contribute to the increased protection of global biodiversity. Over the past two decades, however, systematic approaches to conservation planning were developed to guide the efficient allocation of funding and scarce resources for protecting biodiversity (Margules & Pressey 2000). Although many areas are identified as important for representing biodiversity, only a small number of these can be realistically protected in the immediate future (Reyers 2004). Biodiversity is, however, not distributed evenly across the globe (Gaston 2000), and efforts to expand the present conservation network should therefore be focused on regions that would contribute most to the global protected area network (Myers *et al*. 2000). Contrary to frequent recommendations, current protection levels within a given country or biome is a poor indicator of additional conservation needs, and areas most in need of conservation are often those with higher levels of endemism (Rodrigues *et al*. 2004).

The Maputaland Centre of Plant Endemism in the northern parts of the KwaZulu-Natal province, South Africa and extending into the southern parts of Mozambique, is an area that is well known for its conservation importance (Moll 1977; Everard *et al.* 1994; Van Wyk 1994; 1996; Kirkwood & Midgley 1999; Van Wyk

& Smith 2001). It is recognised by the International Union for the Conservation of Nature and Natural Resources (IUCN) as a Centre of Plant Diversity. Moreover, Conservation International (IC) recently added this area and the Pondoland Centre of Plant Endemism to a list of global hotspots of the world. These hotspots represent areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat (Myers *et al*. 2000). Consequently, when prioritising conservation efforts based on rational area selection principles, this region is invariably included for South Africa (Lombard 1995; Gaston *et al.* 2001).

The occurrence of spatial and temporal heterogeneity in local animal and/or plant populations further complicates conservation planning. Existing reserves are unable to adequately capture the regional diversity that is associated with habitats that are characterised by substantial between-patch heterogeneity in animals and plants. Typically, an assemblage consists of species with a range of different abundances and levels of spatial occurrence (Gaston 1994). Several investigations examining the nature of fine-scale spatial heterogeneity in communities or assemblages have shown a large degree of such heterogeneity in the Maputaland Centre of Plant Endemism (Van Rensburg *et al.* 1999; Van Rensburg *et al.* 2000; Matthews *et al.* 2001; Gaugris *et al.* 2004). This indicates that conservation efforts in a variety of habitat patches are necessary to ensure the long-term persistence of its associated biota. Consequently, conservation efforts often have to extend beyond the boundaries of formally protected areas (Bennett *et al*. 2004).

Efforts to stem the ongoing loss of biodiversity are additionally hampered by the escalating conflict between conservation and development (Balmford *et al*. 2001; Chown *et al*. 2003). Conservation is more difficult and expensive in areas with high human population densities (Huston 2001), but options for expanding the current conservation network to areas with low human densities are as limited across South Africa (Chown *et al*. 2003), as it is across other parts of the world (Newmark 1996; Harcourt *et al.* 2001; Hansen & Rotella 2002; Parks & Harcourt 2002). Moreover, species richness and human population density throughout Africa are positively correlated because both variables apparently respond similarly to increasing primary productivity (Cincotta *et al*. 2000; Balmford *et al*. 2001). Human population density also tends to be high in areas surrounding current reserves (Harcourt *et al*. 2001; Chown *et al*. 2003). In South Africa, nearly 90% of all officially protected areas border on communal rural communities or are situated close to them (Els 2002). As human populations increase, and the demand for renewable natural resources grow, the frequency and intensity of conflict between protected areas and local people will also increase. This is especially true for South Africa where the population growth rate

(2.2% yr^{-1}) is substantially higher than the corresponding growth rate for the rest of the world (1.3% yr^{-1}), and above that of most developing countries (1.6% yr^{-1})(Van Rensburg *et al*. 2004).

Future conflicts between conservation and development cannot readily be avoided and as a result maintaining reserves in high human population density areas will become increasingly difficult. Virtually all the major managerial problems facing conservation areas today have a human component. The most common of these problems relate to the increasing human settlement of adjacent lands and the unauthorized harvesting of resources within protected areas (Newmark 1996). Land transformation for human use is known to be responsible for the vast majority of habitat loss (Soulé 1991), and is furthermore widely accepted as a key component in the extinction of species (Brooks *et al*. 2002). The basic role of reserves is to separate elements of biodiversity from processes that threaten their existence in the wild (Margules & Pressey 2000). Unfortunately, many reserves are becoming increasingly isolated as a result of human activity (Newmark 1996). In addition, there is a significant decline in the size of newly proclaimed conservation areas (Chown *et al*. 2003), which increases the negative effects of external threats. An integrated approach incorporating both conservation and human development needs is required. Such an approach should emphasise the value of existing conservation areas and view parks as a central component of conservation strategies (Bruner *et al.* 2001; McKinney 2002). The sustainable development of rural communal areas surrounding conservation areas should be promoted from within (Editorial 2003), while establishing buffer zones around the protected areas.

Although several conservation activities have been, and currently still are, taking place in the Maputaland Centre of Plant Endemism, there are still several conservation concerns within the region. A case in point is the conservation of the Sand Forest habitat type, a distinctive habitat type in southern Africa. The Sand Forest is characterised by a unique combination of plant and animal species and has the highest diversity of woody plant species in the region, with a significant number of these being endemic to the Maputaland Centre of Plant Endemism (Everard *et al.* 1994; Matthews *et al.* 2001). Quantitative evidence suggests that most of the endemic vertebrate species in the Maputaland Centre of Plant Endemism are likewise restricted to this habitat type (Van Wyk 1996; Van Rensburg *et al.* 2000). Although Sand Forest is considered to be the smallest habitat type in South Africa, covering only 0.03% of the region's total land surface area, *circa* 45% of this habitat type has already been transformed due to anthropogenic activities and only small portions of the remainder are currently being formally protected (Low & Rebelo 1996).

One of the local communities who live adjacent to Tembe Elephant Park in the Maputaland Centre of Plant Endemism recently nominated a part of their ward, namely the Tshanini Community Conservation Area, as a community-based natural resource management project to serve as a possible conservation area in the region. The purpose of the area is to establish a nature reserve in the Manqakulani Ward of the Tembe Tribal Authority. The reserve is to be managed as an economic sustainable wildlife ranching and eco-culture tourism venture through the sustainable utilisation of renewable natural resources, but especially those resources that are associated with Sand Forest ecosystems. The key questions, however, are whether the Tshanini Community Conservation Area could be regarded as biologically important for conservation, and more specifically whether this area will contribute towards the conservation of the rare Sand Forest habitat type.

The first aim of the present study was therefore to determine the biological importance of this community area in contributing towards the conservation of the rare Sand Forest habitat type. This was done by comparing the Sand Forest bird assemblages that are found in areas characterised by low levels of human utilisation, such as the Tshanini Community Conservation Area with those characterised by primary wildlife utilisation, such as Tembe Elephant Park. This approach aimed to indicate the extent to which local human activities were having an effect on Sand Forest bird assemblages and it was used here as a point of departure to determine the feasibility of setting aside a part of the Manqakulani Ward as a wildlife resource use area. Birds were selected as a focal taxon because the Maputaland Centre of Plant Endemism has a rich avifauna, including a number of endemic species and subspecies (Clancy 1996; Harrison *et al.* 1997; Van Rensburg *et al.* 2000), the southern African birds are systematically well-known and well-surveyed (Harrison *et al.* 1997), and birds are relatively easy to sample quantitatively when compared with some other vertebrate taxa (Mac Nally 1997).

Even within some of the protected areas in the Maputaland Centre of Plant Endemism, Sand Forest conservation is also under pressure. For example, Tembe Elephant Park contains the largest protected portion of Sand Forest in South Africa (Van Rensburg *et al.* 1999, 2000; McGeoch *et al*. 2002), but although elephants *Loxodonta africana* prefer plant species from woodland habitats, they are increasingly impacting Sand Forest plant species within the park (Matthews *et al*. 2001). Heavy utilisation of Sand Forest by elephants is thought to lead to the opening up of these habitats, and the subsequent development of a Mixed Woodland structure. To date no reversion to the original habitat structure has been recorded for disturbed Sand Forest patches even after extensive protection (Van Rensburg *et al.* 1999). This could have an adverse effect on all the species associated with the Sand Forest habitat. Monitoring the impact of large herbivores on these forests and their associated species within current protected areas is therefore critical for future conservation.

The second objective of this study was to gather information on the habitat preference and conservation status of selected herbivore species within the Tembe Elephant Park. The maintenance of mixed ungulate populations in an area, without causing damage to the habitat or animals requires insight into the habitat needs, habitat use and potential competition within and between populations in the area (Scogings *et al*. 1990). The interactions between herbivore species can either be competitive or beneficial. Interference competition occurs when one species physically excludes another from resources, while exploitative competition occurs when the reduction of resources by one species adversely affects another (Begon *et al*. 1996). Facilitation on the other hand is the process by which one species benefits from the activities of another. Wildlife management can manipulate both competition and facilitation to increase the density of a preferred plant or animal species (Caughley & Sinclair 1994). Knowledge of the habitat preference, ecological requirements and conservation status of large herbivores is thus basic to any management programme for a conservation area and a pre-requisite to determine stocking densities and possible translocations (Dekker *et al*. 1996).

Current techniques for calculating stocking rates can only be justified if the ungulates display no separation by habitat. As more knowledge is gained on the habits of animals, it becomes clearer that they do not simply roam aimlessly through their habitat, but instead use it in a fixed and orderly manner (Joubert 2002). The degree of dependency of a ruminant on a certain habitat is determined by the availability of its preferred food, the minimum size of the area required for daily and seasonal activities, the absence of extreme competition, the availability of cover and free surface water, the freedom to escape unnatural climatic extremes and the opportunity for reproduction (Pienaar 1974). The fact that most species are linked to major vegetation types helps in understanding their distribution patterns. In conservation areas, one of the primary objectives is to maintain viable populations of all the animal species present. In several parks and reserves, which aim to conserve a variety of species, it has been necessary to control the populations of highly competitive species for some time to prevent the decline of rare species and/or the overutilisation of a number of plant communities. The present study therefore aimed to investigate the habitat preferences and status of selected herbivores to identify possible competition between species and/or a decrease in numbers of rare species. It was furthermore aimed to identify herbivores that might be adversely affected by the destruction of Sand Forest, or who may themselves have a destructive effect on Sand Forest. Target herbivores included the nyala *Tragelaphus angasii*, impala *Aepyceros melampus*, Burchell's zebra *Equus burchellii*, greater kudu *Tragelaphus strepsiceros*, red duiker *Cephalophus natalensis* and suni *Neotragus moschatus*.

A description of the study area is presented in chapter 2. In order to reduce the amount of repetition the detailed methods employed during this study are presented in chapter 3. The methods in the respective chapters are restricted to the broad outlines of the methods employed. The comparison of the Sand Forest bird assemblages that are found in the Tshanini Community Conservation Area, with those found in the Tembe Elephant Park is presented in chapter 4. Information on the habitat preference and status of the target herbivores is presented in chapter 5 to chapter 10. Literature cited in each chapter is referenced at the end of the relevant chapter and a complete list of references is given at the end of the thesis.

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CHAPTER 2

THE STUDY AREA

The Maputaland Centre of Plant Endemism has been defined as that part of southern Mozambique and northeastern KwaZulu-Natal in South Africa, bounded in the north by the Inkomati-Limpopo River, in the east by the Indian Ocean, in the west by the western foothills of the Lebombo Mountains and in the south by the St. Lucia estuary (Van Wyk 1994). Figure 1 shows the location of the study area in South Africa and Mozambique. Within the Maputaland Centre of Plant Endemism, the present study was conducted in and around the Tembe Elephant Park (27^{o}01'S 32^{o}24'E) on the southern Mozambique Coastal Plain. The park extends over an area of 30 013 ha with the northern limit being the international boundary between South Africa and Mozambique. It falls within the Tembe Tribal Ward. The southern border of the park is on the main tarred road from Jozini to KwaNgwanase, the eastern border on the eastern side of the security road which runs from the tarred road to the Mozambique border, and the western border on the Mbangweni Corridor, an area forming a gap of approximately 5,5 km between Tembe Elephant Park and the Ndumo Game Reserve. Future plans are to link the two reserves by incorporating this corridor (KwaZulu-Natal Nature Conservation Services 1997). Although the Tembe Elephant Park was proclaimed in 1983, the international boundary with Mozambique was only fenced off in 1989, effectively stopping the movement of large animals in and out of the area (Matthews *et al*. 2001). The boundaries are all fenced with wildlife-proof fencing consisting of 2,1 m veldspan with 3 or 4 barbed wire strands on top. On the inside of the main game fence runs an electric stopper fence that is 1,4 m high, consisting of 4 strands of electrified wire (KwaZulu-Natal Nature Conservation Services 1997).

Until recently, this area was relatively undeveloped with little human influence. Few people have lived historically in this area because of the scarcity and seasonality of surface water. Soils in the region are also generally too nutrient-poor for cultivation, except next to the Muzi Swamp along the eastern border of the park. The density of people along the Muzi Swamp has always been low, however, because sections of the swamp can be dry for some months of the year, and the more permanent water of the northern sections of the Muzi Swamp are saline with salinity gradients of 0.5 to 5% (Matthews *et al*. 2001).

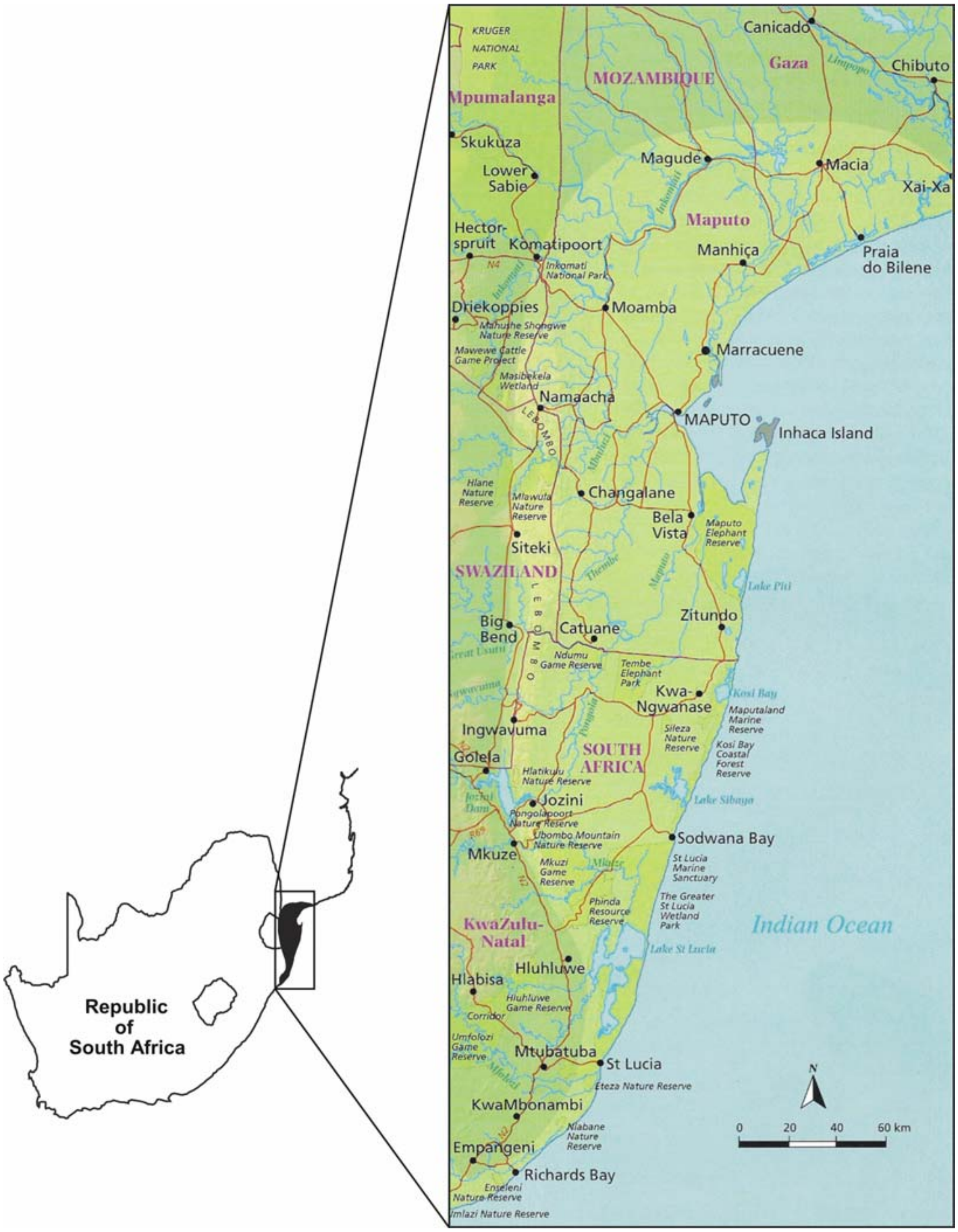

Figure 1: The location of the Maputaland Centre of Plant Endemism (highlighted in light green) within South Africa and Mozambique as adapted from Van Wyk & Smith (2001).

The reasons for the proclamation of the Tembe Elephant Park were to:

- Protect the lives and property of the local people from damage and injury by elephants *Loxodonta africana*.
- Preserve the last naturally occurring population of the African elephant in KwaZulu-Natal.
- Protect one of the largest populations of Livinstone's Suni *Neotragus moschatus* in southern Africa, as well as other wildlife species that occur in the area.
- Preserve and protect the unique Sand Forest. This habitat type is not well represented in other conservation areas within southern Africa. Many species of fauna and flora reach their southernmost distribution in the portion of the Mozambique Coastal Plain covered by the park (KwaZulu-Natal Nature Conservation Services 1997).

In 1989 the KwaZulu Department of Nature Conservation decided that the administration of the Tembe Elephant Park and the Ndumo Game Reserve should be amalgamated and rationalized. This was done to eliminate costly duplications in the administrative structures, and to facilitate the physical link-up of the two reserves via the Mbangweni Corridor. Law enforcement and security matters were linked in January 1990, followed by financial matters in April 1990, and a complete hand over was accomplished in June 1990 (KwaZulu-Natal Nature Conservation Services 1997).

The future vision for the area are primarily:

- To ensure the maintenance and conservation of existing habitat types, their diversity and associated faunas; to maintain viable populations of all species. In Tembe Elephant Park, special emphasis will be placed on Sand Forest / Sandveld thicket habitats and their associated flora and fauna.
- To maintain, via environmentally acceptable programmes and judicious zoning, these habitat types.

The secondary objectives are:

- To allow controlled use of those natural resources which may be harvested on a sustained yield basis.
- To encourage scientific research, especially that which has as its emphasis the solving of management-oriented problems.

- To encourage and promote environment education programmes relevant to the Complex.
- To ensure that development and financial priorities are determined and adequate planning takes place in an endeavour to obtain finances for the efficient establishment and running of chosen projects relevant to the area.
- To encourage economically viable visitor use of the Complex, which is controlled in such a way that it is in harmony and compatible with the primary objectives and overall policies of the KwaZulu-Natal Nature Conservation Service (KwaZulu-Natal Nature Conservation Services 1997).

TOPOGRAPHY

The Maputaland Centre of Plant Endemism lies on a nearly flat low-level coastal plain with a maximum elevation of about 150 m, except for the narrow Lebombo mountain range on the western boundary, rising to an elevation of 600 m (Van Wyk & Smith 2001). At the coast on the eastern boundary, the sea is separated from the land by high coastal dune ridges, which are considered to be among the highest vegetated dunes in the world. The land immediately behind the dunes is flat, containing some extensive wetlands, particularly marshes, lakes and estuaries. The central part of the coastal plain is covered by gently undulating sand dunes, with the Muzi Swamp some 40 km from the coast, running roughly parallel with the shoreline. As one moves further inland, the Pongola River, with its broad floodplain and associated pans, is reached just before the foothills of the Lebombo Mountains (Moll 1977).

The Tembe Elephant Park lies at the southernmost portion of the broad Mozambican Coastal Plain. The topography within the park is defined by high, linear, north-south oriented dune cordons with poorly preserved parabolic dunes superimposed on the surface (Matthews *et al.* 2001). Where the soil clay content is high, perennial pans may form in the depressions between the dune ridges. The two highest dune ridges of the Coastal Plain are Nhlela Ridge and Beacon Ridge in the park, both reaching a height of 129 m above sea level. The lowest-lying area in the park is the Muzi Swamp on the eastern side at approximately 50 m above sea level (Matthews *et al*. 2001).

GEOLOGY AND SOILS

Resistant volcanic rhyolitic lavas (Figure 2) form the Lebombo Mountain Range, while the broad Mozambican Coastal Plain consists mainly of Cretaceous Siltstone units (Van Wyk 1996; Van Wyk & Smith 2001). Since the break-up of Gondwanaland started, some 140 million years ago, the Mozambican Coastal Plain has been affected by a number of marine transgressions, which deposited, eroded and reworked a variety of fossiliferous sands, silts and clays (Watkeys *et al*. 1993). High dune cordons, which can be traced for long distances along the inland margins of the coastal zone, mark periods without transgression during the Mio-Pliocene marine regressions. The oldest dune ridges date back approximately 3 million years to the early Pleistocene, whereas the youngest are probably from the late Pleistocene and are around 10 000 years old. The latter are some of the youngest formations present in southern Africa (Matthews *et al.* 2001; Van Wyk & Smith 2001).

A fertile clayey alluvium occurs in the floodplains of some of the larger rivers (Bruton & Cooper 1980). The oldest Plio-Pleistocene weathering profiles are red and dominant in the western areas or in localised places where old sands rise above the surrounding deposits. Lesser-developed, yellowish and grey profiles formed in younger redistributed sands during the Pleistocene and Holocene and occur in degraded dune fields or areas dominated by a high water table. In the permanent swamps, thick peat deposits have accumulated while calcrete deposits have formed adjacent to the Muzi Swamp (Matthews *et al.* 2001).

Soils over most of the Mozambican Coastal Plain are infertile, homogeneous, grey, silicaceous, aeolian sands that are highly leached (dystrophic) and relatively acidic with a water pH ≈ 6.1 (Matthews *et al.* 2001; Van Wyk & Smith 2001). Within Tembe Elephant Park, the soils typically have a thin organically enriched A-horizon underlain by a sandy subsoil. The higher dune ridges in the park consist of high base status soils, while regic sands dominate the surrounding lower areas. Clay content of the soils within the park is linked to the intensity of weathering of labile minerals over a long period (Matthews *et al.* 2001).

Well-drained profiles characterised by deep, red or yellowish soils are found on the high topographical areas like the Nhlela and Beacon Ridges in the park. These areas also have the steepest gradients and short hill slopes, and the soils have less than 5% clay. Soils on these ridges are classified as Hutton (orthic A-horizon; red apedal B-horizon) or Clovelly Forms (orthic A-horizon; yellow-brown apedal B-horizon) according to the South African system (Soil Classification Working Group 1991; Matthews *et al.* 2001). Land types representing these areas are Ae151 and Ah30 (Figure 3).

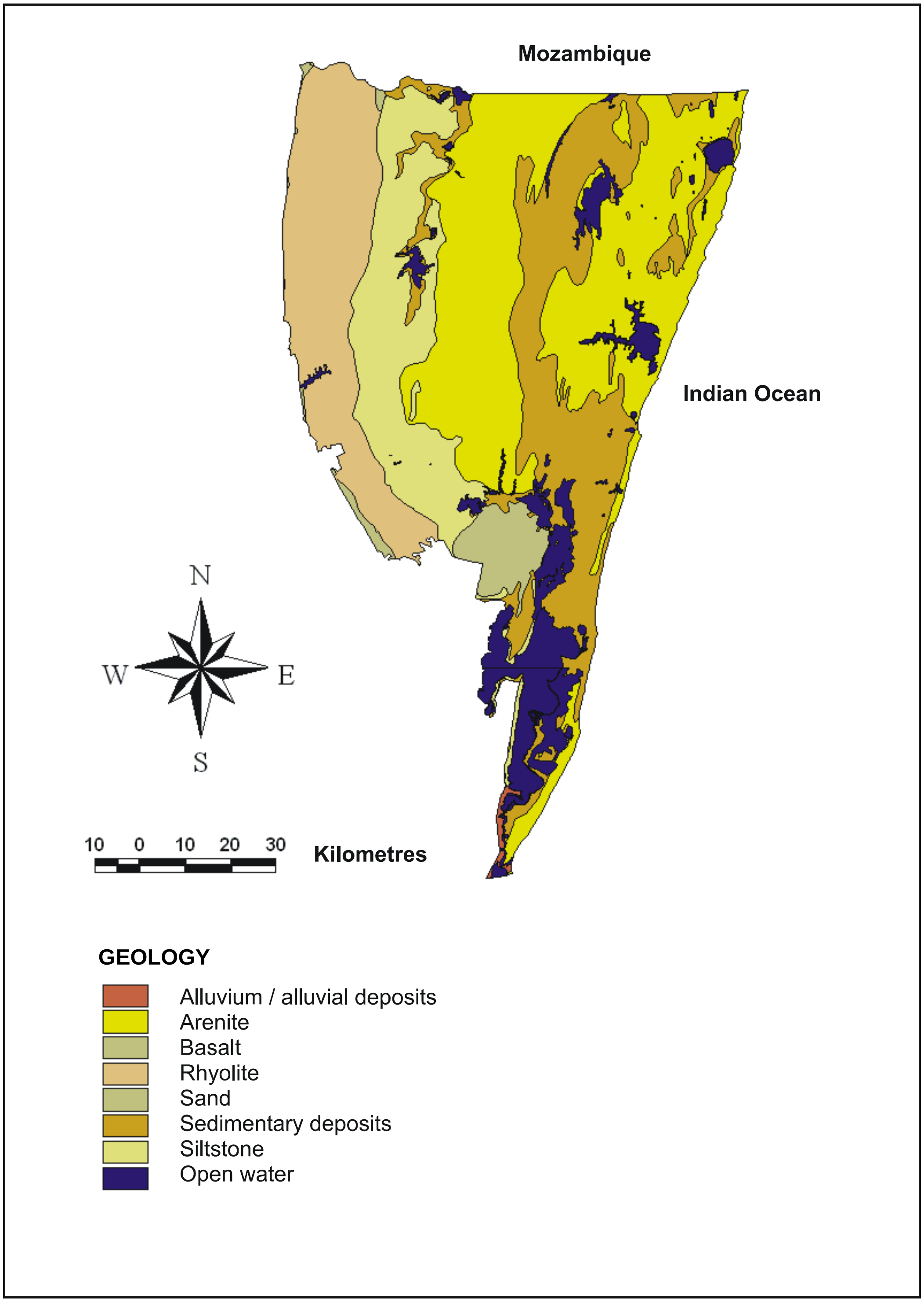

Figure 2: The Maputaland Centre of Plant Endemism in South Africa, showing the location of the different geological formations.

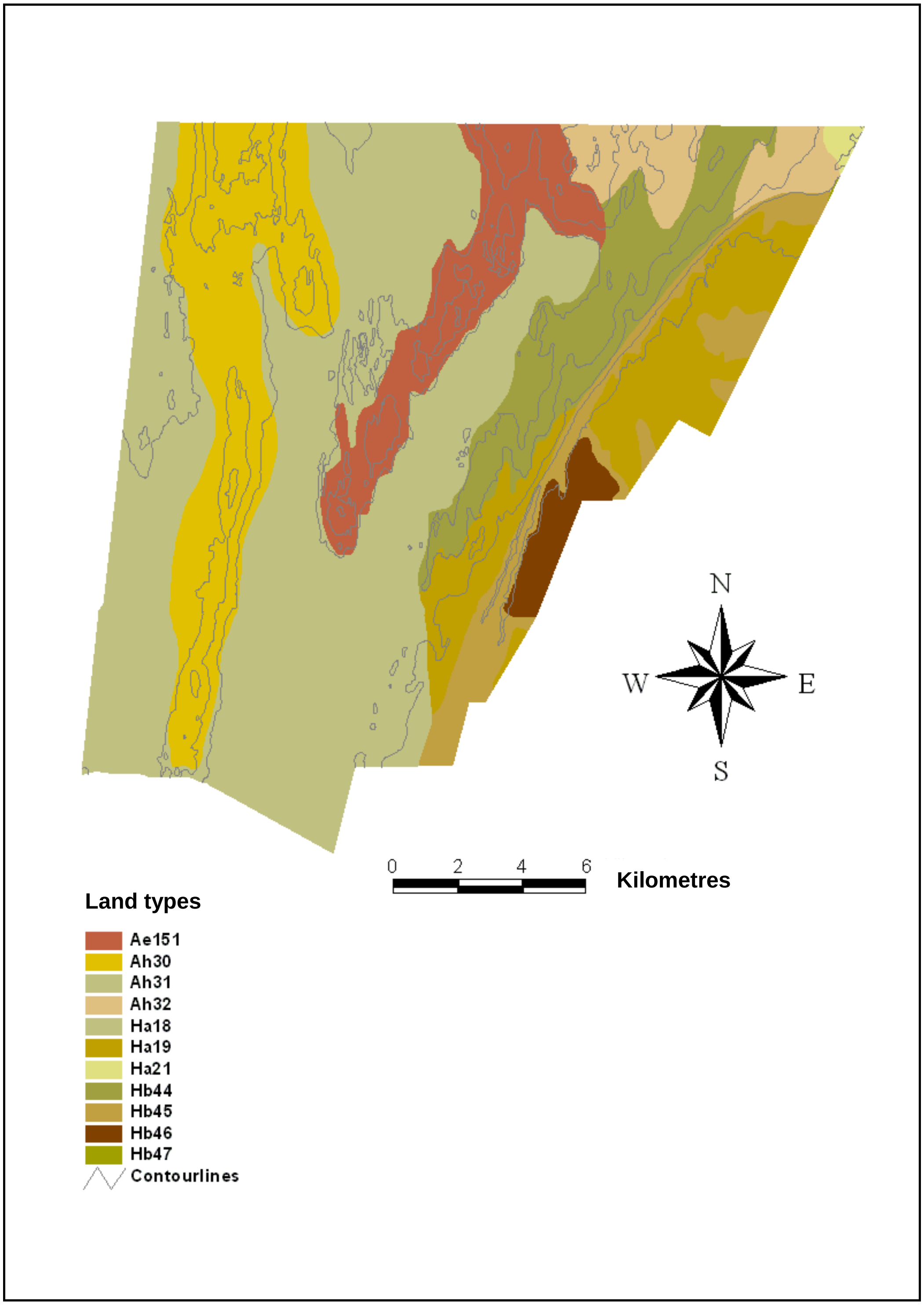

Figure 3: Tembe Elephant Park, South Africa showing the location of the different land types.

Degraded lower dunes are characterised by sandy profiles with yellowish brown or light grey subsoil horizons. The gradient in these areas is low with long slopes, while the profiles are moderately to well drained, although high water tables within low-laying interdune depressions result in bleached, grey soil profiles. The soils in these areas are yellowish Clovelly or grey Fernwood Form (orthic A-horizon; E-horizon) soils (Soil Classification Working Group 1991; Matthews *et al.* 2001). Land types representing these areas are Ah31; Ah32; Ha18; Ha19; Ha21 and Hb46 (Figure 3).

Low-laying areas with lateral ground water migration have resulted in the formation of clay-rich, slightly saline or calcareous duplex soils. Where the dune sands border on the Muzi Swamp it has led to the formation of sodic Estcourt Form (orthic A-horizon; E-horizon; prismacutanic B-horizon) soils with prismatic subsoil structures. The Muzi Swamp is characterised by gleyling conditions with peat formation resulting in Champagne Form (organic O-horizon) soils (Soil Classification Working Group 1991; Matthews *et al.* 2001). Land types representing these areas are Hb44; Hb45 and Hb47 (Figure 3).

CLIMATE

The Maputaland Centre of Plant Endemism lies at the southern end of the tropics in Africa, and a tropical/subtropical climate prevails with no frost in the winter (Van Wyk 1996; Van Wyk & Smith 2001). This centre lies within the summer rainfall area with a mean annual rainfall of 1000 to 1500 mm at the coast, decreasing rapidly towards the interior (Moll 1977). The driest part is in the Pongola region, where the mean annual rainfall is as low as 500 to 600 mm. The crest of the Lebombo Mountain Range receives 800 to 1000 mm of rain per year (Bruton & Cooper 1980).

Winter mist is quite common on the Lebombo Mountain Range, and on the plains through inversion. Relative humidity is also generally high, even away from the coast (Van Wyk & Smith 2001). The temperature is generally hot throughout the year, but higher in the central regions than at the coast (Moll 1977). The Maputaland Centre of Plant Endemism is thus not characterised by four distinctive seasons but rather mostly only by two, summer and winter, due to the nature of the climatic conditions associated with the region (Schulze 1982; Matthews *et al.* 2001).

Rainfall and temperature data for the weather station at Sihangwana (E 32º 25’ 25”; S 27º 02’ 35”), situated at the main entrance gate of the Tembe Elephant Park, are shown in Figure 4. The mean annual rainfall for the park is 721.5 mm, with the minimum recorded annual rainfall being 245.0 mm and the maximum 2105.0 mm. Although rainfall is spread throughout the year, the summer months are the wettest and winter months the driest. The relative humidity of the air in the park is also higher

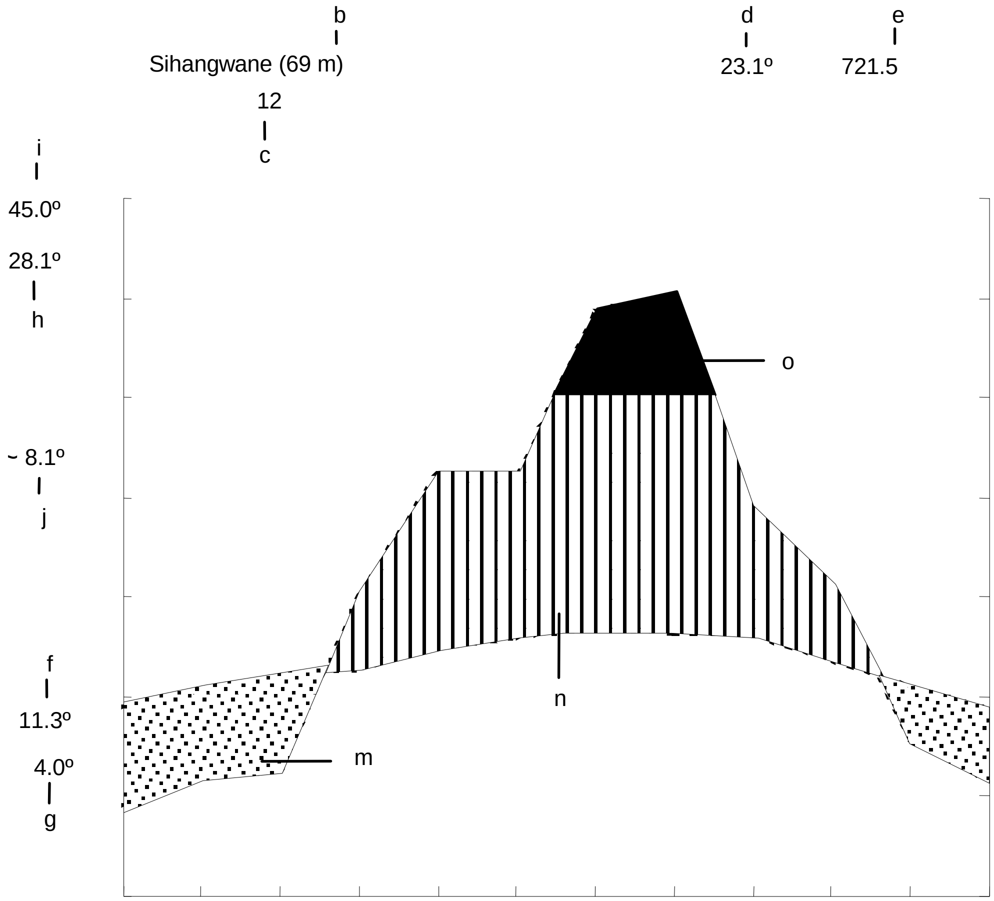

Figure 4: Climatogram of Sihangwane Weather Station, Tembe Elephant Park, following Walter (Cox & Moore, 1994). b = height above sea-level in m; c = duration of observations in years; d = mean annual temperature in ºC; e = mean annual precipitation in mm; f = mean daily minimum temperature of the coldest month; g = lowest temperature recorded; h = mean daily maximum temperature of the warmest month; i = highest temperature recorded; j = mean daily temperature variation; m = relative period of drought; n = relatively humid season; o = mean monthly rainfall > 100 mm (Tarr *et al*. 2004).

during the summer (91%) than during the winter (40%). Morning mist is common, especially around the Muzi Swamp, during the winter (Matthews *et al.* 2001). The mean annual temperature recorded for the park is 23.1°C, with temperatures ranging from an extreme minimum of 4°C to an extreme maximum of 45°C (Tarr *et al*. 2004).

VEGETATION

The vegetation of the Maputaland Centre of Plant Endemism is diverse, with at least 15 broad vegetation types described for the KwaZulu-Natal portion of the region, including different types of grassland, bushveld, thicket, forest and swamp vegetation (Moll 1977). Two remarkable vegetation types, the Sand Forest and the Woody Grassland, are endemic to the region (Van Wyk & Smith 2001). The Sand Forest is characterised by a unique combination of plant and animal species and has the highest diversity of woody plant species in the region, with a significant number of these being endemic to the Maputaland Centre of Plant Endemism (Everard *et al.* 1994; Matthews *et al.* 2001). Quantitative evidence suggests that most of the endemic vertebrate species in the Maputaland Centre of Plant Endemism are likewise restricted to this habitat type (Van Wyk 1996; Van Rensburg *et al.* 2000).

The Tembe Elephant Park lies within the core area of the Maputaland Centre of Plant Endemism (Figure 1) and contains the largest protected portion of Sand Forest in South Africa (Van Rensburg *et al.* 1999, 2000; McGeoch *et al*. 2002). Nine vegetation types were recognised by Matthews *et al.* (2001) within the Tembe Elephant Park. These are the *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, Closed Woodland/Thicket Mosaic on sand, Closed Woodland on clay, Hygrophilous Grassland, Muzi Swamp, Old Lands, Open Woodland, Sand Forest/Grassland Mosaic and Sparse Woodland (Figure 5).

The *Acacia borleae* Shrubland/Bush Clump Mosaic on clay occurs next to marshy areas and clay-based thickets associated with the Muzi Swamp. In structure this vegetation type varied from areas of dense vegetation to thickets that were associated with termitaria. Abundant plant species are the grasses *Eragrostis heteromera* and *Eragrostis plana,* and the shrub *Acacia borleae*. Moreover, perennial pans were found interspersed throughout these clay areas. This vegetation type covered only 0.7% of the park (Matthews *et al*. 2001).

The Closed Woodland/Thicket Mosaic on sand occurs on the dune crests, slopes and interdune depressions throughout the Tembe Elephant Park and could be distinguished based on plant density, which varied from closed to semi-closed crown gaps and a canopy that varied from approximately 8 to 12 m in height. Abundant plant species are the shrubs *Euclea natalensis, Grewia caffra, Catunaregam spinosa*

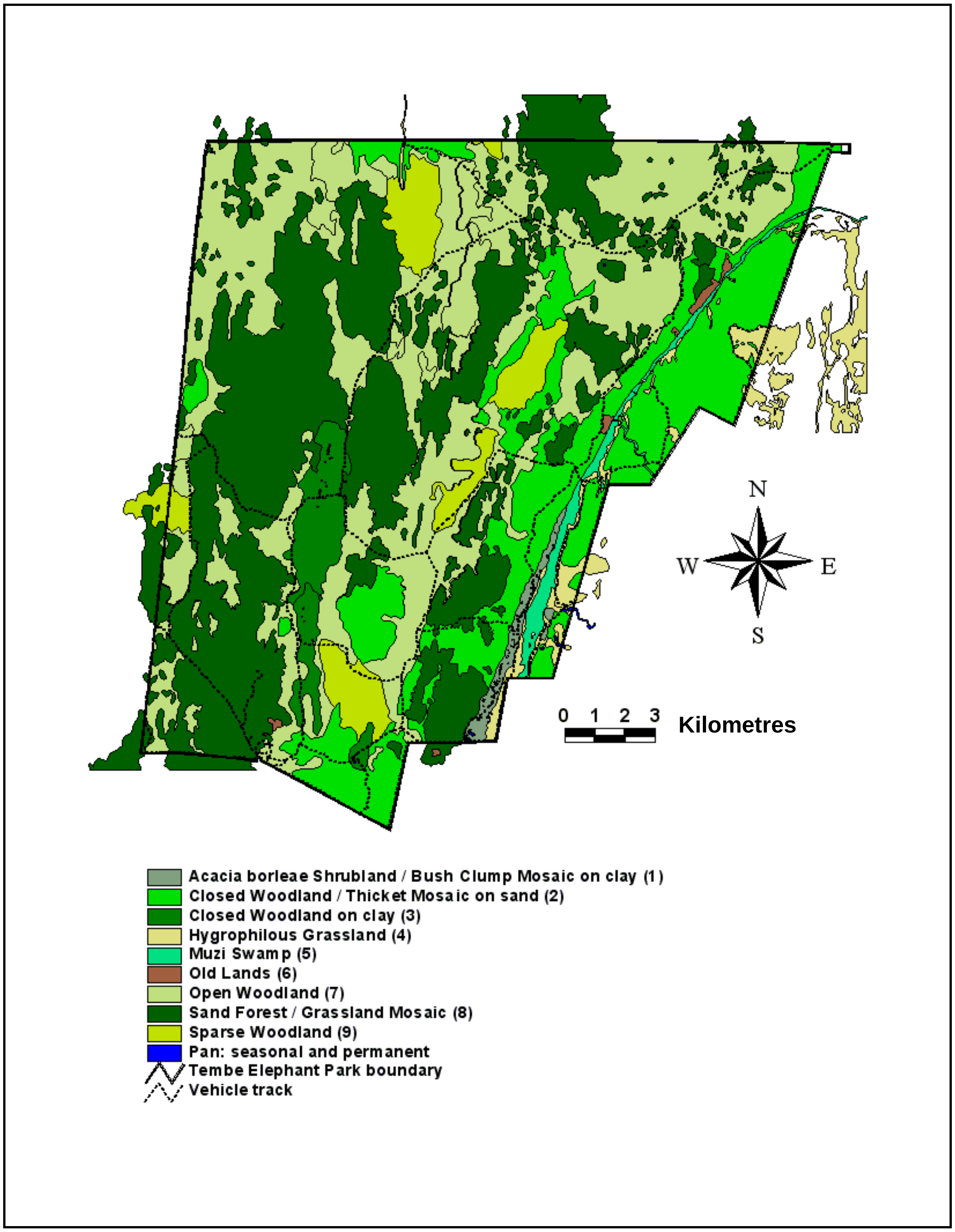

Figure 5: Tembe Elephant Park, South Africa showing the location of the different vegetation types based on Matthews *et al*. (2001).

and *Bridelia cathcartica,* and the tree *Acacia burkei*. This vegetation type covered 15% of the park (Matthews *et al*. 2001).

The Closed Woodland on clay occurs on clay-rich duplex soils that are normally associated with the bottomlands of the dunes and the edges of the Muzi Swamp. Perennial pans were also found throughout this vegetation type, often as the result of mud wallows used by wildlife. Abundant plant species are the trees *Spirostachys africana, Berchemia zeyheri* and *Mystroxylon aethiopica*. This vegetation type covered 2.5% of the park (Matthews *et al*. 2001).

The Hygrophilous Grassland, found adjacent to the Muzi Swamp, had a grassland structure with only scattered trees or thickets. Abundant plant species are the grasses *Imperata cylindrica, Eragrostis lappula, Dactyloctenium geminatum, Panicum genuflexum* and *Eragrostis heteromera* and the shrub *Acacia nilotica* (Matthews *et al*. 2001). None of these grass species present has a high grazing value and therefore the grasses are generally poorly utilised by grazers (Van Oudtshoorn 1999). This vegetation type covered 2.0% of the park (Matthews *et al*. 2001).The Muzi Swamp consists of reed beds in an extensive swamp system that crosses the eastern side of Tembe and extends northwards to Maputo Bay in Mozambique. It is a well-described community that is associated with water bodies throughout South Africa. Abundant plant species were dense stands of *Phragmites australis,* mixed with *Typha capensis* in some areas (Matthews *et al*. 2001). Controlled reed harvesting by some of the local communities living adjacent to the park is currently allowed in the Muzi Swamp within the park (Tarr *et al.* 2004). The Muzi Swamp represents the only natural source of permanent water within the park, even in the driest years. This vegetation type covered 1% of the park (Matthews *et al*. 2001).

The Old Lands comprised only 0.2% of the total available habitat in the Tembe Elephant Park. Since the proclamation of the park more than 10 years ago, these areas have recovered to the point that they are no longer distinguishable in the field and no distinctive description is available. The small size of this vegetation type furthermore renders it futile to discuss in terms of its effects on management decisions.

The Open Woodland was the second largest vegetation type in Tembe and occurs on the dune crests, slopes and interdune depressions throughout the park. This vegetation type is characterised by a good grassy layer interspersed with a few tall trees of approximately 8 to 10 m in height. Grass species abundant in the Open Woodland included several species with a high grazing value such as *Andropogon gayanus*, *Panicum maximum* and *Digitaria eriantha* (Van Oudtshoorn 1999;

Matthews *et al*. 2001). Abundant trees in this vegetation type included *Albizia versicolor*, *Strychnos madagascariensis*, *Combretum molle*, and *Terminalia sericea*. This vegetation type covered 26.6% of the park (Matthews *et al*. 2001).

The Sand Forest/Grassland Mosaic was the largest vegetation type in Tembe and was mostly associated with dunes. This vegetation type was structurally classified as a forest and had a poorly developed understory that is interspersed with grassland (Matthews *et al*. 2001). The forest had, in some instances, a low canopy of approximately 5 m high and in other areas extending up to approximately 15 m high. The grasslands there were open with few to no trees and shrubs, and it gradually acquired a more open woodland character further away from the Sand Forest. Abundant plant species included the forbs *Indigofera inhambanensis* and *Trachyandra* cf. *salti,* the grasses *Bewsia biflora, Urelytrum agropyroides* and *Perotis patens,* and the sedge *Cyperus obtusiflorus*. This vegetation type covered 47.9% of the park (Matthews *et al*. 2001).

The Sparse Woodland mainly occurs on the flat areas between the dunes, but also to a lesser degree on the dune slopes and crests throughout Tembe (Matthews *et al*. 2001). This vegetation type is in effect grassland that is characterised by an abundance of shrub species that produced annual leafy and flowering shoots from a perennial, underground woody rootstock and has few large trees. Abundant plant species are the grasses *Trichoneura grandiglumis* and *Panicum kalaharense,* the geoxylic-suffrutex *Parinari capensis* subsp. *Incohata,* and the tree *Terminalia sericea*. This vegetation type covered 4.2% of the park (Matthews *et al*. 2001).

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CHAPTER 3

GENERAL METHODS

INTRODUCTION

The first aim of the present study was to determine the biological importance of the Tshanini Community Conservation Area in contributing towards the conservation of the rare Sand Forest habitat type. This was done by comparing the Sand Forest bird assemblages that are found in areas characterised by low levels of human utilisation, such as the Tshanini Community Conservation Area, with those characterised by primary wildlife utilisation, such as Tembe Elephant Park. This approach aimed to indicate the extent to which local human activities were having an effect on Sand Forest bird assemblages and it was used here as a point of departure to determine the feasibility of setting aside a part of the Manqakulani Ward as a wildlife resource use area. Birds were selected as a focal taxon because the Maputaland Centre of Plant Endemism has a rich avifauna, including a number of endemic species and subspecies (Clancy 1996; Harrison *et al.* 1997; Van Rensburg *et al.* 2000), the southern African birds are systematically well-known and well-surveyed (Harrison *et al.* 1997), and birds are relatively easy to sample quantitatively when compared with some other vertebrate taxa (Mac Nally 1997).

The second objective of this study was to gather information on the habitat preference and conservation status of selected herbivore species within the Tembe Elephant Park. This was done to identify possible competition between species and/or a decrease in numbers of rare species. It was furthermore aimed to identify herbivores that might be adversely affected by the destruction of Sand Forest, or who may themselves have a destructive effect on Sand Forest. Target herbivores included the nyala, impala, Burchell's zebra, greater kudu, red duiker and suni. Information on the habitat preference and status of the target herbivores is presented in separate chapters. In order to reduce the amount of repetition the detailed methods for the habitat preference and status of the respective target herbivores are presented here. The methods in the respective chapters are restricted to the broad outlines of the methods employed.

Bird surveys

In a previous study, Van Rensburg *et al.* (2000) investigated the habitat-associated heterogeneity and endemism of avian assemblages within and between Sand Forest patches and the savanna-like Mixed Woodland matrix that surrounds it. They collected bimonthly data for 12 months within the Tembe Elephant Park, hereafter referred to as Tembe and Sileza Nature Reserves that are *circa* 20 km apart and concluded that the relevant bird assemblages differed between habitats both within a given reserve and between reserves and also between reserves for a given habitat. No significant difference was, however, found between bird assemblages from different sample sites within the same habitat type within a particular reserve. For the present analysis, we used the basic data of Van Rensburg *et al.* (2000) on Tembe as a measure of avian assemblage structure as being representative of the Sand Forest and Mixed Woodland in a protected area and compared it with that of the Sand Forest and Mixed Woodland assemblages on unprotected communal land in the Tshanini Community Conservation Area, hereafter referred to as Tshanini.

Visual and auditory bird surveys were done monthly in the Tshanini area between 1 July and 31 December 2002 and therefore include data only for the austral winter and summer months. Because this area is not characterised by four distinctive seasons but rather mostly by two (i.e. summer and winter) due to the nature of the climatic conditions associated with the region (Schulze 1982; Matthews *et al.* 2001), this temporal extent during which time surveys were conducted was considered appropriate. Only one breeding migratory bird species present in Tembe from the Van Rensburg *et al.* (2000) study was not recorded in the present study, while five breeding and four non-breeding migratory bird species not recorded in the Tembe study were recorded in the present study.

We followed the same bird surveying protocol as Van Rensburg *et al.* (2000) in Tembe, except that only a single Sand Forest and Mixed Woodland site each were surveyed in Tshanini as opposed to two replicated sites of each habitat type in Tembe. This was mainly done due to the small geographical size of Tshanini (*circa* 2420 ha) and the lack of continuous Sand Forest habitat due to its patchy nature and previous human utilisation, leading to limited space for the placement of more replicated sites without increasing potential edge or pseudoreplication effects. However, knowing that bird assemblages from several study areas within the region showed no significant differences within a given habitat when replicated sites were compared within a small geographical space (Van Rensburg *et al.* 2000), this approach should not greatly effect the outcome of the present study. Also, seeing that the present study focused more on the potential role of a community-based conservation initiative based on the description of a bird assemblages in an area with proportionally few Sand Forest, as opposed to further understand the local scale heterogeneity dynamics or making inferences about the birds of Sand Forests in general, this limitation, although not ideal, should be negligible.

Each survey site comprised 16 randomly selected fixed survey points as determined originally by Van Rensburg *et al.* (2000) following the method of Buckland *et al.* (1994). To minimise the probability of double detection, to ensure data independence and to provide suitable replicates for the present study, the distances between the 16 survey points within a site and between the different sites were at least 200 and 500 m respectively. Bird surveys were done using point sampling as discussed by Buckland *et al.* (1994). The 16 survey points from a single site representing a given habitat type, were surveyed in one morning, taking 10 minutes per survey point. Each of the two sites was surveyed four times per month (i.e. 24 times over the six month sampling period). We varied the order in which the survey points was visited to ensure that each point was surveyed at different times during different mornings. The surveys were not done during rain that exceeded a light drizzle or during periods of strong winds.

The number of individuals of each species observed over the course of each sampling period in Tembe by Van Rensburg *et al.* (2000) and during the present study was summed for each survey point within each site. Multivariate community analysis of the absolute bird species abundance data was then made by using PRIMER v 5.2 (Clark & Warwick 1994). Cluster analysis, using group averaging and Bray Curtis similarity measures (Bray & Curtis 1957) was used to examine the relationships between habitat types both within and between study areas, and within a given habitat type between study areas. These data were double square root transformed prior to analysis so as to weight the common and rare species equally (Clark & Warwick 1994). Analyses of similarity were used to establish the significance of differences in bird assemblages between and within habitats. In this procedure a significant global *R*-statistic of close to 1 indicates distinct differences between the assemblages or habitats compared (Clark 1993). Non-metric multi-dimensional scaling was used to display the relationship between the survey sites in a two-dimensional ordination analysis.

To further describe and compare the bird assemblage that is found in Tshanini with those in Tembe, the degree of variation between the bio-indicator species that were identified for the different habitat types was calculated. Characteristic bird species (indicator species) were identified for each habitat type using the Indicator Value Method (Dufrêne & Legendre 1997). This assesses the degree (expressed as a percentage) to which each species fulfils the criteria of specificity (uniqueness to a particular site) and fidelity (frequency within that habitat type) for each habitat cluster compared with all other habitats. The higher the percentage IndVal (indicator value) obtained, the higher the specificity and fidelity values for that species, and the more representative the species is of that particular habitat.

The species abundance matrix from each survey site was used to identify the indicator species. The following comparisons were made: Tshanini Sand Forest versus Tshanini Mixed Woodland, Tembe Sand Forest versus Tembe Mixed Woodland, Tshanini Sand Forest versus Tembe Sand Forest, Tshanini Mixed Woodland versus Tembe Mixed Woodland, and Tshanini versus Tembe. Dufrêne and Legendre's (1997) random re-allocation procedure of sites among site groups was used to test the significance of the *IndVal* measures for each species. Those species with significant *IndVals* > 70% (a subjective benchmark) were then regarded as indicator species for the habitat in question (Van Rensburg *et al.* 1999; McGeoch *et al.* 2002).

The identification of rare species on a local scale seems unlikely to provide insight into the conservation requirements of the species involved unless information on their regional distribution and abundance elsewhere is taken into account (Van Rensburg *et al.* 1999). To assess whether such diffusive rarity occurs between habitat types at a fine spatial scale and/or nationally at a broad spatial scale, rare bird species were identified for each habitat type and each study area. This part of the study was done by using the proportion of species method of Gaston (1994) that defines rare species as the 25% least abundant species in a sample area.

Habitat preference

Road counts of the spatial distribution of the target herbivores were done in Tembe from December 2002 to November 2003. Three transects were used, together covering all the vegetation types occurring in the reserve (Figure 6). Transects were set out independent of ungulate distribution and the observations were done at random. The counts were done by driving a given transect during the first hours after sunrise and again during the last hours before sunset on the same day whenever possible. The route direction was reversed on alternate surveys during every month to minimise observer bias. The total study area was consequently surveyed four times per month for a full year.

All the observations were documented on a field form and the closest coordinates of the position of an observed herbivore on the transect was determined by using geographic positioning equipment (GPS). Where more than one animal was

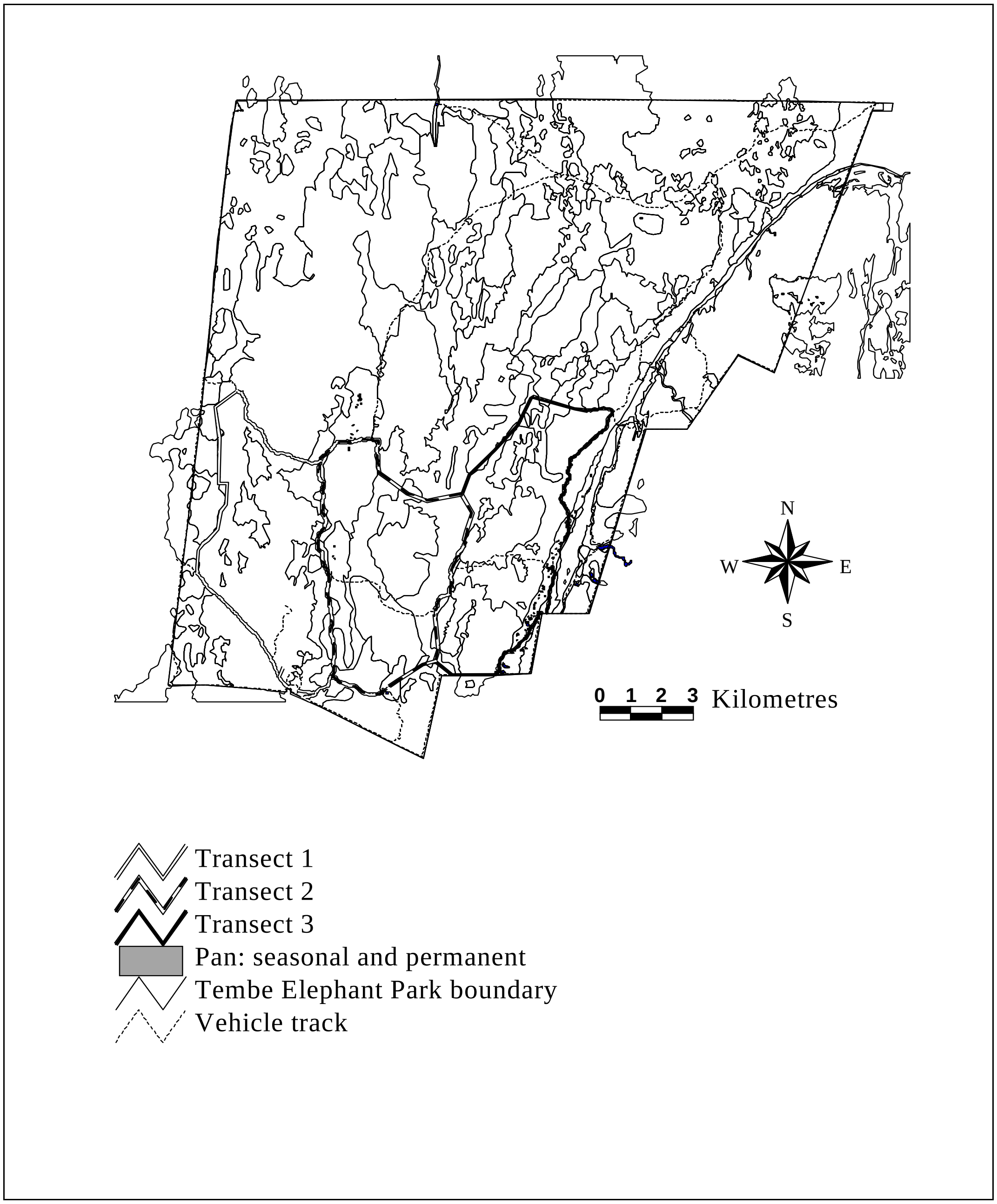

Figure 6: Transects that were used to determine the spatial distribution of the impala in Tembe Elephant Park, South Africa from December 2002 to November 2003.

encountered in the same location, such as a group of animals feeding together, the observation was regarded as one record and no distinction was made between the sex or age of the observed animals. All the data were captured on a computer database for further analysis. A measure of habitat preference for the target herbivore was obtained by comparing patterns of habitat use with habitat availability within the study area. Marked coordinates were used to determine the specific habitat where an animal was observed by plotting the points on the vegetation map of Tembe and using ArcView GIS (ESRI Inc. 1998). Habitat availability was calculated by dividing the area covered by habitat x within the study area by the total area covered by the study area. The Index of Jacobs (1974) was then used to calculate a preference index of use (P) for each vegetation type. A value of 0 indicated that a vegetation type was used in the same ratio as its proportional occurrence, a positive value ($P > 0$, maximum +1.0) indicated preference of use for a specific vegetation type and a negative value ($P < 0$, minimum –1.0) indicated no preference of use for the vegetation type. Habitat preference was then calculated with the following equations:

when $U > A$ then $P_{(x)} = (-1 \div U) \times (A - U)$ ——— equation 1

when $U < A$ then $P_{(x)} = (+1 \div A) \times (U - A)$ ——— equation 2

where: P = preference for vegetation type x,
U = proportion of use of vegetation type x,
A = proportion of vegetation type x available in the study area.

Preference was defined as the degree of difference between the use and availability of a specific vegetation type in the study area and gave an index of habitat preference. However, the preference index only provided a ratio of habitat use to habitat availability and was not based on a statistical test. This was overcome by performing a Chi-square goodness-of-fit test. The observed counts in each vegetation type were compared with the expected counts if each vegetation type were used in proportion to its availability. When a significant difference in use versus availability was detected, a Bonferroni Z-statistic was used to determine which vegetation types were used more or less often than expected by constructing 95% simultaneous confidence intervals around the proportion of the target herbivore recorded in each vegetation type (Beyers *et al*. 1984; Allredge & Ratti 1992; Pienaar *et al*. 1992). The confidence intervals were calculated by using the following equation:

$$U \pm Z_{1-\alpha/2k} \left[U\,(1-U) / n\right]^{½} \qquad \text{——— equation 3}$$

where: U = the proportion of use,

$Z_{1-\alpha/2k}$ = the upper standard normal table value corresponding to a probability tail area of α/2k,

k = the number of vegetation types,

n = the total number of observations.

Confidence intervals were calculated for α = 0.05, k = nine vegetation types and $Z_{1-\alpha/2k}$ = 2.75. The results indicated whether each vegetation type was used significantly more or less than expected by checking for overlap with the percentage availability of the corresponding vegetation type.

Population status

An aerial survey that was done in October 2003 was used to determine the current population status of the target herbivores in Tembe. It was the third major survey of large herbivores that was done in Tembe since 1994 and was built on the recommendations of the previous surveys that were done in August 2000 and October 2002 (Matthews 2000; 2002). The overall aim of the survey was to derive trends and estimates of the large herbivore populations in Tembe that would be useful for management decisions and would stand as a record of abundance for future trend analyses. Total aerial counts and transect distance sampling counts were used to estimate the number of the target herbivores in Tembe and to calculate trends in the population from 1993 to 2003 (Matthews 2004).

The method used in 2002 for the total aerial counts was similar to that used in 2000, but both were refined and improved versions of that used in 1994 (Matthews 2004). A helicopter, with the pilot and recorder at the front and two observers at the back, was flown on pre-determined transects. Transects were orientated in a parallel north-south direction, situated one kilometre apart, and arranged systematically to cover the whole park (Figure 7). Devices were fitted to both sides of the helicopter to

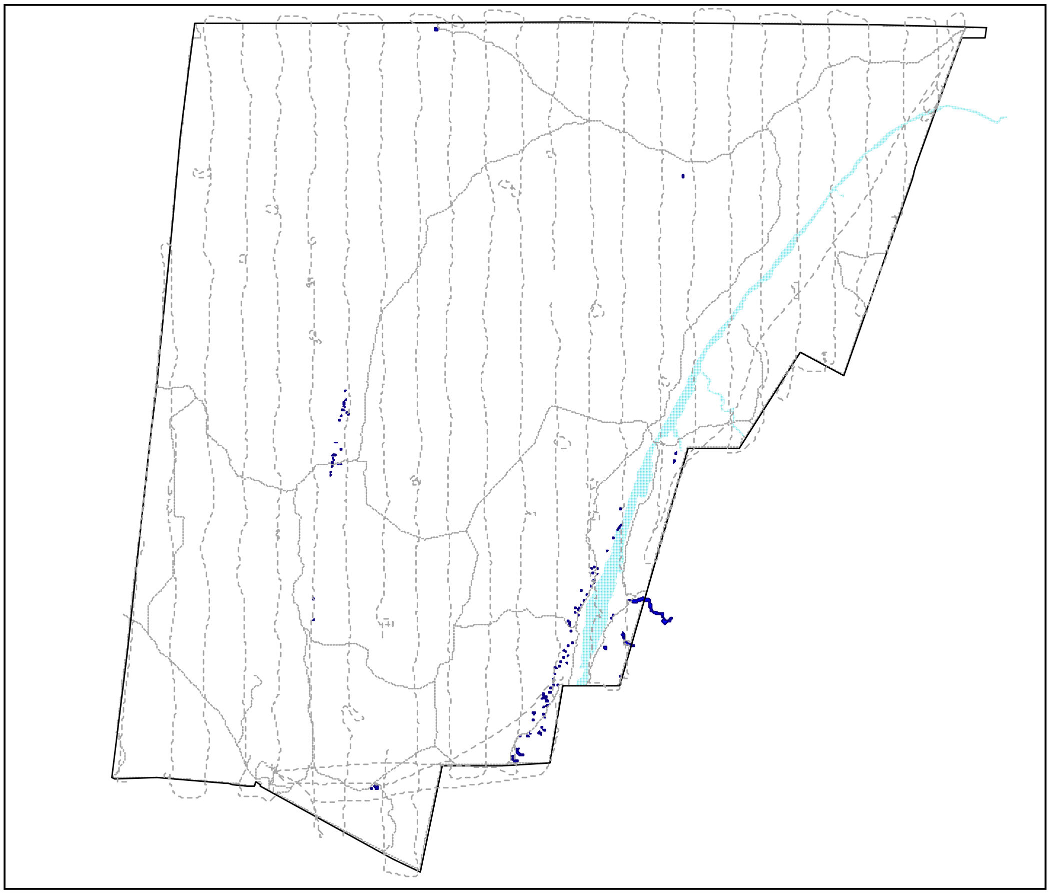

Figure 7: Flight path used for the total aerial counts and the transect distance sampling counts in Tembe Elephant Park, South Africa during October 2003 (Matthews 2004).

demarcate a distance of 500 m on each side when flying at a height of 90 m above the ground. Individuals of all large herbivore species within this belt were recorded.

Data for the transect distance sampling counts were also collected during the total aerial count. For this purpose, the devices on both sides of the helicopter were divided into distance classes with intervals of: 0 to 91 m, 91 to 200 m, 201 to 350 m and 351 to 500 m. All observed large herbivores were recorded within one of these distance sectors for further analysis (Matthews 2004).

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CHAPTER 4

THE VALUE OF COMMUNITY-BASED CONSERVATION IN A HETEROGENEOUS LANDSCAPE: A CASE STUDY FROM THE MAPUTALAND CENTRE OF PLANT ENDEMISM, SOUTH AFRICA

INTRODUCTION

The Maputaland Centre of Plant Endemism (see Van Wyk 1994 and 1996 for its boundary definitions) is an area that is well known for its conservation importance (Moll 1977; Kirkwood & Midgley 1999; Van Wyk & Smith 2001). One reason most likely responsible for the high levels of biodiversity and endemism associated with the Maputaland Centre is that this area lies at the southern end of the tropics in Africa and many organisms reach the southernmost limit of their range there (Watkeys *et al.* 1993; Hearne & Mckenzie 2000; Matthews *et al.* 2001; Van Wyk & Smith 2001). The region therefore is a biogeographical transitional zone between the tropics to the north and the subtropics to the south, and is characterised by a diverse array of biomes. Consequently, several species pools that cover large parts of continents and are characterised by a variety of vegetation types and climatic conditions, may therefore act as reservoirs to enhance species diversity at the smaller regional scale such as the Maputaland Centre (see e.g. bird richness patterns - Maddock & Benn 2000).

Although several conservation activities have been, and currently still are, taking place in the Maputaland Centre, there are still several conservation concerns within the region. A case in point is the conservation of the Sand Forest habitat type, a distinctive habitat type in southern Africa. The Sand Forest is characterised by a unique combination of plant and animal species and has the highest diversity of woody plant species in the region, with a significant number of these being endemic to the Maputaland Centre (Everard *et al.* 1994; Matthews *et al.* 2001). Quantitative evidence suggests that most of the endemic vertebrate species in the Maputaland Centre are likewise restricted to this habitat type (Van Wyk 1996; Van Rensburg *et al.* 2000). Although Sand Forest is considered the smallest habitat type in South Africa, covering only 0.03% of the region's total land surface area, *circa* 45% of this habitat type has already been transformed due to anthropogenic activities and only small portions of the remainder are currently being formally protected (Low & Rebelo 1996). Even within some of these protected areas, Sand Forest conservation is also under pressure. For example, Tembe Elephant Park contains the largest protected portion of Sand Forest in South Africa (Van Rensburg *et al.* 1999), but although elephants *Loxodonta africana* prefer plant species from woodland habitats, they are increasingly impacting Sand Forest plant species within the park (Matthews *et al*. 2001). To date no reversion to the original habitat structure has been recorded for disturbed Sand Forest patches even after extensive protection (Van Rensburg *et al.* 1999).

Another facet that conservation strategies have to take into account in order to integrate Sand Forest conservation requirements more carefully into future land-use planning is local scale heterogeneity. Several investigations examining the nature of fine-scale spatial heterogeneity in communities or assemblages have shown a large degree of such heterogeneity between different Sand Forest patches for dung beetles (Van Rensburg *et al.* 1999), birds (Van Rensburg *et al.* 2000) and plants (Matthews *et al.* 2001; Gaugris *et al.* 2004). This heterogeneity is most likely coupled with the biogeographical complexity of the area and indicates that conservation efforts in a variety of habitat patches are necessary to ensure the long-term persistence of its associated biota. This conclusion is particularly important given the increased impact, and hence destruction, of Sand Forest in Tembe (Van Rensburg *et al.* 1999, 2000).

One of the local communities who live adjacent to Tembe recently nominated a part of their ward, namely the Tshanini Community Conservation Area, as a community-based natural resource management project to serve as a possible conservation area in the region. The purpose of the area is to establish a nature reserve in the Manqakulani Ward of the Tembe Tribal Authority. The reserve is to be managed as an economic sustainable wildlife ranching and eco-culture tourism venture through the sustainable utilisation of renewable natural resources, but especially those resources that are associated with Sand Forest ecosystems. The aim of the present study was to describe and compare the Sand Forest bird assemblage that is found in Tshanini, which is characterised by low levels of human utilisation, with those characterised by wildlife utilisation such as in Tembe. This approach is to be used as a point of departure to determine the biological importance of this community area in contributing towards the conservation of the rare Sand Forest habitat type.

METHODS

The field work was done 5 km south of Tembe (27° 01'S; 32° 24'E), in Tshanini, located on the southern Mozambique Coastal Plain of the northern parts of the KwaZulu-Natal province in South Africa (Figure 8).

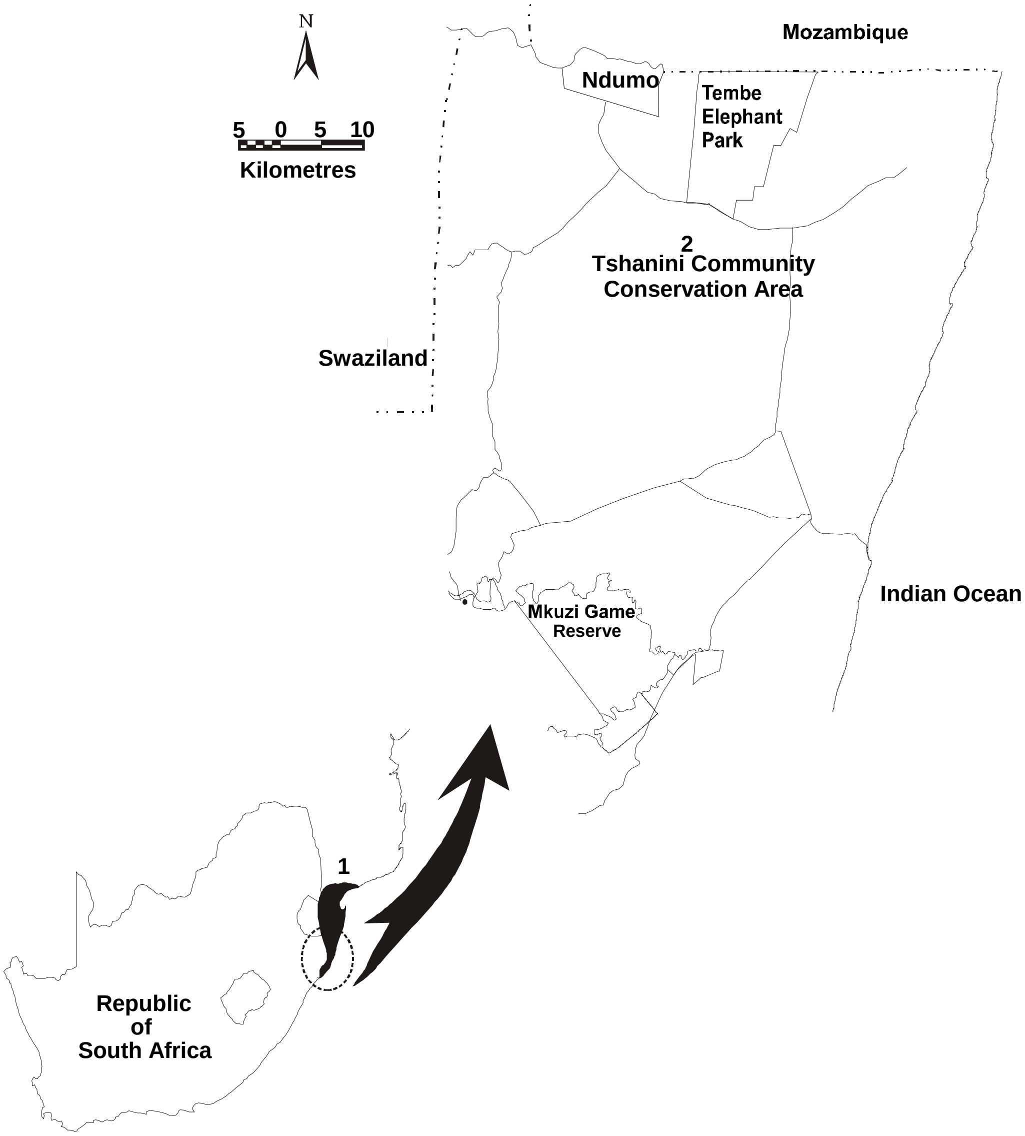


Figure 8. The location of (1) the Maputaland Centre of Plant Endemism and (2) the study area within the Maputaland Centre of Plant Endemism in South Africa.

Similar to Tembe, there are two distinct, clearly bounded habitat types in Tshanini, namely Sand Forest and Mixed Woodland. Visual and auditory bird surveys were done monthly in the Tshanini area between 1 July and 31 December 2002. We followed the same bird surveying protocol as Van Rensburg *et al.* (2000) in Tembe, except that only a single Sand Forest and Mixed Woodland site each were surveyed in Tshanini as opposed to two replicated sites of each habitat type in Tembe. The number of individuals of each species observed over the course of each sampling period in Tembe by Van Rensburg *et al.* (2000) and during the present study was summed for each survey point within each site. Multivariate community analysis of the absolute bird species abundance data was then made by using PRIMER v 5.2 (Clark & Warwick 1994). Cluster analysis, using group averaging and Bray Curtis similarity measures (Bray & Curtis 1957) was used to examine the relationships between habitat types. Analyses of similarity were used to establish the significance of differences in bird assemblages between and within habitats, and Non-metric multi-dimensional scaling was used to display the relationship between the survey sites in a two-dimensional ordination analysis.

To further describe and compare the bird assemblage that is found in Tshanini with those in Tembe, the degree of variation between the bio-indicator species that were identified for the different habitat types was calculated. Characteristic bird species (indicator species) were identified for each habitat type using the Indicator Value Method (Dufrêne & Legendre 1997). The proportion of species method of Gaston (1994), that defines rare species as the 25% least abundant species in a sample area, were used to identify rare bird species for each habitat type and each study area. For a detailed description of the methods, please refer to the general methods in chapter 3.

RESULTS

During the two study periods (1995 to 1996 and 2002) a total of 11 296 observations were made representing 121 bird species (Appendix 1). Significant differences in species richness (*S*) and abundance (*N*) values were found between the unprotected Tshanini area and the protected Tembe area, both values being higher in the former area (Table 1). As for Tembe (Van Rensburg *et al*. 2000), the species accumulation curve for Tshanini reached an asymptote within the sample size used indicating representative bird data for the area of interest (Figure 9).

Analysis of similarity indicated significant differences in bird assemblages between habitat types within and between study areas (Figure 10). This was also true between study areas within a given habitat type. Of all the possible habitat type

Table 1. Species richness and abundance values of birds surveyed in Tembe Elephant Park and the Tshanini Communal Area, South Africa between May 1995 to April 1996, and between July to December 2002 respectively. Significance was calculated at $P \leq 0.05$.

Site	Mean species richness ± Standard error. ($F_{1,62} = 1.294$, $P < 0.01$)	Mean species abundance ± Standard error. ($F_{1,62} = 7.679$, $P < 0.01$)	Number of sampling sites (*n*)	Total species richness (S)	Total species abundance (*N*)
Tshanini	41.06 ± 1.2	260.03 ± 8.9	32	99	8321
Tembe	31.81 ± 1.1	93.0 ± 3.2	32	96	2975

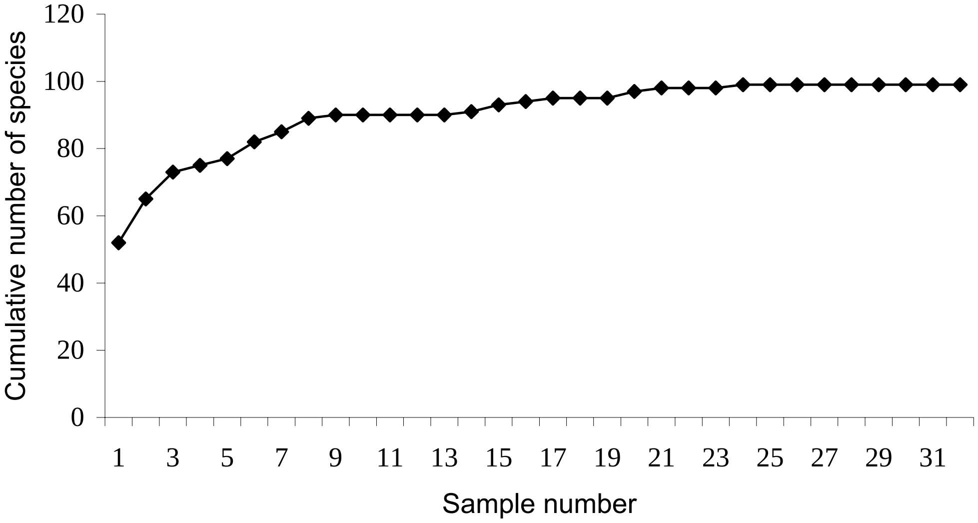
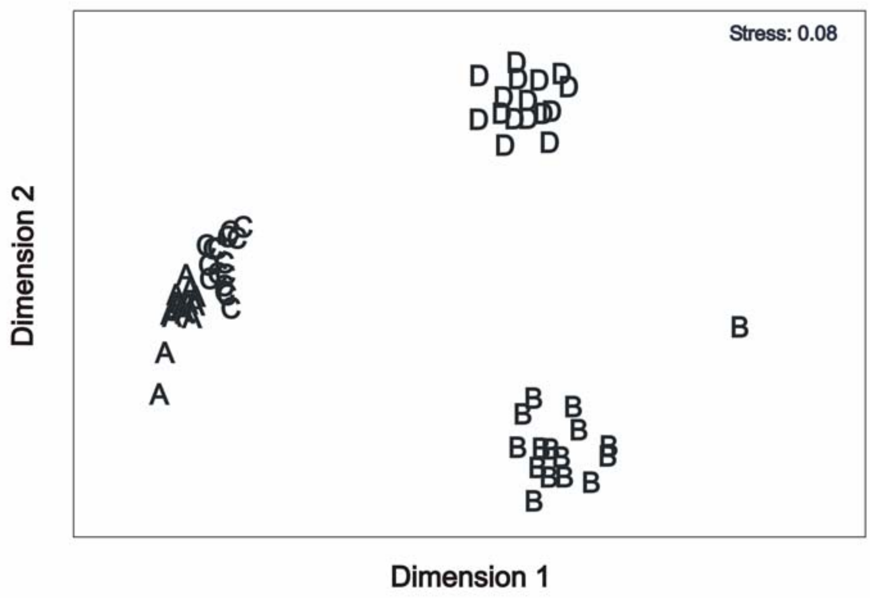


Figure 9. Species accumulation curve for bird assemblages in the Tshanini Community Conservation Area, South Africa from 1 July to 31 December 2002. Each point on the curve represents the mean of five randomly selected survey points from the full data set of survey points.



Tshanini Mixed Woodland	vs	Tembe Mixed Woodland	*R* = 0.998 (*P* = 0.001)
Tshanini Mixed Woodland	vs	Tshanini Sand Forest	*R* = 0.782 (*P* = 0.001)
Tshanini Mixed Woodland	vs	Tembe Sand Forest	*R* = 1.000 (*P* = 0.001)
Tembe Mixed Woodland	vs	Tshanini Sand Forest	*R* = 0.995 (*P* = 0.001)
Tembe Mixed Woodland	vs	Tembe Sand Forest	*R* = 0.974 (*P* = 0.001)
Tshanini Sand Forest	vs	Tembe Sand Forest	*R* = 1.000 (*P* = 0.001)

Figure 10. Non-metric ordination of four habitat sites in the Maputaland Centre of Plant Endemism, South Africa based on multidimensional scaling to indicate the degree of similarity of the abundances of bird species and subspecies in each assemblage where: A = Tshanini Mixed Woodland, B = Tembe Mixed Woodland, C = Tshanini Sand Forest and D = Tembe Sand Forest. The *R* – statistic is a measure of the similarity of assemblages. If *R* is significantly different from zero, then there are significant differences between assemblages. The data were captured between May 1995 and April 1996, and between July and December 2002.

comparisons, the bird assemblages of the Mixed Woodland and Sand Forest habitats in Tshanini showed the lowest degree of dissimilarity. In contrast, bird assemblages showed the highest degree of dissimilarity between Tembe and Tshanini Sand Forest sites and between Tshanini Mixed Woodland and Tembe Sand Forest sites. Clearly, from an avian point of view, these results suggest marked differences between the Tembe and Tshanini avian assemblages, and these differences seem to be more intense within the Sand Forest habitat than in the Mixed Woodland one. The apparent high habitat-associated heterogeneity between the two study areas is also supported by the different levels of habitat specific bird species that occurred consistently within a given habitat type for a particular study area (Table 2). Furthermore, Tshanini had a more even spread of indicator values and more species reaching higher absolute indicator values than Tembe, indicating a larger complex of more characteristic species in Tshanini than in Tembe (Figure 11).

Of the habitat-specific birds, three species and five subspecies are endemic to the Maputaland Centre (Table 2). Of the endemic species, Neergaard's sunbird *Cinnyris neergaardi* (100.0%) and Woodward's batis *Batis fratrum* (84.6%) were indicators of Tembe Sand Forest and the pink-throated twinspot *Hypargos margaritatus* (75.6%) as an indicator of Tembe Mixed Woodland. Neergaard's sunbird was absent from the Tembe Mixed Woodland areas but was relatively abundant in all the other habitat types, reaching its highest densities in the two Sand Forest habitats. Woodward's batis was present in all four of the habitat types but was consistently more abundant in the two Sand Forest ones. The pink-throated twinspot was also present in all four the habitat types but it was more abundant in the Mixed Woodland habitat and rare in the Tshanini Sand Forest (Appendix 1).

Of the endemic subspecies, the brown scrub-robin *Cercotrichas signata tongensis* (96.8%) and southern boubou *Laniarius ferrugineus tongensis* (86.5%) were indicators of the Tembe Sand Forest and the neddicky *Cisticola fulvicapilla lebombo* (87.5%) and white-browed scrub-robin *Cercotrichas leucophrys simulator* (70.0%) of the Tembe Mixed Woodland. The red-fronted tinkerbird *Pogoniulus pusillus niethammeri* (74.0%) was an indicator of the Tshanini Mixed Woodland. The brown scrub-robin was present in all four the habitat types, but it was consistently more abundant in the two Sand Forest ones compared to the Mixed Woodland ones, and it was rare in the Tembe Mixed Woodland. Although present in all four the habitat types, the southern boubou was more abundant in those associated with Tshanini than the Tembe ones. It was not rare in any habitat type but the lowest numbers were found in the Tembe Mixed Woodland.

Table 2. Percentage indicator values (*IndVal* > 70%) of bird species and subspecies for three different study area comparisons in the Maputaland Centre of Plant Endemism, South Africa from 1 July to 31 December 2002. Only significant ($P \leq 0.05$) values were included.

Sand Forest	% IndVal	Mixed Woodland	% IndVal	Combined	% IndVal
TEMBE					
Neergaard's sunbird†	100.0	Blue waxbill	93.8	Black-bellied starling	77.4
Brown scrub-robin‡	96.8	Rattling cisticola	93.8		
Southern boubou‡	86.6	Dark-capped bulbul	91.2		
Woodward’s batis†	84.6	Chinspot batis	88.9		
Blue-mantled crested flycatcher	83.7	Southern black tit	88.1		
Eastern nicator	71.1	Neddicky‡	87.5		
		Black-crowned tchagra	78.2		
		Pink-throated twinspot†	75.6		
		Golden-breasted bunting	75.0		
		Brown-crowned tchagra	74.1		
		White-browed scrub-robin‡	70.0		
TSHANINI					
Square-tailed drongo	93.8	Fork-tailed drongo	91.3	Red-eyed dove	99.2
		White-bellied sunbird	85.5	Purple-crested turaco	96.1
		Black-headed oriole	83.7	Orange-breasted bush-shrike	95.5
		Chinspot batis	82.25	Gorgeous bush-shrike	93.9
		Klaas’s cuckoo	77.27	Red-chested cuckoo	92.4

Table 2 *continued*

Sand Forest	% IndVal	Mixed Woodland	% IndVal	Combined	% IndVal
		Purple-crested turaco	70.45	African broadbill	83.0
		Yellow-rumped tinkerbird	76.47	Southern boubou	91.8
		Crowned hornbill	74.63	Sombre greenbull	86.0
		Red-fronted tinkerbird‡	74.04	Eastern nicator	84.4
		Cardinal woodpecker	72.79	Barn swallow	84.4
		Crested francolin	71.43	Emerald-spotted wood-dove	83.2
				Black-backed puffback	73.3
				Grey-headed bush-shrike	71.2

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† Species and ‡ subspecies endemic to the Maputaland Centre of Plant Endemism.

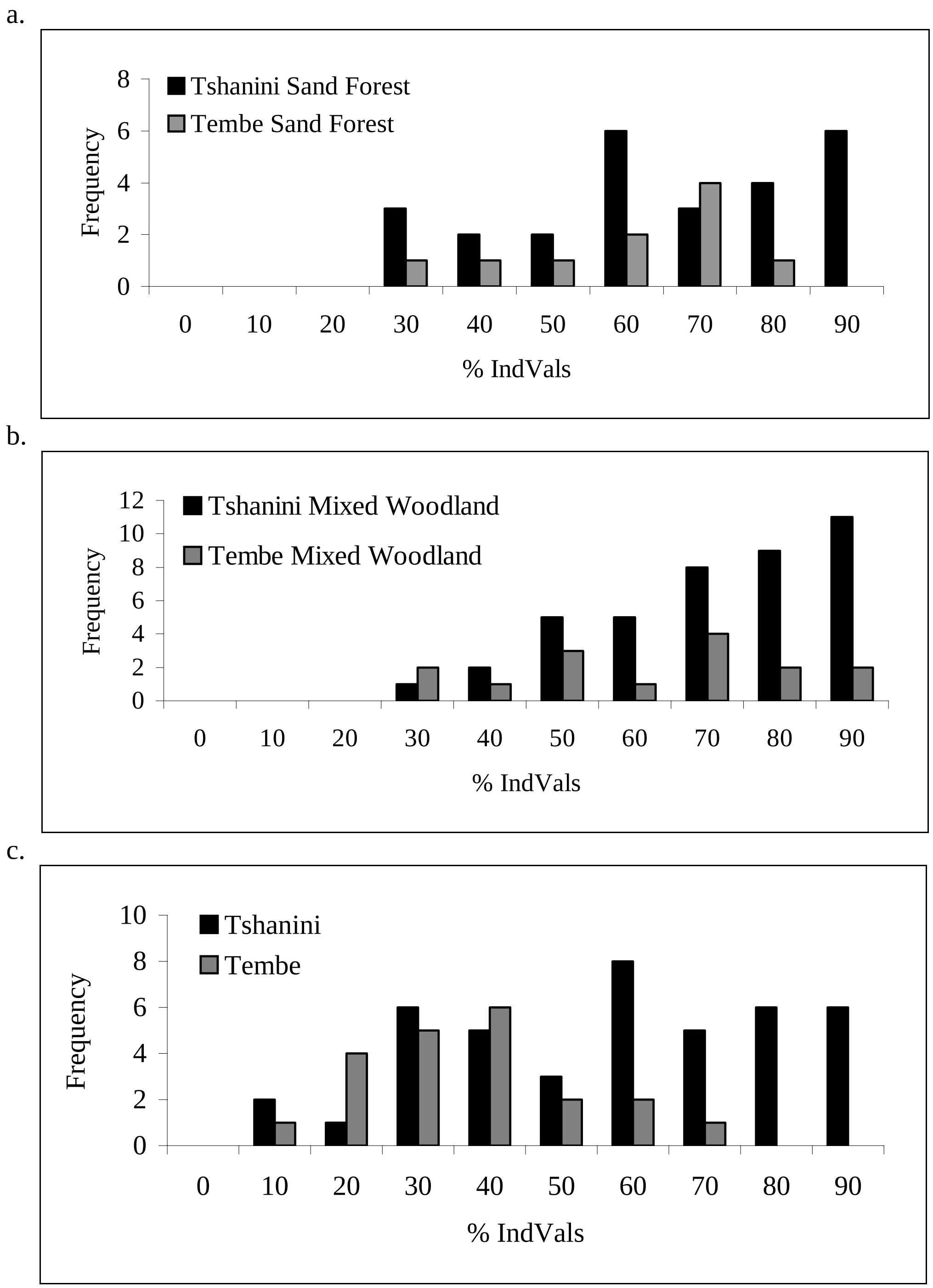

Figure 11. Bird indicator species value distributions for (a) Tshanini Sand Forest versus Tembe Sand Forest, (b) Tshanini Mixed Woodland versus Tembe Mixed Woodland and (c) the entire Tshanini versus the entire Tembe in the Maputaland Centre of Plant Endemism, South Africa. The data were captured between May 1995 and April 1996, and between July and December 2002.

The neddicky was considered rare in the Tshanini Mixed Woodland and was absent from both the Sand Forest habitat types, reaching its highest numbers in the Tembe Mixed Woodland. The white-browed scrub-robin was also present in all four the habitat types and was not considered rare in any one of them. It was, however, consistently more abundant in the Mixed Woodland. The red-fronted tinkerbird was rare in the Tembe Mixed Woodland, was absent from the Tembe Sand Forest, and reached its highest numbers in the Tshanini Mixed Woodland (Appendix 1).

A total of 65 bird species and 5 subspecies were rare in at least one of the habitat types, varying from 17 to 28 species and subspecies per locality (Appendix 1). Of these, 14 species each were restricted to Tshanini and Tembe respectively. None of these rare and restricted species was endemic to the Maputaland Centre, or was identified as an indicator species for any given habitat type within the study area. However, of the 14 species that were considered to be rare and restricted to Tshanini, six were classified as red data species based on Baillie and Groombridge (1996) and Barnes (2000). None of these species was considered rare in South Africa (Harrison *et al*. 1997) and none of the 14 rare and Tembe restricted species was classified as a red data species. The plain-backed sunbird *Anthreptes reichenowi* is, however, rare in South Africa (Harrison *et al.* 1997).

Of the 51 species or subspecies considered to be common in this study area, 11 and 8 of the species were restricted to Tshanini and Tembe, respectively. Of these 51 species or subspecies, none was endemic to the Maputaland Centre or rare in South Africa. The blue waxbill *Uraeginthus angolensis* (93.8% IndVal) was an indicator species for the Tembe Mixed Woodland, the barn swallow *Hirundo rustica* (84.4% IndVal) for the Tshanini habitat as a whole and Klaas's cuckoo *Chrysococcyx klaas* (77.3% IndVal) for the Tshanini Mixed Woodland. Of the species considered common and restricted to Tshanini, only the African goshawk *Accipiter tachiro* was classified as a red data species (Baillie & Groombridge 1996; Barnes 2000). None of the eight common species that were restricted to Tembe was classified as a red data species.

DISCUSSION

This study demonstrated the biological importance of the Tshanini Community Conservation Area to further Sand Forest conservation, especially from an avian perspective. When compared with Tembe, Tshanini contained an unique avian Sand Forest assemblage that is often characterised by more characteristic species and subspecies that shows higher abundance and higher area fidelity values. Moreover, when compared to the different habitat comparisons, reliable indicator species and subspecies were identified at the study area scale after comparing Tshanini with Tembe as a whole. Because the two study areas were sampled in different years (1995/96 and 2002), a component (albeit probably small) of the differences between study areas may have been due to temporal variation in populations and communities.

Differences in local avian assemblages, especially those in forests, are often a function of the physical structure of a plant community, showing how the foliage is distributed vertically, as opposed to the actual composition of plant species (Rotenberry & Wiens 1980; Van Rensburg *et al.* 2000). In a recent study by Gaugris *et al.* (2004), comparisons were made between the plant communities of Tshanini and similar vegetation units in Tembe. Although their results indicated a high degree of floristic similarity between the two areas, values representing plant physiognomy showed significant differences. For example, within the Sand Forest habitat the vegetation community in Tshanini had a significantly higher mean cover value per species than its equivalent in Tembe. Such structural differences in the vegetation between the two areas most likely contributed most towards the observed differences found in the Sand Forest avian assemblages (see also Van Rensburg *et al.* 2000).

Owing to the high degree of biological heterogeneity in the Maputaland Centre, previous studies recommended that a comprehensive representation of different Sand Forest patches be incorporated into the region's conservation network. Most of these recommendations were based on studies that were done in the region during the late 1990's (e.g.: Van Rensburg *et al.* 1999, 2000; Matthews *et al.* 2001; McGeoch *et al.* 2002). Nevertheless, when comparing the conservation network in South Africa in 1997 (World Conservation Monitoring Centre 1997) with that of 2004 (WDPA Consortium 2004), no additional reserves containing pure Sand Forest plant communities have been added since 1997. This is true regardless of the more than 155 000 ha of land that has been added to the terrestrial protected-area system in South Africa from 1994 to 2002 (Wynberg 2002).

In a complex endemic zone like the Maputaland Centre, one can expect to find a large number of range-restricted species (Poynton 1961). Because these species are part of those most effected by anthropogenic activities, and therefore of most conservation concern (Balmford *et al.* 2001), emphasis should be placed on the extent to which current and future conservation areas within the Maputaland Centre contribute towards conserving endemic species. Indeed, in a recent study on the effectiveness of the global protected area network in representing species diversity, it was indicated that the areas most in need of conservation are often those with high levels of endemism (Rodriques *et al.* 2004). This was true even for endemic areas where the conservation network already captured a large percentage of the land surface area. This conclusion raises the question of Tshanini's value to enhance the conservation of endemic species. Although the majority of bird species and subspecies that are endemic to the Maputaland Centre achieve their greatest abundance within Tembe when compared with Tshanini, none of these species or subspecies was restricted to Tembe. Moreover, one of these, the red-fronted tinker barbet, was identified as being reliably habitat specific for the Tshanini Mixed Woodland (Table 2). Tshanini can therefore contribute towards the conservation of endemic species and subspecies being represented in as many as possible areas, an important feature for the long-term persistence of wildlife, particularly those with strict habitat requirements (Rodriques *et al.* 2004). Because 43% of the avian species or subspecies that were only recorded in Tshanini are also red data species or subspecies (Baillie & Groombridge 1996; Barnes 2000), Tshanini will further regional conservation efforts and contribute towards national ones.

As is the case in most countries, conservation: human conflicts will likely escalate in southern Africa in the future. Therefore an integrated approach incorporating both conservation and human development needs is required. Such an approach should emphasise the value of existing conservation areas and view parks as a central component of conservation strategies (Bruner *et al.* 2001; McKinney 2002), from which to promote the sustainable development of rural communal areas surrounding these sites (Editorial 2003), while establishing buffer zones around protected areas. Since the eradication of poverty is an indispensable requirement for sustainable development (UNDP 2003), the alleviation of poverty in areas surrounding protected areas will contribute largely towards the required future integrated approach. The present study has shown that the Tshanini Community Conservation Area not only has the potential to contribute significantly towards biodiversity conservation, but that it will also serve as an example for conservation-based community development in South Africa. It is one of the first reserves of its kind to be established in a ward of a tribal area in the northern parts of the KwaZulu-Natal province of South Africa through the initiative taken by the local people themselves. This is a huge step forward for conservation in South Africa, given the current negative attitude of the rural people towards conservation. However, the success of such ventures will require structures to promote initiatives that will support their establishment and maintain their long-term sustainability. We can ill afford to lose any chance to promote conservation in South Africa where the highest known concentration of threatened plants and the highest extinction estimates for any area in the world are found (Wynberg 2002).

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Appendix 1. The total number of individual birds, bird species and subspecies recorded in the Tembe Elephant Park and the Tshanini Community Conservation Area Sand Forest and Mixed Woodland habitats. Bold values denote rare species or subspecies, defined as the 25% least-abundant birds in each of the four habitat types. SUM *r* = sum of the habitat types in which a species or subspecies was classified as rare.

			Mixed Woodland		Sand Forest	
Common name	Scientific name	Sum *r*	Tshanini	Tembe	Tshanini	Tembe
Taxa rare in one or more habitats						
African crowned eagle	*Stephanoaetus coronatus* §	1	1	0	0	0
African dusky flycatcher	*Muscicapa adusta*	2	2	5	1	0
African green-pigeon	*Treron calvus*	1	15	6	1	0
African hoopoe	*Upupa Africana*	1	1	0	0	0
African paradise flycatcher	*Terpsiphone viridis*	3	3	2	0	1
African yellow white-eye	*Zosterops senegalensis*	3	1	2	1	0
Amethyst sunbird	*Chalcomitra amethystine*	2	3	1	0	0
Ashy flycatcher	*Muscicapa caerulescens*	3	2	2	0	1
Bearded scrub-robin	*Cercotrichas quadrivirgata wilsoni* ‡	1	13	3	22	3
Black kite	*Milvus migrans* §	1	0	0	3	0
Black-chested snake-eagle	*Circaetus pectoralis* §	1	1	0	0	0
Black-crowned tchagra	*Tchagra senegalus*	1	4	26	6	1
Blue-mantled crested flycatcher	*Trochocercus cyanomelas*	1	1	6	17	50
Brimstone canary	*Serinus sulphuratus*	1	1	0	0	0
Brown scrub-robin	*Cercotrichas signata tongensis*‡	1	5	3	28	90
Brown-hooded kingfisher	*Halcyon albiventris*	2	2	11	0	1
Brubru	*Nilaus afer*	2	24	1	7	1
Cardinal woodpecker	*Dendropicos fuscescens*	1	43	9	5	1
Collared sunbird	*Hedydipna collaris*	1	5	15	2	5
Crested francolin	*Peliperdix sephaena*	1	60	4	24	1
Crested guineafowl	*Guttera edouardi*	2	2	2	9	7
Diederick cuckoo	*Chrysococcyx caprius*	1	1	0	0	0
Eastern olive sunbird	*Cyanomitra olivacea*	2	2	1	0	0
European bee-eater	*Merops apiaster*	2	2	0	1	0
Fiscal flycatcher	*Sigelus silens*	1	0	2	0	2
Fork-tailed drongo	*Dicrurus adsimilis*	1	136	2	13	0
Golden-breasted bunting	*Emberiza flaviventris*	1	1	21	0	0
Gorgeous bush-shrike	*Telophorus quadricolor*	1	174	3	229	23
Greater honeyguide	*Indicator indicator*	1	1	4	0	0
Green twinspot	*Mandingoa nitidula*	1	0	1	0	0
Green-winged pytilia	*Pytilia melba*	1	0	3	0	0
Grey sunbird	*Cyanomitra veroxii*	2	3	17	3	38
Grey waxbill	*Estrilda perreini*	1	0	0	1	0
Grey-headed bush-shrike	*Malaconotus blanchoti*	1	29	1	22	4
Hadeda ibis	*Bostrychia hagedash*	2	19	0	3	1
Jacobin cuckoo	*Oxylophus jacobinus*	1	1	0	0	0
Kurrichane thrush	*Turdus libonyanus*	1	16	0	1	4
Levaillant's cuckoo	*Oxylophus levaillantii*	1	0	0	0	1

Appendix 1 *continued*

			Mixed Woodland		Sand Forest	
Common name	Scientific name	Sum *r*	Tshanini	Tembe	Tshanini	Tembe
Martial eagle	*Polemaetus bellicosus*§	2	1	0	1	0
Narina trogon	*Apaloderma narina*	1	11	3	24	14
Neddicky	*Cisticola fulvicapilla lebombo* ‡	1	1	29	0	0
Orange-breasted bush-shrike	*Telophorus sulfureopectus*	1	227	16	135	1
Pale flycatcher	*Bradornis pallidus sibilans* ‡	2	6	3	1	0
Pink-throated twinspot	*Hypargos margaritatus* †	1	8	38	2	6
Plain-backed sunbird	*Anthreptes reichenowi*	1	0	0	0	1
Purple-banded sunbird	*Cinnyris bifasciatus*	1	14	18	3	21
Purple-crested turaco	*Musophaga porphyreolopha*	1	174	9	73	1
Red-eyed dove	*Streptopelia semitorquata*	1	285	1	210	3
Red-faced cisticola	*Cisticola erythrops*	1	0	2	0	0
Red-faced mousebird	*Urocolius indicus*	2	3	0	2	0
Red-fronted tinkerbird	*Pogoniulus pusillus niethammeri* ‡	1	33	1	6	0
Retz's helmet-shrike	*Prionops retzii*	2	3	9	1	11
Rudd's apalis	*Apalis ruddi* †	1	6	10	1	2
Rufous-naped lark	*Mirafra Africana*	1	0	3	0	0
Rufous-winged cisticola	*Cisticola galactotes*	1	0	3	0	0
Sabota lark	*Calendulauda sabota*	1	0	9	0	1
Southern black flycatcher	*Melaenornis pammelaina*	2	0	3	1	0
Steppe buzzard	*Buteo vulpinus* §	2	1	0	1	0
Striped kingfisher	*Halcyon chelicuti*	1	0	1	0	0
Tambourine dove	*Turtur tympanistria*	1	0	0	2	15
Tawny-flanked prinia	*Prinia subflava*	1	14	22	0	1
Violet-backed starling	*Cinnyricinclus leucogaster*	1	2	0	5	0
White-starred robin	*Pogonocichla stellata*	2	0	1	0	1
White-throated robin-chat	*Cossypha humeralis*	3	0	2	1	1
Yellow-bellied eremomela	*Eremomela icteropygialis*	1	0	1	0	0
Yellow-fronted canary	*Serinus mozambicus*	2	1	18	1	0
Yellow-rumped tinkerbird	*Pogoniulus bilineatus*	1	48	4	3	2
Zitting cisticola	*Cisticola juncidis*	1	0	5	0	1
Taxa common in all habitats recorded						
African broadbill	*Smithornis capensis*		56	0	76	22
African emerald cuckoo	*Chrysococcyx cupreus*		28	0	23	0
African goshawk	*Accipiter tachiro* §		7	0	7	0
Barn swallow	*Hirundo rustica*		55	0	39	0
Bearded woodpecker	*Dendropicos namaquus*		5	0	0	0
Black cuckoo	*Cuculus clamosus*		31	0	8	0
Black cuckooshrike	*Campephaga flava*		14	0	0	4
Black-backed puffback	*Dryoscopus cubla*		227	80	207	78
Black-bellied starling	*Lamprotornis corruscus*		0	29	10	82
Black-collared barbet	*Lybius torquatus*		17	0	0	0
Black-headed oriole	*Oriolus larvatus*		82	14	16	14
Blue waxbill	*Uraeginthus angolensis*		0	36	0	0
Brown-crowned tchagra	*Tchagra australis*		24	31	14	3
Burchell's coucal	*Centropus burchelli*		37	0	10	0

Appendix 1 *continued*

			Mixed Woodland		Sand Forest	
Common name	Scientific name	Sum *r*	Tshanini	Tembe	Tshanini	Tembe
Cape turtle-dove	*Streptopelia capicola*		16	18	0	21
Cape white-eye	*Zosterops capensis*		0	0	0	2
Chinspot batis	*Batis molitor molitor*		139	55	30	3
Croaking cisticola	*Cisticola natalensis*		0	4	0	0
Crowned hornbill	*Tockus alboterminatus*		50	20	17	14
Dark-backed weaver	*Ploceus bicolor sclateri* ‡		105	35	131	70
Dark-capped bulbul	*Pycnonotus tricolour*		242	83	106	8
Grey tit-flycatcher	*Myioparus plumbeus*		0	7	0	0
Jameson's firefinch	*Lagonosticta rhodopareia*		0	4	0	0
Klaas’s cuckoo	*Chrysococcyx klaas*		68	0	20	0
Long-billed crombec	*Sylvietta rufescens*		39	6	4	0
Marico sunbird	*Cinnyris mariquensis*		4	0	0	0
Neergaard's sunbird	*Cinnyris neergaardi* †		23	0	29	82
Rattling cisticola	*Cisticola chiniana*		24	112	4	0
Red-capped robin-chat	*Cossypha natalensis*		17	8	19	11
Red-chested cuckoo	*Cuculus solitarius*		110	5	170	18
Scaly-throated honeyguide	*Indicator variegates*		30	0	20	18
Sombre greenbull	*Andropadus importunes*		369	67	288	40
Southern black tit	*Parus niger*		13	31	6	2
Southern boubou	*Laniarius ferrugineus tongensis* ‡		366	5	365	60
Speckled mousebird	*Colius striatus*		4	0	0	0
Spectacled weaver	*Ploceus ocularis*		7	0	0	0
Square-tailed drongo	*Dicrurus ludwigii*		0	71	101	109
Terrestrial brownbull	*Phyllastrephus terrestris*		30	57	34	62
White-bellied sunbird	*Cinnyris talatala*		134	8	13	0
White-browed robin-chat	*Cossypha heuglini*		0	0	0	3
White-browed scrub-robin	*Cercotrichas leucophrys simulator* ‡		29	32	16	8
White-crested helmet-shrike	*Prionops plumatus*		0	5	0	0
Woodward’s batis	*Batis fratrum* †		4	5	10	46
Yellow-bellied greenbull	*Chlorocichla flaviventris*		329	58	286	132
Yellow-breasted apalis	*Apalis flavida*		161	101	167	129
Species richness			**92**	**85**	**76**	**66**
Total number of individuals			**4805**	**1492**	**3516**	**1483**

† Species and ‡ subspecies endemic to the Maputaland Centre of Plant Endemism.

§ Red data species or subspecies restricted to a given study area.

CHAPTER 5

HABITAT PREFERENCE AND STATUS OF THE NYALA IN TEMBE ELEPHANT PARK, SOUTH AFRICA

INTRODUCTION

The nyala is a member of the family Bovidae and the exclusively African tribe Tragelaphini (Grubb 1993; Estes 1997). The name nyala is derived from the Zulu name “inxala” that was given to it in South Africa. Gray first described it scientifically in 1849 (Skinner & Smithers 1990; Fürstenburg 2002). Other species in this tribe include the bushbuck *Tragelaphus scriptus*, sitatunga *Tragelaphus spekii*, mountain nyala *Tragelaphus buxtoni*, greater kudu *Tragelaphus strepsiceros*, lesser kudu *Tragelaphus imberbis*, bongo *Tragelaphus eurycerus*, southern eland *Taurotragus oryx* and Derby’s eland *Taurotragus derbianus* (Grubb 1993; Estes 1997; Fürstenburg 2002). Tribal traits include a medium-sized to large body, spiralled horns, white vertical stripes and a pronounced sexual dimorphism.

The basic social group of the nyala is the family unit, which consists of an adult female and her offspring, while males are usually solitary (Anderson 1980). Several authors have described the nyala as being primarily or predominantly a browser, although it includes a fair amount of grass in its diet when grass is available (Vincent *et al*. 1968; Anderson & Pooley 1977). Van Rooyen (1990) showed that the nyala in the Ndumu Game Reserve is flexible when selecting food items and that it selects a diet that varies according to season as influenced by rainfall. The nyala can therefore be defined as an intermediate feeder that prefers browse but who will graze to a large extent only during the initial period of fresh growth following the onset of the summer rains.

The nyala occurs in the southeastern parts of the African continent and has a localised distribution because of its habitat requirements. The distribution of the nyala closely corresponds with the Mozambique Coastal Plain and valleys of the major rivers in this area but this distribution has been greatly reduced in recent years and the nyala has become isolated within the last century (Estes 1997). Today the nyala is found naturally in the hot, low-lying areas of northern and southern Zimbabwe, Mozambique and in the Limpopo, Mpumalanga and KwaZulu-Natal provinces of South Africa. However, it has recently been translocated to numerous private reserves and wildlife ranches in southern Africa, with Ezemvelo KwaZulu-Natal Wildlife translocating more than 8 000 nyala over the past 25 years alone (Mills & Hes 1997). When translocated outside its normal distributional range, the nyala competes successfully with ecologically close species like the bushbuck. In several parks and reserves it has been necessary to control the populations of nyala for some time to prevent the overutilisation of a number of plant communities. The demand for the nyala for trophy hunting has also led to the improvement of its status outside reserves and national parks, and viable populations are present on several privately owned ranches because of its economic value (Mills & Hes 1997).

Knowledge of the habitat preference and conservation status of large herbivores is basic to any management programme for a reserve and a pre-requisite to determine stocking densities and possible translocations (Dekker *et al*. 1996). Stocking density is the area of land allocated per animal unit (Tainton 1999). The optimal stocking density of various species depends on the available habitat, the quality of the habitat and the objectives of use (Van Rooyen *et al*. 1996). A sound knowledge of the diet and factors affecting it are also crucial to understanding ungulate ecology and management (Van Rooyen 1990). The fact that most species are linked to major vegetation types helps in understanding their distribution patterns (Pienaar 1974).

In the present study, we tested the hypothesis that the nyala responded to the variables in its physical habitat in proportion to its availability within the Tembe Elephant Park. If the nyala showed a preference of use for certain vegetation types, then the suitability of different areas can be determined for the nyala by evaluating the physical characteristics of the preferred vegetation types. More accurate stocking densities can then also be determined based on the habitat preferences of the nyala. The objective of the present study was therefore to gather information on the habitat preference and conservation status of the nyala within the park. This information is crucial for the effective management of the nyala population in the park, as well as for future reintroductions of nyala to neighbouring areas.

METHODS

The methods presented below are restricted to the broad outlines of the methods employed. For a more detailed description of the methods, please refer to the general methods in chapter 3.

Habitat preference

Road counts of the spatial distribution of the nyala were done in Tembe from December 2002 to November 2003. The study area was surveyed four times per month for a full year. All the observations were documented on a field form and the closest coordinates of the position of an observed nyala was determined by using geographic positioning equipment (GPS). All the data were captured on a computer database for further analysis.

A measure of habitat preference for the nyala was obtained by comparing patterns of habitat use with habitat availability within the study area. The Index of Jacobs (1974) was then used to calculate a preference index of use (*P*) for each vegetation type. The preference index only provided a ratio of habitat use to habitat availability and was not based on a statistical test. This was overcome by performing a Chi-square goodness-of-fit test. When a significant difference in use versus availability was detected, a Bonferroni *Z*-statistic was used to determine which vegetation types were used more or less often than expected by constructing 95% simultaneous confidence intervals around the proportion of the nyala recorded in each vegetation type (Beyers *et al*. 1984; Allredge & Ratti 1992; Pienaar *et al*. 1992).

Direct observations of feeding were also made to identify the preferred height and plant species that were being browsed by the nyala in Tembe. Plant species were identified either while the animal was actually feeding, or by site inspection once it had moved on. If a plant species could not be identified in the field, a sample was taken for later identification. Feeding records were taken during diurnal activity only.

Population status

An aerial survey that was done in October 2003 was used to determine the current population status of the nyala in Tembe. The overall aim of the survey was to derive trends and estimates of the large herbivore populations in Tembe that would be useful for management decisions and would stand as a record of abundance for future trend analyses. Total aerial counts and transect distance sampling counts were used to estimate the number of nyala in Tembe and to calculate trends in the population from 1993 to 2003 (Matthews 2004).

RESULTS

Habitat preference

A total of 724 observations were recorded during the study period. The nyala was most often found in Closed Woodland/Thicket Mosaic on sand (31.5% of observations) and Open Woodland (30.4%), less often in Closed Woodland on clay (13.4%), Sand Forest/Grassland Mosaic (13.3%) and *Acacia borleae* Shrubland/Bush Clump Mosaic on clay (10.8%), and least often in Hygrophilous Grassland (0.6%) and the Muzi Swamp (0.1%). The nyala was never found in Old Lands or in Sparse Woodland (Table 3). The Chi-square goodness-of-fit test for the

Table 3. Vegetation types in Tembe Elephant Park, South Africa, their respective sizes (km²), proportion of the available habitat, proportion of use by the nyala and preference index of use by the nyala from December 2002 to November 2003.

Number	Vegetation type	Size (km²)	Percentage of available habitat (*A*)	Percentage of use (*U*)	Preference index (*P*)
1	*Acacia borleae* Shrubland/Bush Clump Mosaic on clay	2.3	0.7	10.8	0.935
2	Closed Woodland/Thicket Mosaic on sand	51.8	15.0	31.4	0.524
3	Closed Woodland on clay	8.7	2.5	13.4	0.813
4	Hygrophilous Grassland	6.7	2.0	0.6	-0.700
5	Muzi Swamp	3.4	1.0	0.1	-0.900
6	Old Lands	0.6	0.2	0.0	-1.000
7	Open Woodland	91.5	26.6	30.4	0.125
8	Sand Forest/Grassland Mosaic	164.8	47.8	13.3	-0.722
9	Sparse Woodland	14.4	4.2	0.0	-1.000

overall data set showed a significant difference ($\chi^2 = 242.817$; $p \leq 0.05$; $df = 8$) in use versus availability for the different vegetation types in Tembe. The preference index of use of vegetation types by the nyala in Tembe indicated vegetation types 1, 2 and 3 as being preferred for use, vegetation types 4, 5, 6, 8 and 9 as not being preferred and vegetation type 7 as being used in the same ratio as its proportional occurrence (Table 4).

Based on 102 feeding observations, a total of 29 plant species was browsed by the nyala in Tembe (Table 5). Generally, only the leaves of the food plants were eaten, although shoots, flowers and fruit were also eaten sporadically. Browsing height was predominantly from 0.5 m to 1.5 m (74.5% of all the observations) with 20.6% of feeding observations at a height < 0.5 m and 4.9% > 1.5 m. Using the number of times that a nyala was observed feeding on a particular species as a measure of the frequency of consumption, *Grewia caffra* (21.6%), *Strychnos madagascariensis* (17.7%) and *Strychnos spinosa* (13.7%) were the most commonly eaten plants (Table 5). During field observations the nyala was also observed eating fresh green grass sprouting after rain.

Population status

During the total aerial count, 584 nyala were recorded in 178 groups. Based on the distance sample estimate this indicated a population of 1341 individuals, which is the current estimate for the nyala population in Tembe (Matthews 2004). Population trends appear to indicate an increase in the nyala population, from a total aerial count of 45 individuals in 1993 to the 584 in 2003 (Figure 12).

DISCUSSION

Habitat preference

The nyala in Tembe showed a preference of use for the *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, the Closed Woodland/Thicket Mosaic on sand and the Closed Woodland on clay. No observations of the nyala were ever recorded in the Old Lands and the Sparse Woodland and these vegetation types are clearly not being used. The Hygrophilous Grassland, Muzi Swamp and Sand Forest/Grassland Mosaic were also not being used often and the Open Woodland was used in proportion to its availability.

Table 4. The preference of use of the vegetation types in Tembe Elephant Park, South Africa by the nyala from December 2002 to November 2003 ($\alpha = 0.05$; $k = 9$; $Z_{1-\alpha/2k} = 2.75$)

Vegetation type*	Percentage of habitat	Chi-square contribution	Confidence interval	Habitat use
1	0.7	145.7	$0.076 \leq p_1 \leq 0.140$	Prefer
2	15	17.9	$0.268 \leq p_2 \leq 0.362$	Prefer
3	2.5	47.5	$0.099 \leq p_3 \leq 0.169$	Prefer
4	2.0	0.9	$-0.002 \leq p_4 \leq 0.014$	Not used
5	1.0	0.8	$-0.002 \leq p_5 \leq 0.004$	Not used
6	0.2	0.2	$0.000 \leq p_6 \leq 0.000$	Not used
7	26.6	0.5	$0.257 \leq p_7 \leq 0.351$	No pattern
8	47.8	24.9	$0.098 \leq p_8 \leq 0.168$	Not used
9	4.2	4.2	$0.000 \leq p_9 \leq 0.000$	Not used
Total	100	242.6	-	-

*Vegetation type numbers correspond with Figure 5 in chapter 2, and Table 3.

Table 5. The percentage occurrence of various plant species in the diet of the nyala based on 102 feeding observations from December 2002 to November 2003 in Tembe Elephant Park, South Africa.

Plant species	Actual observations	Percentage of occurrence
Acacia borleae	1	1.0
Acacia burkei	5	4.9
Afzelia quanzensis	1	1.0
Albizia versicolor	1	1.0
Brachylaena discolor	1	1.0
Bridelia cathartica	2	2.0
Carissa bispinosa	1	1.0
Coddia rudis	1	1.0
Commelina africana	1	1.0
Dialium schlechteri	3	2.9
Dichrostachys cinerea	5	4.9
Euclea natalensis	1	1.0
Gardenia volkensii	1	1.0
Grewia caffra	22	21.6
Helichrysum kraussii	1	1.0
Jasminum breviflorum	3	2.9
Margaritaria discoidea	1	1.0
Mundulea sericea	1	1.0
Pollichia campestris	1	1.0
Psydrax locuples	1	1.0
Pteleopsis myrtifolia	1	1.0
Rhus lucida	1	1.0
Senecio pleistocephalus	6	5.9
Strychnos madagascariensis	18	17.7
Strychnos spinosa	14	13.7
Tabernaemontana elegans	3	2.9
Trichilia emetica	2	2.0
Vepris lanceolata	1	1.0
Vernonia colorata	2	2.0

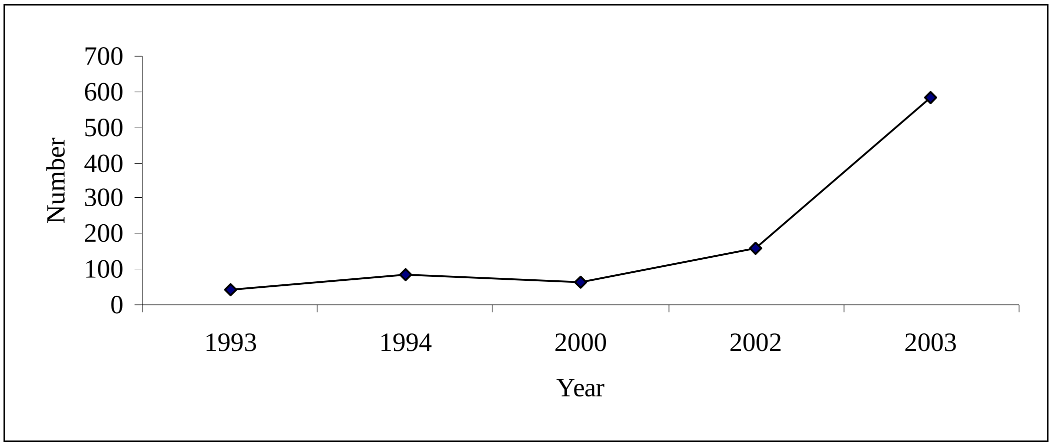

Figure 12: Aerial survey of the nyala as based on total counts conducted in Tembe Elephant Park, South Africa from 1993 to 2003. Source: Matthews *et al*. (2004).

The *Acacia borleae* Shrubland/Bush Clump Mosaic on clay occurs next to marshy areas and clay-based thickets associated with the Muzi Swamp. In structure this vegetation type varied from areas of dense vegetation to thickets that were associated with termitaria. Moreover, perennial pans were found interspersed throughout these clay areas (Matthews *et al*. 2001). Of all the observations of the nyala, 10.8% were in this vegetation type but it only comprised < 1% of the total available habitat.

The Closed Woodland/Thicket Mosaic on sand occurs on the dune crests, slopes and interdune depressions throughout Tembe and can be distinguished based on plant density, which in most cases varied from closed to semi-closed crown gaps and a canopy that varied from approximately 8 to 12 m in height. The nyala reached its highest density (31.5%) in this vegetation type.

The Closed Woodland on clay occurs on soils that were normally associated with bottomlands of dunes (Matthews *et al*. 2001). Although this vegetation type only covered 2.5% of the surface area of Tembe, 13.4% of observations of the nyala were made there. The shrub *Grewia caffra* showed a strong affinity to all three of these above vegetation types (Matthews *et al*. 2001) and was the most commonly used plant species for browse by the nyala in Tembe. The presence of dense vegetation or thickets, and to a lesser degree of perennial pans, seemed to play an important role in the distribution of the nyala and their preference towards certain vegetation types in Tembe.

The Sparse Woodland mainly occurs on the flat areas between the dunes, but also to a lesser degree on the dune slopes and crests throughout Tembe (Matthews *et al*. 2001). This vegetation type was in effect a grassland that was characterised by an abundance of shrub species that produced annual leafy and flowering shoots from a perennial, underground woody rootstock and has few large trees. Even though the nyala occurred in a wide variety of habitats, various studies have shown that the presence of cover in the form of dense vegetation is vital (Vincent *et al*. 1968; Anderson 1978; Skinner & Smithers 1990; Van Rooyen 1990). The open nature of the Old Lands and the Sparse Woodland were therefore the most likely reason why the nyala did not use these habitat types in Tembe.

No preference of use was shown towards the Hygrophilous Grassland that occurs adjacent to the Muzi Swamp, the Muzi Swamp itself or the Sand Forest/Grassland Mosaic. The Hygrophilous Grassland and the Muzi Swamp have a grassland structure with no abundant trees or thickets (Matthews *et al*. 2001). The Sand Forest/Grassland Mosaic was the largest vegetation type in Tembe and was mostly associated with dunes. This vegetation type was structurally classified as a forest that was interspersed with grassland (Matthews *et al*. 2001). The grasslands there were open with little to no trees and shrubs. It gradually acquired a more open woodland character further away from the Sand Forest. Of all the observations recorded for the nyala, 13.3% were in this vegetation type. Although the nyala has been shown to occur in the open, as in other studies they were always close to dense vegetation and made straight for the nearest cover when disturbed (Vincent *et al*. 1968; Skinner & Smithers 1990).

The Open Woodland was the second largest vegetation type in Tembe and it occurs on the dune crests, slopes and interdune depressions throughout the park. It has a small number of trees of approximately 8 to 10 m tall scattered throughout a well-developed grass layer. Abundant trees in this vegetation type included *Albizia versicolor*, *Strychnos madagascariensis* (the second most abundant woody plant used by the nyala), *Combretum molle*, and *Terminalia sericea* (Matthews *et al*. 2001). The second highest occurrence of the nyala (30.4% of all observations) was in this vegetation type. Although the nyala was often observed in the Open Woodland during field observations, the overall density of the nyala there was low because of the size of this vegetation type and it was used by the nyala in the same ratio as its proportional occurrence in Tembe.

The habitat of ungulates provides them with food, water and cover, and the feeding style of each species is therefore of primary importance in determining its preferred habitat (Van Rooyen 1990). Species in the tribe Tragelaphini have diets that include a high proportion of dicotyledonous plants (Gagnon & Chew 2000), and the nyala is no exception. The nyala is, however, flexible when selecting food items due to the influence of rainfall and shows considerable variation in dicotyledonous intake according to the season, from 18.7% in November to 81.9% in July (Van Rooyen 1990). Of the 29 plant species identified as being browsed by the nyala in Tembe, six accounted for 68.7% of the feeding observations on the nyala (Table 3). These plant species also reached their highest abundance within one or more of the vegetation types preferred for use by the nyala in Tembe (Matthews *et al*. 2001). Furthermore, all these plant species were recorded in rumen analyses of the nyala in Ndumo Game Reserve (Anderson & Pooley 1977) and are thus considered to be important in the diet of the nyala.

Population status

The population of the nyala in Tembe is currently estimated at 1341 individuals, possibly the first reliable estimate for the nyala in Tembe (Matthews *et al*. 2001). With the nyala, animal density is not a primary function of social spatial behaviour but rather of food and habitat suitability. Therefore, nyala density can vary from 0.7 nyala/ha to 0.03 nyala/ha with the maximum recommended density being 0.4 nyala/ha under optimal conditions (Fürstenburg 2002). The nyala population in a given area should therefore be controlled in order to prevent the overutilization of their preferred habitat. The influence of the nyala on its preferred habitat should also be monitored, especially where less abundant species share these habitat preferences. In Tembe, 6280 ha of preferred habitat (vegetation types 1, 2 and 3) are available. This equates to an estimated maximum recommended stocking density of 2512 nyala based on habitat availability. The expected population growth rate for the nyala is 28% per year (Fürstenburg 2002). Should no control of the nyala population in Tembe take place, the current estimated population is likely to reach the maximum recommended stocking density within 3 years. In order to keep the nyala population in Tembe at its current level, 375 individuals will have to be removed annually based on the expected population growth rate, whether this is through predation, culling, live capture for translocation or other causes.

Since most harvesting programmes disrupt animal herds, it should be done at a time that will have the least effect on reproduction. Animals should not be disturbed just before, during or immediately after the lambing season (Bothma 2002). The nyala breed year-round with two breeding peaks in autumn and spring (Van Rooyen 1990; Estes 1997). The best time to harvest it would therefore be during May or June. Apart from being the least disruptive on reproduction, this will have the added advantage of reducing the nyala population before late winter when food is in short supply. The removal of lone female nyala should be avoided since they might have hidden calves. Instead the removal of complete female units must be attempted. Male nyala will probably be encountered in relation to the proportional age distribution of the population and should be removed accordingly. The nyala is unlikely to change its existing range use pattern and harvesting should thus be confined to areas with visible habitat degradation (Anderson 1978).

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CHAPTER 6

HABITAT PREFERENCE AND STATUS OF THE IMPALA IN TEMBE ELEPHANT PARK, SOUTH AFRICA

INTRODUCTION

The impala is a member of the family Bovidae, and it is the sole member of the tribe Aepycerotini. Although efforts have been made to tidy up bovid classification by putting the impala in the same tribe as the gazelles, kobs and most recently the hartebeests, it is so different from other antelope that it clearly belongs in a separate tribe (Estes 1997). Lichtenstein first described it scientifically in 1812 from a specimen collected in the Kuruman district of the Northern Cape Province of South Africa (Skinner & Smithers 1990; Grubb 1993). The impala is distributed widely in the eastern woodland parts of Africa, from northern Kenya all the way south to the northern parts of the KwaZulu-Natal province of South Africa. In the southern parts of its distribution, it extends westwards to the extreme southern parts of Angola (Skinner & Smithers 1990). It is an ecotone species, preferring light woodland with little undergrowth and grassland of low to medium height (Estes 1997). In all regions, the impala is highly residential and it seldom moves more than 10 km from the centre of its home range (Kingdon 1997). Cover and the availability of surface water are essential habitat requirements for the impala. Although it is rarely found more than 8 km from water in the dry season, the impala can survive without drinking water with access to green vegetation (Skinner & Smithers 1990; Estes 1997; Mills & Hes 1997).

Based on its diet, the impala is classified as an intermediate feeder, being an animal with a diet that consists of 30 to 70% monocotyledonous and dicotyledonous plant material but always < 20% fruits (Gagnon & Chew 2000). The ability of the impala to utilise both monocotyledonous and dicotyledonous plant material gives it an unusually varied and reliable food source and makes it highly adaptable to different areas. The impala includes more grasses in its diet during the summer, and gradually shifts to more shrubs and bushes as the season becomes drier. The shift in its diet is not only linked to the season, but it is also influenced by the available habitat. Consequently, the impala can also thrive in areas where the natural vegetation has degenerated because of overgrazing or bush encroachment (Estes 1997; Kingdon 1997). The habitat of ungulates provides them with food, water and cover and the feeding styles of each species are therefore of primary importance in determining their preferred habitat (Van Rooyen 1990).

The impala is gregarious but shows regular changes in social organisation and the males are only territorial during the annual rut. Outside this period, the males congregate in bachelor herds and the females occur in breeding herds. Territorial males have exclusive mating rights and females entering a male's territory are herded by him and are aggressively defended against other males. After the rut the territorial system deteriorates and males form bachelor herds or join the breeding herds (Skinner & Smithers 1990; Anderson 1997).

Knowledge of the habitat preference, ecological requirements and conservation status of large herbivores is basic to any management programme for a reserve, and a pre-requisite to determine stocking densities and possible translocations (Dekker *et al*. 1996). Stocking density is the area of land allocated per animal unit (Tainton 1999). In conservation areas, one of the primary objectives is to maintain viable populations of all the indigenous species present. The control of impala numbers is a major consideration when trying to maintain both habitat and species diversity. A sound knowledge of the diet and factors affecting it are also crucial to understanding ungulate ecology and management (Van Rooyen 1990). The fact that most species are linked to major vegetation types helps in understanding their distribution patterns (Pienaar 1974).

In the present study, we tested the hypothesis that the impala responded to the variables in its physical habitat in proportion to its availability within the Tembe Elephant Park. If the impala showed a preference of use for certain vegetation types, then the suitability of different areas for the impala can be determined by evaluating the physical characteristics of the preferred vegetation types. More accurate stocking densities can then also be determined based on the habitat preferences and diet of the impala. The objective of the present study was therefore to gather information on the habitat preference and conservation status of the impala within the park. This information is crucial for the effective management of the impala population in the park, as well as for future reintroductions of the impala to neighbouring areas.

METHODS

The methods presented below are restricted to the broad outlines of the methods employed. For a more detailed description of the methods, please refer to the general methods in chapter 3.

Habitat preference

Road counts of the spatial distribution of the impala were done in Tembe from December 2002 to November 2003. The study area was surveyed four times per month for a full year. All the observations were documented on a field form and the closest coordinates of the position of an observed impala was determined by using geographic positioning equipment (GPS). All the data were captured on a computer database for further analysis.

A measure of habitat preference for the impala was obtained by comparing patterns of habitat use with habitat availability within the study area. The Index of Jacobs (1974) was then used to calculate a preference index of use (*P*) for each vegetation type. The preference index only provided a ratio of habitat use to habitat availability and was not based on a statistical test. This was overcome by performing a Chi-square goodness-of-fit test. When a significant difference in use versus availability was detected, a Bonferroni *Z*-statistic was used to determine which vegetation types were used more or less often than expected by constructing 95% simultaneous confidence intervals around the proportion of the impala recorded in each vegetation type (Beyers *et al*. 1984; Allredge & Ratti 1992; Pienaar *et al*. 1992).

Population status

An aerial survey that was done in October 2003 was used to determine the current population status of the impala in Tembe. The overall aim of the survey was to derive trends and estimates of the large herbivore populations in Tembe that would be useful for management decisions and would stand as a record of abundance for future trend analyses. Total aerial counts and transect distance sampling counts were used to estimate the number of impala in Tembe and to calculate trends in the population from 1993 to 2003 (Matthews 2004).

RESULTS

Habitat preference

In all, 818 observations of impala were recorded during the study period. It was most often found in Open Woodland (42.7% of observations) and *Acacia borleae* Shrubland/Bush Clump Mosaic on clay (29.8%), less often in Sand Forest/Grassland Mosaic (10.3%), Closed Woodland/Thicket Mosaic on sand (9.7%) and Closed Woodland on clay (4.8%), and least often in Hygrophilous Grassland (1.7%), Sparse Woodland (1.0%) and the Muzi Swamp (0.1%). The impala was never found in Old Lands (Table 6). The Chi-square goodness-of-fit test for the overall data set showed

Table 6. Vegetation types in Tembe Elephant Park, South Africa, their respective sizes (km²), proportion of the available habitat, proportion of use by the impala and preference index of use by the impala from December 2002 to November 2003.

Number	Vegetation type	Size (km²)	Percentage of available habitat (*A*)	Percentage of use (*U*)	Preference index (*P*)
1	*Acacia borleae* Shrubland/Bush Clump Mosaic on clay	2.3	0.7	29.8	0.977
2	Closed Woodland/Thicket Mosaic on sand	51.8	15.0	9.7	-0.353
3	Closed Woodland on clay	8.7	2.5	4.8	0.479
4	Hygrophilous Grassland	6.7	2.0	1.7	-0.150
5	Muzi Swamp	3.4	1.0	0.1	-0.900
6	Old Lands	0.6	0.2	0.0	-1.000
7	Open Woodland	91.5	26.6	42.6	0.376
8	Sand Forest/Grassland Mosaic	164.8	47.8	10.3	-0.785
9	Sparse Woodland	14.4	4.2	1.0	-0.762

a significant difference ($\chi^2 = 1256.254$; $p \leq 0.05$; $df = 8$) in use versus availability for the different vegetation types in Tembe. The preference index of use of vegetation types by the impala in Tembe indicated vegetation types 1, 3 and 7 as being preferred for use, vegetation types 2, 5, 6, 8 and 9 as not being preferred and vegetation type 4 as being used in the same ratio as its proportional occurrence (Table 7).

Population status

During the total aerial count, 460 impala were recorded in 69 groups. Based on the distance sample estimate this indicated a population of 1331 individuals, which is the current estimate for the impala population in Tembe (Matthews 2004). Population trends appear to indicate an increase in the impala population from a total aerial count of 69 individuals in 1993 to the 460 in 2003 (Figure 13).

DISCUSSION

Habitat preference

The impala in Tembe showed a preference of use for the *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, the Closed Woodland on clay and the Open Woodland. The Hygrophilous Grassland was used in proportion to its availability within the park while the Closed Woodland/Thicket Mosaic on sand, Muzi Swamp, Sand Forest/Grassland Mosaic and Sparse Woodland were not being used often and no observations of the impala were ever recorded in the Old Lands.

The *Acacia borleae* Shrubland/Bush Clump Mosaic on clay occurs next to marshy areas and clay-based thickets associated with the Muzi Swamp. In structure this vegetation type varied from areas of dense vegetation to thickets that were associated with termitaria. Moreover, perennial pans were found interspersed throughout these clay areas (Matthews *et al*. 2001). Of all the observations of the impala, the second highest number (29.8%) was in this vegetation type but it only comprised 0.7% of the total available habitat.

The Closed Woodland on clay occurs on clay-rich duplex soils that are normally associated with the bottomlands of the dunes and the edges of the Muzi Swamp. Perennial pans were also found throughout this vegetation type and it contained few grass species. Since the impala is dependent on the availability of drinking water, and is seldom found far from it, the presence of perennial pans in these vegetation types were most likely the reason for their preference by the impala in Tembe (Skinner & Smithers 1990; Estes 1997).

Table 7. The preference of use for the vegetation types in Tembe Elephant Park, South Africa by the impala from December 2002 to November 2003 ($\alpha = 0.05$; $k = 9$; $Z_{1-\alpha/2k} = 2.75$)

Vegetation type*	Percentage of habitat	Chi-square contribution	Confidence interval	Habitat use
1	0.7	1209.7	$0.254 \leq p_1 \leq 0.342$	Prefer
2	15	1.9	$0.069 \leq p_2 \leq 0.125$	Not used
3	2.5	2.1	$0.027 \leq p_3 \leq 0.069$	Prefer
4	2.0	0.1	$0.005 \leq p_4 \leq 0.029$	No pattern
5	1.0	0.8	$-0.002 \leq p_5 \leq 0.004$	Not used
6	0.2	0.2	$0.000 \leq p_6 \leq 0.000$	Not used
7	26.6	9.6	$0.378 \leq p_7 \leq 0.474$	Prefer
8	47.8	29.4	$0.074 \leq p_8 \leq 0.132$	Not used
9	4.2	2.4	$0.000 \leq p_9 \leq 0.020$	Not used
Total	100	1256.2	-	-

*Vegetation type numbers correspond with Figure 5 in chapter 2, and Table 6.

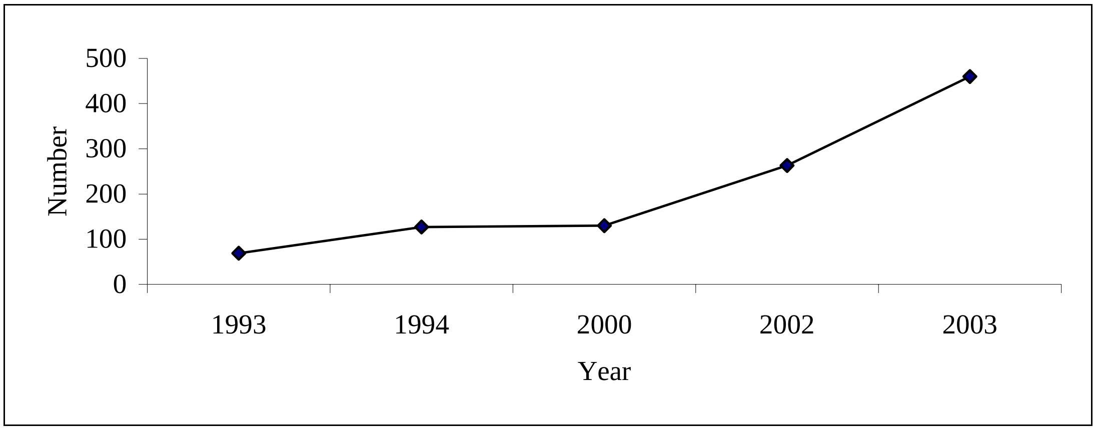

Figure 13: Aerial survey of the impala as based on total counts conducted in Tembe Elephant Park, South Africa from 1993 to 2003. Source: Matthews *et al*. (2004).

The Open Woodland was the second largest vegetation type in Tembe and occurs on the dune crests, slopes and interdune depressions throughout the park (Matthews *et al*. 2001). This vegetation type was characterised by a good grassy layer interspersed with a few tall trees of approximately 8 to 10 m in height. This vegetation type had the highest occurrence of the impala in Tembe (42.7%). Grass species abundant in the Open Woodland included several species with a high grazing value such as *Andropogon gayanus*, *Panicum maximum* and *Digitaria eriantha* (Van Oudtshoorn 1999; Matthews *et al*. 2001). Abundant trees in this vegetation type included *Albizia versicolor*, *Strychnos madagascariensis*, *Combretum molle*, and *Terminalia sericea* (Matthews *et al*. 2001). Most of these species are common in the diet of the impala elsewhere, and most likely also the reason why they prefer this vegetation type in Tembe (Skinner & Smithers 1990).

The Hygrophilous Grassland had a grassland structure with only scattered trees or thickets and occurs adjacent to the Muzi Swamp as well as in marshy areas associated with sand. Abundant plant species in the Hygrophilous Grassland were the grasses *Imperata cylindrica, Eragrostis lappula, Dactyloctenium geminatum, Panicum genuflexum* and *Eragrostis heteromera* and the shrub *Acacia nilotica* (Matthews *et al*. 2001). None of these grasspecies present has a high grazing value and therefore the grasses are generally poorly utilised by grazers (Van Oudtshoorn 1999).

The Closed Woodland/Thicket Mosaic on sand occurs on the dune crests, slopes and interdune depressions throughout Tembe and could be distinguished based on plant density, which in most cases varied from closed to semi-closed crown gaps and a canopy that varied from approximately 8 to 12 m in height. The Muzi Swamp have a grassland structure with no abundant trees or thickets and comprised of reed beds of the extensive Muzi Swamp system that crosses the eastern side of Tembe and extends northwards to Maputo Bay in Mozambique. The Sand Forest/Grassland Mosaic was the largest vegetation type in Tembe and was mostly associated with dunes. This vegetation type was structurally classified as a forest that was interspersed with grassland (Matthews *et al*. 2001). Abundant grass species included species with a low grazing value like *Andropogon chinensis*, *Perotis patens*, *Diheteropogon amplectens* and *Aristida stipitata* subsp. *spicata*. The grasslands there were open with little to no trees and shrubs. It gradually acquired a more open woodland character further away from the Sand Forest.

The Old Lands comprised only 0.2% of the total available habitat in Tembe. Since the proclamation of the park more than 10 years ago, these areas have recovered to the point that they are not distinguishable in the field anymore. This, and the absence of water was most likely the reason that the impala was never recorded in the Old Lands despite the fact that impala are usually associated with a heavily utilised herbaceous layer (Wentzel *et al.* 1991). The ability of the impala to utilise both monocotyledonous and dicotyledonous plant material makes it highly adaptable to different areas. The impala also have the ability to shift its diet according to the season and the available habitat (Estes 1997; Kingdon 1997). In Tembe, vegetation types with an intermediate density was consistently selected for use by the impala over dense vegetation or vegetation with an open grassland structure.

Population status

The population of the impala in Tembe is currently estimated at 1331 individuals. This can be considered more reliable than past estimates although it might be higher than the actual number (Matthews *et al*. 2001). The impala is today more widely distributed and occurs in greater numbers in a wider range of habitats than ever before. It forms the basis of game farming wherever it occurs and has been translocated extensively into areas beyond its natural range, where it is out-competing other species (Skinner & Smithers 1990; Anderson 1997; Friedmann & Daly 2004). The control of impala numbers is thus a major consideration when trying to maintain both habitat and species diversity. The impala population in a given area should therefore be controlled in order to prevent the overutilisation of the habitat. The influence of the impala on its preferred habitat should also be monitored, especially where less abundant species share these habitat preferences.

The long-term ecological capacity for the impala is 300 animals for 1000 ha of optimal impala habitat, or 0.3 impala/ha (Fürstenburg 1997). In Tembe, 10 250 ha of preferred habitat (vegetation types 1, 3 and 7) are available. This equates to an estimated maximum recommended stocking rate of 3075 impala based on habitat availability. The impala is, however, dependent on water and is rarely found more than 8 km from surface water (Mills & Hes 1997). Tembe, being situated in the drier central regions of Maputaland, have few permanent waterholes and water for animals are mostly available in the form of perennial pans found interspersed throughout the clay areas. The Muzi Swamp is the only natural source of permanent water present in Tembe throughout the year (Matthews *et al*. 2001). A high density of the impala around water will inevitably lead to veld degradation. In order to keep the impala population in Tembe at its current level, 466 individuals will have to be removed annually, based on an expected population growth rate of 35%, whether this is through predation, culling, live capture for translocation or other causes (Bothma *et al*. 2002).

Since most harvesting programmes disrupt animal herds, it should be done at a time that will have the least effect on reproduction. Animals should not be disturbed just before, during or immediately after the lambing season (Bothma 2002). The impala breeds seasonally, with a restricted mating season during the rut in autumn. The onset of the rut is in May, with most mating between full moons (Skinner & Smithers 1990; Van Rooyen 1990; Estes 1997). Lambs are born within a restricted period of a few weeks during the months of November to January after a gestation period of 194 to 200 days. The young are weaned and able to survive without their mothers by 4½ months (Skinner & Smithers 1990). The best time to harvest would therefore be during June and July. Apart from being the least disruptive on reproduction, this will have the added advantage of reducing the impala population before late winter when food is in short supply. Because of the fact that the impala is highly residential and seldom moves more than 10 km, harvesting should be confined to areas with visible habitat degradation.

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CHAPTER 7

HABITAT PREFERENCE AND STATUS OF BURCHELL'S ZEBRA IN TEMBE ELEPHANT PARK, SOUTH AFRICA

INTRODUCTION

Burchell's zebra is a member of the family Equidae comprising large, single-hoofed ungulates that are built for speed and long-distance movements (Estes 1997). The name zebra is derived from the Italian/Portuguese form of the name that was given to a group of species in the Democratic Republic of the Congo (Skinner & Smithers 1990; Fürstenburg 2002). Gray first described it scientifically in 1824, based on a skin obtained by Burchell in the Kuruman district of the Northern Cape, South Africa (Grubb 1999). Burchell's zebra is one of Africa's most adaptable and successful grazers, utilising a broad range of savanna habitats. It is equipped to deal both with tall, tough grass stems and the early stages of grass growth after the rains. Burchell's zebra is totally dependent on frequent water drinking (Kingdon 1997) and is among the most water-dependent of the plains wildlife (Estes 1997). Burchell's zebra is seldom found more than 10 to 12 km from water, and it moves daily between its preferred grazing and water supplies. Being gregarious, Burchell's zebra either lives in small family groups consisting of a stallion and one or more mares and their foals, or in bachelor herds (Skinner & Smithers 1990).

Modern horses and zebras developed in North America and colonised Eurasia and Africa during the last 3 million years (Kingdon 1997). Four of the six wild *Equus* species are today confined to Africa, including three zebra species, *Equus burchellii* (Burchell's zebra); *Equus zebra* (Mountain zebra); *Equus grevyi* (Grevy's zebra) as well as the African wild ass *Equus africanus* (Grubb 1993; Estes 1997; Fürstenburg 2002). Burchell's zebra was formerly distributed from the Orange River northwards through the Limpopo and Mpumalanga provinces of South Africa, the northern parts of Botswana and Namibia northwards and eastwards, and the northern parts of the KwaZulu-Natal province of South Africa. Naturally occurring populations in South Africa are today confined to conserved areas in the northern parts of the KwaZulu-Natal province, and the Mpumalanga and Limpopo provinces. Although Burchell's zebra has been introduced into private nature reserves and wildlife ranches throughout the country (Mills & Hes 1997), the extent and status of the global population is still unknown. There is, furthermore, some debate over the taxonomic clarification of the subspecies distinctions in southern Africa (Friedmann & Daly 2004). It is suggested by some authors that the population occurring in the northern KwaZulu-Natal province in South Africa and northwards might be a separate subspecies of the Burchell's zebra, possibly *Equus burchellii selousi* (Kingdon 1997).

Three of the four indigenous African equids are rare or restricted in distribution, while the Burchell's zebra rivals the horse as the most successful member of the family (Estes 1997). Although Burchell's zebra is still by far the most abundant and widespread of all the African equids, several subspecies occur at low population levels and several are declining (Stuart & Stuart 1996). Given the uncertain future of small, isolated populations of Burchell's zebra, some subspecies may well become vulnerable or endangered in the near future (Kingdon 1997). While the cause of the decline of Burchell's zebra is not known, its incompatibility with modern agriculture and ranching has led to its widespread extermination outside formally protected areas (Kingdon 1997).

Knowledge of the habitat preference, ecological requirements and conservation status of large herbivores is basic to any management programme for a reserve, and is a pre-requisite to determine stocking densities and possible translocations (Dekker *et al*. 1996). Stocking density is the area of land allocated per animal unit (Tainton 1999). The optimal stocking density of various species depends on the available habitat, the quality of the habitat and the objectives of use (Van Rooyen *et al*. 1996). The fact that most species are linked to major vegetation types helps in understanding their distribution patterns (Pienaar 1974).

In the present study, we tested the hypothesis that Burchell's zebra responded to the variables in its physical habitat in proportion to its availability within the Tembe Elephant Park. If the Burchell's zebra showed a preference of use for certain vegetation types, then the suitability of different areas could be determined for it by evaluating the biophysical characteristics of the preferred vegetation types. More accurate stocking densities could then also be calculated according to the habitat preferences and diet of the Burchell's zebra. The primary objective of the present study was therefore to gather information on the habitat preference and conservation status of the Burchell's zebra within the park. This information is crucial for the effective management of the population of Burchell's zebra in the park, as well as for future reintroductions to neighbouring areas.

METHODS

The methods presented below are restricted to the broad outlines of the methods employed. For a more detailed description of the methods, please refer to the general methods in chapter 3.

Habitat preference

Road counts of the spatial distribution of Burchell's zebra were done in Tembe from December 2002 to November 2003. The study area was surveyed four times per month for a full year. All the observations were documented on a field form and the closest coordinates of the position of an observed Burchell's zebra was determined by using geographic positioning equipment (GPS). All the data were captured on a computer database for further analysis.

A measure of habitat preference for Burchell's zebra was obtained by comparing patterns of habitat use with habitat availability within the study area. The Index of Jacobs (1974) was then used to calculate a preference index of use (*P*) for each vegetation type. The preference index only provided a ratio of habitat use to habitat availability and was not based on a statistical test. This was overcome by performing a Chi-square goodness-of-fit test. When a significant difference in use versus availability was detected, a Bonferroni *Z*-statistic was used to determine which vegetation types were used more or less often than expected by constructing 95% simultaneous confidence intervals around the proportion of Burchell's zebra recorded in each vegetation type (Beyers *et al*. 1984; Allredge & Ratti 1992; Pienaar *et al*. 1992).

Population status

An aerial survey that was done in October 2003 was used to determine the current population status of Burchell's zebra in Tembe. The overall aim of the survey was to derive trends and estimates of the large herbivore populations in Tembe that would be useful for management decisions and would stand as a record of abundance for future trend analyses. Total aerial counts and transect distance sampling counts were used to estimate the number of Burchell's zebra in Tembe and to calculate trends in the population from 1993 to 2003 (Matthews 2004).

RESULTS

Habitat preference

A total of 42 observations were recorded during the study period. Burchell's zebra was most often found in the Open Woodland (47.6% of all observations) and Sand Forest/Grassland Mosaic (33.3%), less often in the Hygrophilous Grassland (7.1%), Muzi Swamp (4.8%) and Sparse Woodland (4.8%), and least often in the Closed Woodland on clay (2.4%). Burchell's zebra was never recorded in *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, Closed Woodland/Thicket Mosaic on sand or Old Lands (Table 8).

Table 8. Vegetation types in Tembe Elephant Park, South Africa, their respective sizes (km²), proportion of the available habitat, proportion of use by Burchell's zebra and preference index of use by Burchell's zebra from December 2002 to November 2003.

Number	Vegetation type	Size (km²)	Percentage of available habitat (*A*)	Percentage of use (*U*)	Preference index (*P*)
1	*Acacia borleae* Shrubland/Bush Clump Mosaic on clay	2.3	0.7	0.0	-1.000
2	Closed Woodland/Thicket Mosaic on sand	51.8	15.0	0.0	-1.000
3	Closed Woodland on clay	8.7	2.5	2.3	-0.080
4	Hygrophilous Grassland	6.7	2.0	7.1	0.718
5	Muzi Swamp	3.4	1.0	4.8	0.792
6	Old Lands	0.6	0.2	0.0	-1.000
7	Open Woodland	91.5	26.6	47.7	0.441
8	Sand Forest/Grassland Mosaic	164.8	47.8	33.3	-0.305
9	Sparse Woodland	14.4	4.2	4.8	0.125

The Chi-square goodness-of-fit test for the overall data set showed a significant difference ($\chi^2 = 64.582$; $p \leq 0.05$; $df = 8$) in use versus availability for the different vegetation types in Tembe. The preference index of use of vegetation types by Burchell's zebra in Tembe indicated that vegetation types 1, 2 and 6 were not being used and that vegetation types 3, 4, 5, 7, 8 and 9 were being used in the same ratio as their proportional occurrence (Table 9).

Population status

During the total aerial count, 170 Burchell's zebra were recorded in 39 groups. Based on the distance sample estimate, this indicated a population of 492 individuals. However, due to the small sample size, this estimate was not considered to be reliable and the Burchell's zebra population in Tembe is currently estimated at 200 individuals (Matthews 2004). This current estimate of the population is, however, still higher than the previous estimates and the population of Burchell's zebra appears to be increasing from a total aerial count of 51 individuals in 1993 to the 170 in 2003 (Figure 14).

DISCUSSION

Habitat preference

No observation of the Burchell's zebra was recorded in the *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, the Closed Woodland/Thicket Mosaic on sand or the Old Lands, and it was clearly not using these vegetation types. The Closed Woodland on clay, Hygrophilous Grassland, Muzi Swamp, Open Woodland, Sand Forest/Grassland Mosaic and Sparse Woodland were all used in proportion to their availability within the park. The *Acacia borleae* Shrubland/Bush Clump Mosaic on clay occurs next to marshy areas and clay-based thickets associated with the Muzi Swamp. In structure this vegetation type varied from areas of dense vegetation to thickets that were associated with termitaria. Moreover, perennial pans were found interspersed throughout these clay areas. The Closed Woodland/Thicket Mosaic on sand occurs on the dune crests, slopes and interdune depressions throughout Tembe and could be distinguished based on plant density, which varied from closed to semi-closed crown gaps and a canopy that approximately varied from 8 to 12 m in height (Matthews *et al*. 2001). In general, Burchell's zebra was partial to open areas, avoiding areas of dense woodland except when moving through them (Skinner & Smithers 1990).

Table 9. The preference of use for the vegetation types in Tembe Elephant Park, South Africa by Burchell's zebra from December 2002 to November 2003 ($\alpha = 0.05$; $k = 9$; $Z_{1-\alpha/2k} = 2.75$)

Vegetation type number*	Percentage of habitat	Chi-square contribution	Confidence interval	Habitat use
1	0.7	0.7	$0.000 \leq p_1 \leq 0.000$	Not used
2	15	15.0	$0.000 \leq p_2 \leq 0.000$	Not used
3	2.5	0.0	$-0.041 \leq p_3 \leq 0.087$	No pattern
4	2.0	13.0	$-0.038 \leq p_4 \leq 0.180$	No pattern
5	1.0	14.4	$-0.043 \leq p_5 \leq 0.139$	No pattern
6	0.2	0.2	$0.000 \leq p_6 \leq 0.000$	Not used
7	26.6	16.7	$0.264 \leq p_7 \leq 0.688$	No pattern
8	47.8	4.4	$0.133 \leq p_8 \leq 0.533$	No pattern
9	4.2	0.1	$-0.043 \leq p_9 \leq 0.139$	No pattern
Total	100	64.5	-	-

*Vegetation type numbers corresponds with Figure 5 in chapter 2, and Table 8.

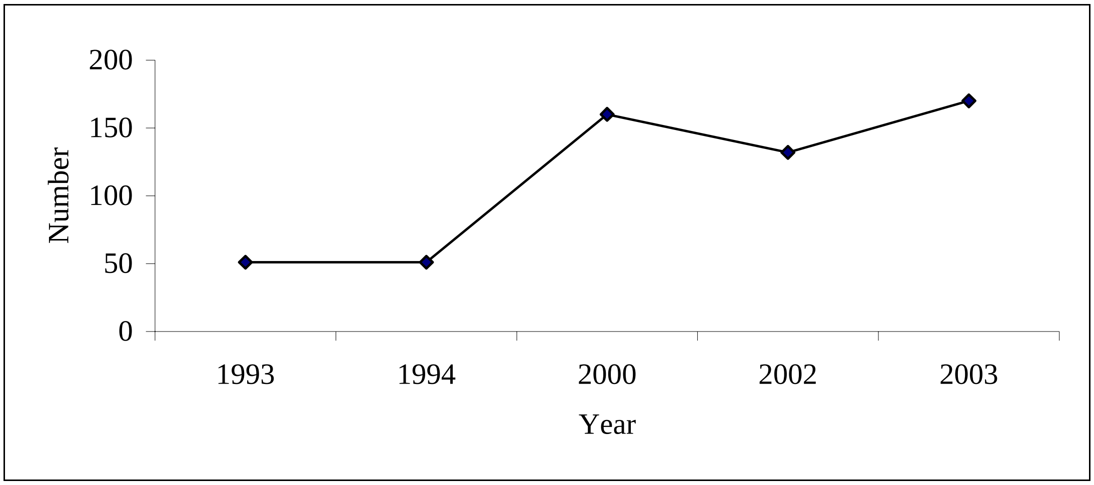

Figure 14: Aerial survey of the Burchell’s zebra as based on total counts conducted in Tembe Elephant Park, South Africa from 1993 to 2003. Source: Matthews *et al*. (2004).

The dense nature of large areas of the *Acacia borleae* Shrubland/Bush Clump Mosaic on clay and Closed Woodland/Thicket Mosaic on sand were therefore probably the reason why these vegetation types were not being used by the Burchell's zebra in Tembe.

The Closed Woodland on clay occurs on clay-rich duplex soils that are normally associated with the bottomlands of the dunes and the edges of the Muzi Swamp. Perennial pans were also found throughout this vegetation type and it had few grass species.

Both the Hygrophilous Grassland and the Muzi Swamp had a grassland structure with only scattered trees or thickets. The Muzi Swamp consists of reed beds in an extensive swamp system that crosses the eastern side of Tembe and extends northwards to Maputo Bay in Mozambique. Abundant plant species in the Hygrophilous Grassland were the grasses *Imperata cylindrica, Eragrostis lappula, Dactyloctenium geminatum, Panicum genuflexum* and *Eragrostis heteromera* and the shrub *Acacia nilotica* (Matthews *et al*. 2001). None of these grass species present has a high grazing value and therefore the grasses are generally poorly utilised by grazers (Van Oudtshoorn 1999). Burchell's zebra is dependent on frequent drinking of water (Skinner & Smithers 1990; Estes 1997; Kingdon 1997; Fürstenburg 2002) and the presence of water in the Closed Woodland on clay, Hygrophilous Grassland and Muzi Swamp most likely promoted the use of these vegetation types in Tembe. The Muzi Swamp was the only natural source of permanent water present in Tembe throughout the year (Matthews *et al*. 2001).

The Open Woodland was the second largest vegetation type in Tembe and occurs on dune crests, slopes and interdune depressions throughout the park (Matthews *et al*. 2001). This vegetation type was characterised by a good grassy layer interspersed with a few tall trees of approximately 8 to 10 m in height. Grass species abundant in this vegetation type included several species with high grazing values such as *Andropogon gayanus*, *Panicum maximum* and *Digitaria eriantha* (Van Oudtshoorn 1999; Matthews *et al*. 2001). During field observations, Burchell's zebra was often observed feeding in the Open Woodland and it also reached its highest density in this vegetation type (47.6% of all observations).

Although the Sand Forest/Grassland Mosaic had the second highest density (33.3%) of Burchell's zebra in Tembe, it was the largest vegetation type present, causing the overall density of Burchell's zebra in it to be low. The Sand Forest/Grassland Mosaic was mostly associated with dune crests and slopes, but also some interdune depressions, and was structurally classified as a forest, interspersed with grassland (Matthews *et al*. 2001). The grassland there was open with few to no trees and shrubs. Abundant grass species included species with a low grazing value like *Andropogon chinensis*, *Perotis patens*, *Diheteropogon amplectens* and *Aristida stipitata* subsp. *spicata*. In areas where the percentage of sand in the soils was lower, stands of *Digitaria eriantha* with a high grazing value could be found (Van der Walt 2004). These grasslands gradually acquired a more open woodland character the further away it was from the Sand Forest (Matthews *et al* 2001). During field observations, Burchell's zebra was observed feeding on the grassland areas in this vegetation type, but it seldom entered the Sand Forest. It also used the game trails present in the Sand Forest with hesitation.

The Sparse Woodland was mainly found on flat areas between the dunes, but also to a lesser degree on the dune slopes and crests throughout the park. It was a type of grassland that was characterised by an abundance of shrub species that produced annual leafy and flowering shoots from a perennial, underground woody rootstock. The grass layer was characterised by a large variety of species (Matthews *et al*. 2001). Only 4.8% of observations of Burchell's zebra were in this vegetation type, but it also only covered 4.2% of the surface area of the study area.

The habitat of ungulates provides them with food, water and cover and the feeding styles of each species are therefore of primary importance in determining their preferred habitat. Generally, Burchell's zebra is not selective towards grass species, but rather to grass height when feeding and all the green parts of a grass plant up to 150 mm in height, regardless of species, are usually eaten (Fürstenburg 2002). Although no vegetation type in Tembe was preferred for use by Burchell's zebra, the Open Woodland, Sand Forest/Grassland Mosaic and Sparse Woodland seemed suitable to sustain them there. Vegetation types with an open structure and a well-developed grass layer on more sandy soils were consistently selected for use over dense vegetation types with thickets on clay-rich soils.

Population status

The population of Burchell's zebra in Tembe is currently estimated at 200 individuals, although the reliability of this estimate was questionable. The mean size of the family groups of Burchell's zebra generally varies within conservation areas and it appears to be correlated with the condition of the habitat and the predation levels (Skinner & Smithers 1990). In optimal habitat, a maximum of 0.04 zebras/ha should, however, be stocked according to Fürstenburg (2002). In Tembe, 27 072 ha of suitable habitat (vegetation types 7, 8 and 9) are available, although only the grassland of the Sand Forest/Grassland Mosaic are currently being utilised by the zebra. By excluding the Sand Forest/Grassland Mosaic from the calculation, 10 589 ha of suitable habitat (vegetation types 7 and 9) are available. This translates into an estimated maximum recommended stocking rate of 424 Burchell's zebra in Tembe, based on habitat availability. The current estimated population of 200 individuals therefore constitute approximately half of the maximum recommended stocking rate.

As wildlife populations increase, it becomes necessary to set limits to their population size in order to keep them in balance with their food resources and to provide for their social needs (Bothma *et al*. 2004). Breeding in the Burchell's zebra is not seasonal and foals may be born at any time of the year. There does, however, appear to be a breeding peak from December to January, and 85% of the foals are usually born from October to March (Skinner & Smithers 1990; Fürstenburg 2002). The population growth rate, and therefore the number of animals that can be harvested annually, fluctuates from 15 to 29%, depending on the environmental conditions, predation pressure and social interactions in a given habitat (Fürstenburg 2002). In order to keep the Burchell's zebra population in Tembe at its current size, 30 to 58 individuals will have to be removed annually, based on the expected population growth rate, whether this is through predation, culling, live capture for translocation or other means. This is, however, not recommended before reliable estimates of the population size and its annual growth rate in Tembe have been obtained. Until then it is recommended to monitor the Burchell's zebra population in Tembe and to leave the population to increase naturally until it approaches the estimated maximum recommended population of 424 individuals.

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CHAPTER 8

HABITAT PREFERENCE AND STATUS OF THE GREATER KUDU IN TEMBE ELEPHANT PARK, SOUTH AFRICA

INTRODUCTION

The greater kudu is a member of the family Bovidae and the exclusively African tribe Tragelaphini (Grubb 1993; Estes 1997). The name kudu is derived from the Khoikhoi name "ku:du" that was given to it in South Africa. Pallas first described it scientifically in 1766 from a specimen from the Cape of Good Hope (Skinner & Smithers 1990). Other species in this tribe include the bushbuck *Tragelaphus scriptus*, sitatunga *Tragelaphus spekii*, nyala *Tragelaphus angasii*, mountain nyala *Tragelaphus buxtoni*, lesser kudu *Tragelaphus imberbis*, bongo *Tragelaphus eurycerus*, southern eland *Taurotragus oryx* and Derby's eland *Taurotragus derbianus* (Grubb 1993; Estes 1997). Tribal traits include a medium-sized to large body, spiralled horns, white vertical stripes and a pronounced sexual dimorphism. The greater kudu is the tallest antelope after the eland and has the longest horns, reaching a record length of 1.8 m (Estes 1997; Mills & Hes 1997).

The greater kudu is found throughout the drier savanna zones of southern, south- central and eastern Africa south of the Sahara desert. It is a savanna woodland species that does not occur in desert, forest or open grassland areas. It is partial to areas of broken, rocky terrain with a cover of woodland and a water supply nearby (Skinner & Smithers 1990; Friedmann & Daly 2004). Today, it is common throughout the bushveld areas of southern Africa, even outside conservation areas, and it has been extending its range westwards into parts of the Karoo (Mills & Hes 1997). The greater kudu is one of the few large mammals that are capable of surviving close to human settlements. When fleeing, it can clear obstacles like fences up to 2.5 m high (Estes 1997).

The greater kudu is gregarious, with females and their offspring forming cohesive social units and males associating in transient bachelor groups. Herds are usually small, commonly comprising about four animals and rarely up to 20 animals, and occupying overlapping ranges (Skinner & Smithers 1990; Estes 1997). In South Africa, males join female herds in April to May during the mating season, but favour different habitats outside this period. Calves are born in January and February after a gestation period of 9 months, but out of season births are not unusual (Mills & Hes 1997).

Based on its diet, the greater kudu is classified as a generalist feeder, being an animal with a diet that consists of >20% monocotyledonous plant material, >20% dicotyledonous plant material and >20% fruits (Gagnon & Chew 2000). The greater kudu predominantly browses, although it may eat fresh grass and fruit. It eats a greater variety of woody plants than any other bovid occurring in the same region (Skinner & Smithers 1990). During the dry season, when only a few evergreen trees retain their leaves, the greater kudu usually experiences a food shortage. During this time, mortalities are higher in males than in females. Old and young animals are also more severely affected by droughts and diseases than mature animals. Nevertheless, the greater kudu population recovers rapidly after such die-offs and it remains common, even outside formally conserved areas (Owen-Smith 1997).

Knowledge of the habitat preference and the conservation status of large herbivores is basic to any management programme for a reserve, and it is also a pre-requisite to determine stocking densities and possible translocations (Dekker *et al*. 1996). Stocking density is the area of land allocated per animal unit (Tainton 1999). The optimal stocking density of various species depends on the available habitat, the quality of the habitat and the objectives of use (Van Rooyen *et al*. 1996). A sound knowledge of the diet and factors affecting it are also crucial to understanding ungulate ecology and management. The fact that most species are linked to major vegetation types helps in understanding their distribution patterns (Pienaar 1974).

In the present study, we tested the hypothesis that the greater kudu responded to the variables in its physical habitat in proportion to its availability within the Tembe Elephant Park. If the greater kudu showed a preference of use for certain vegetation types, then the suitability of different areas can be determined for it by evaluating the physical characteristics of the preferred vegetation types. More reliable stocking densities can then also be calculated based on the habitat preferences of the greater kudu. The objectives of the present study were therefore to gather information on the habitat preference and conservation status of the greater kudu within the park. This information is crucial for the effective management of the greater kudu population in the park, as well as for possible future reintroductions to neighbouring areas.

METHODS

The methods presented below are restricted to the broad outlines of the methods employed. For a more detailed description of the methods, please refer to the general methods in chapter 3.

Habitat preference

Road counts of the spatial distribution of the greater kudu were done in Tembe from December 2002 to November 2003. The study area was surveyed four times per month for a full year. All the observations were documented on a field form and the closest coordinates of the position of an observed greater kudu was determined by using geographic positioning equipment (GPS). All the data were captured on a computer database for further analysis.

A measure of habitat preference for the greater kudu was obtained by comparing patterns of habitat use with habitat availability within the study area. The Index of Jacobs (1974) was then used to calculate a preference index of use (P) for each vegetation type. The preference index only provided a ratio of habitat use to habitat availability and was not based on a statistical test. This was overcome by performing a Chi-square goodness-of-fit test. When a significant difference in use versus availability was detected, a Bonferroni Z-statistic was used to determine which vegetation types were used more or less often than expected by constructing 95% simultaneous confidence intervals around the proportion of the greater kudu recorded in each vegetation type (Beyers *et al*. 1984; Allredge & Ratti 1992; Pienaar *et al*. 1992).

Direct observations of feeding were also made to identify the preferred height and plant species that were being browsed by the greater kudu in Tembe. Plant species were identified either while the animal was actually feeding, or by site inspection once it had moved on. If a plant species could not be identified in the field, a sample was taken for later identification. Feeding records were taken during diurnal activity only.

Population status

An aerial survey that was done in October 2003 was used to determine the current population status of the greater kudu in Tembe. The overall aim of the survey was to derive trends and estimates of the large herbivore populations in Tembe that would be useful for management decisions and would stand as a record of abundance for future trend analyses. Total aerial counts and transect distance sampling counts were used to estimate the number of greater kudu in Tembe and to calculate trends in the population from 1993 to 2003 (Matthews 2004).

RESULTS

Habitat preference

A total of 174 observations were recorded during the study period. The greater kudu was most often found in Open Woodland (43.7% of observations) and Sand Forest/Grassland Mosaic (29.3%), less often in Closed Woodland/Thicket Mosaic on sand (12.6%) and Closed Woodland on clay (9.2%), and least often in Sparse Woodland (2.9%), *Acacia borleae* Shrubland/Bush Clump Mosaic on clay (1.7%) and the Muzi Swamp (0.6%). The greater kudu was never found in the Hygrophilous Grassland or Old Lands (Table 10). The Chi-square goodness-of-fit test for the overall data set showed a significant difference ($\chi^2 = 40.7$; $p \leq 0.05$; $df = 8$) in use versus availability for the different vegetation types in Tembe. The preference index of use of vegetation types by the greater kudu in Tembe indicated vegetation types 3 and 7 to be preferred for use, vegetation types 4, 6 and 8 were not preferred while vegetation types 1, 2, 5 and 9 were used in the same ratio as its proportional occurrence (Table 11).

Based on 86 feeding observations, a total of 31 plant species was browsed by the greater kudu in Tembe (Table 12). Generally, only the leaves of the food plants were eaten, although shoots, flowers and fruit were also eaten sporadically. Browsing height was predominantly from 1.5 to 2 m (67% of all the observations) with 33% of feeding observations at a height < 1.5 m. The mean feeding height was estimated at 1.5 m. Using the number of times that a greater kudu was observed feeding on a particular species as a measure of the frequency of consumption, Strychnos madagascariensis (20.9%), Combretum molle (12.8%), Strychnos spinosa (11.6%) and Acacia burkei (9.3%) were the most commonly eaten plants (Table 12).

Population status

During the total aerial count, 376 greater kudu were recorded in 75 groups. Based on the distance sample estimate this indicated a population of 780 individuals, which is the current estimate for the greater kudu population in Tembe (Matthews 2004). Population trends indicate an increase in the kudu population from a total aerial count of 27 individuals in 1993 to the 376 in 2003 (Figure 15).

Table 10. Vegetation types in Tembe Elephant Park, South Africa, their respective sizes (km²), proportion of the available habitat, proportion of use by the greater kudu and preference index of use by the greater kudu from December 2002 to November 2003.

Number	Vegetation type	Size (km²)	Percentage of available habitat (*A*)	Percentage of use (*U*)	Preference index (*P*)
1	*Acacia borleae* Shrubland/Bush Clump Mosaic on clay	2.3	0.7	1.7	0.588
2	Closed Woodland/Thicket Mosaic on sand	51.8	15.0	12.6	-0.160
3	Closed Woodland on clay	8.7	2.5	9.2	0.728
4	Hygrophilous Grassland	6.7	2.0	0.0	-1.000
5	Muzi Swamp	3.4	1.0	0.6	-0.400
6	Old Lands	0.6	0.2	0.0	-1.000
7	Open Woodland	91.5	26.6	43.7	0.391
8	Sand Forest/Grassland Mosaic	164.8	47.8	29.3	-0.388
9	Sparse Woodland	14.4	4.2	2.9	-0.310

Table 11. The preference of use of the vegetation types in Tembe Elephant Park, South Africa by the greater kudu from December 2002 to November 2003 ($\alpha = 0.05$; $k = 9$; $Z_{1-\alpha/2k} = 2.75$)

Vegetation type*	Percentage of habitat	Chi-square contribution	Confidence interval	Habitat use
1	0.7	1.4	$-0.010 \leq p_1 \leq 0.044$	No pattern
2	15	0.4	$0.057 \leq p_2 \leq 0.195$	No pattern
3	2.5	18.0	$0.032 \leq p_3 \leq 0.152$	Prefer
4	2.0	2.0	$0.000 \leq p_4 \leq 0.000$	Not used
5	1.0	0.2	$-0.010 \leq p_5 \leq 0.022$	No pattern
6	0.2	0.2	$0.000 \leq p_6 \leq 0.000$	Not used
7	26.6	11.0	$0.334 \leq p_7 \leq 0.540$	Prefer
8	47.8	7.2	$0.198 \leq p_8 \leq 0.388$	Not used
9	4.2	0.4	$-0.006 \leq p_9 \leq 0.064$	No pattern
Total	100	40.7	-	-

*Vegetation type numbers correspond with Figure 5 in chapter 2, and Table 10.

Table 12. The percentage occurrence of various plant species in the diet of the greater kudu based on 86 feeding observations from December 2002 to November 2003 in Tembe Elephant Park, South Africa.

Plant species	Actual observations	Percentage of occurrence
Acacia burkei	8	9.3
Acacia nilotica	1	1.2
Afzelia quanzensis	1	1.2
Aloe marlothii	1	1.2
Brachylaena discolor	2	2.3
Catunaregam spinosa	1	1.2
Combretum molle	11	12.8
Dalechampia capensis	1	1.2
Dialium schlechteri	3	3.5
Dichrostachys cinerea	1	1.2
Erythroxylum delagoense	1	1.2
Euclea natalensis	1	1.2
Grewia caffra	3	3.5
Landolphia kirkii	2	2.3
Margaritaria discoidea	1	1.2
Maytenus senegalensis	1	1.2
Mundulea sericea	1	1.2
Peltophorum africanum	1	1.2
Plectroniella armata	1	1.2
Psydrax locuples	1	1.2
Rhoicissus digitata	1	1.2
Sapium integerrimum	1	1.2
Sclerocarya birrea	1	1.2
Spirostachys africana	5	5.8
Strychnos madagascariensis	18	20.9
Strychnos spinosa	10	11.6
Tabernaemontana elegans	1	1.2

Table 12 *continue*

Terminalia sericea	3	3.5
Vanqueria infausta	1	1.2
Zanthoxylum leprieurii	1	1.2
Ziziphus mucronata	1	1.2

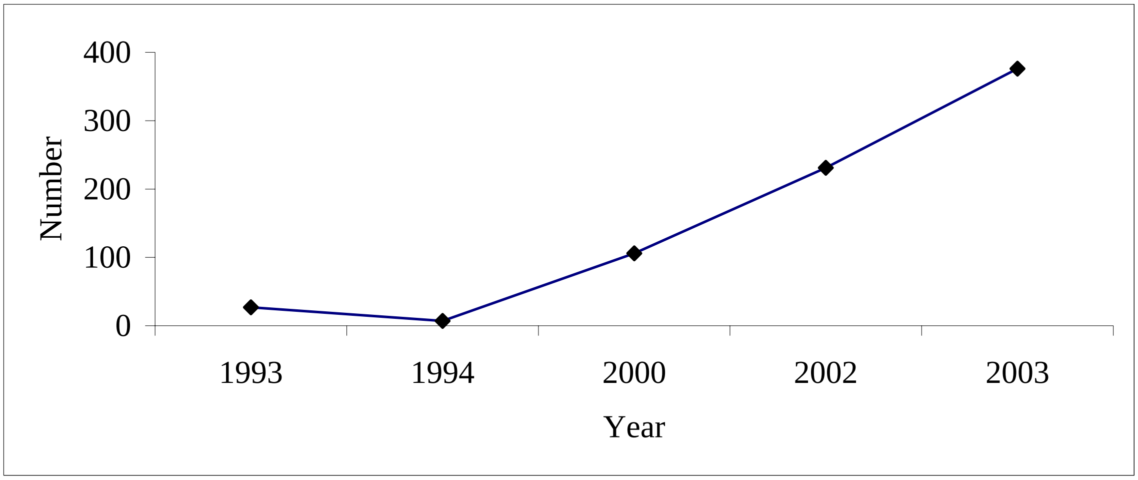

Figure 15: Aerial survey of the greater kudu as based on total counts conducted in Tembe Elephant Park, South Africa from 1993 to 2003. Source: Matthews *et al*. (2004).

DISCUSSION

Habitat preference

The greater kudu in Tembe showed a preference of use for the Closed Woodland on clay and Open Woodland. The *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, Closed Woodland/Thicket Mosaic on sand, Muzi Swamp and Sparse Woodland were used in proportion to its availability, while the Sand Forest/Grassland Mosaic was not being used often. No observations of the greater kudu were ever recorded in the Hygrophilous Grassland or in the Old Lands and these vegetation types were clearly not being used.

The Closed Woodland on clay occurs on clay-rich duplex soils that are normally associated with the bottomlands of the dunes and the edges of the Muzi Swamp. Perennial pans were also found throughout this vegetation type. The structure of the Closed Woodland on clay varied from areas of dense vegetation to thickets associated with termitaria (Matthews *et al*. 2001). Although this vegetation type only covered 2.5% of the surface area of Tembe, 9.2% of observations of the greater kudu were made there.

The Open Woodland was the second largest vegetation type in Tembe and it occurs on the dune crests, slopes and interdune depressions throughout the park. It has a small number of trees of approximately 8 to 10 m tall scattered throughout a well-developed grass layer. Abundant trees in this vegetation type included *Albizia versicolor*, *Strychnos madagascariensis* (the most abundant woody plant used by the greater kudu), *Combretum molle* (the second most abundant woody plant used by the greater kudu), and *Terminalia sericea* (Matthews *et al*. 2001). The highest occurrence of the greater kudu (43.9% of all observations) was in this vegetation type. The presence of dense vegetation and thickets offering protection and food in the Closed Woodland on clay, and thepresence of preferred food plants in the Open Woodland was most likely the reason why the greater kudu preferred these vegetation types for use in Tembe.

The *Acacia borleae* Shrubland/Bush Clump Mosaic on clay occurs next to marshy areas and clay-based thickets associated with the Muzi Swamp. In structure this vegetation type varied from areas of dense vegetation to thickets that were associated with termitaria. Moreover, perennial pans were found interspersed throughout these clay areas. The Muzi Swamp comprised of reed beds of the extensive Muzi Swamp system that crosses the eastern side of Tembe and extends northwards to Maputo Bay in Mozambique. The Muzi Swamp was the only natural source of permanent water present in Tembe throughout the year (Matthews *et al*. 2001). The fact that the greater kudu is dependent on water and requires a permanent source of surface water within its range was most likely the reason for it using these vegetation types (Bothma *et al*. 2002).

The Closed Woodland/Thicket Mosaic on sand occurs on the dune crests, slopes and interdune depressions throughout Tembe and could be distinguished based on plant density, which in most cases varied from closed to semi-closed crown gaps and a canopy that varied from approximately 8 to 12 m in height. The Sparse Woodland mainly occurs on the flat areas between the dunes, but also to a lesser degree on the dune slopes and crests throughout Tembe (Matthews *et al*. 2001). This vegetation type was grassland that was characterised by an abundance of shrub species that produced annual leafy and flowering shoots from a perennial, underground woody rootstock and has few large trees. Although not preferred for use in Tembe, these vegetation types were used in proportion to their availability in Tembe and seem to be suitable to sustain the greater kudu.

The Sand Forest/Grassland Mosaic was the largest vegetation type in Tembe and was mostly associated with dunes. This vegetation type was structurally classified as a forest that was interspersed with grassland (Matthews *et al*. 2001). The grasslands there were open with few to no trees and shrubs. It gradually acquires a more open woodland character further away from the Sand Forest. The second highest occurrence of the greater kudu (29.3% of all observations) was in this vegetation type. Although the greater kudu was often observed in the Sand Forest/Grassland Mosaic during field observations, the overall density of the greater kudu there was low because of the size of this vegetation type, and it was used by the greater kudu in the same ratio as its proportional occurrence in Tembe. The greater kudu generally does not occur in forest or open grassland areas and this is most likely also the reason why the Sand Forest/Grassland Mosaic was not used often in Tembe by it, and why it was never recorded in the Hygrophilous Grassland or in the Old Lands (Skinner & Smithers 1990). Vegetation types with an intermediate density that provide protection, preferred food plants and surface water nearby was consistently selected for use by the greater kudu over dense vegetation or vegetation with an open grassland structure.

Population status

The population of the greater kudu in Tembe is currently estimated at 780 individuals. The greater kudu is one of the most resilient larger mammal species in South Africa and persists even under heavy hunting pressure and settlement (Skinner & Smithers 1990). It is currently listed as Least Concern in the South African Red Data Book, implying that it is widespread and abundant in South Africa, and there is evidence that the population is increasing (Friedmann & Daly 2004). Population trends in Tembe indicate an increase in the number of individuals from 1993 to 2003, with an annual rate of increase of 28% from 2002 to 2003 (Matthews 2004). The natural population increase for the greater kudu can be about 20 to 30% per year (Bothma *et al*. 2002). There is at present no immediate threat of a decline for the population in Tembe.

The greater kudu has a low natural density and in savanna areas the stocking density is approximately 1 greater kudu per 40 ha (Bothma *et al*. 2002). According to Bothma *et al.* (2002), in areas with a higher woody plant density like the Valley Bushveld or Succulent Thicket of the Eastern Cape province in South Africa, the density of the greater kudu is also much higher. In these areas the density of the greater kudu can be up to 1 greater kudu per 6.3 ha. In Tembe, 10 020 ha of preferred habitat (vegetation types 3 and 7) and 7190 ha of habitat that is used in proportion to its availability (vegetation types 1, 2, 5 and 9) are available, giving 17 210 ha of suitable habitat. The woody plant density in Tembe is much higher than in other savanna areas, although not as dense as in the Eastern Cape. The stocking density in Tembe is estimated to be around 1 greater kudu per 20 ha. This equates to an estimated maximum recommended stocking density of 861 greater kudu based on habitat availability. In other areas, the greater kudu is mostly exposed to a shortage of browse during the late dry season and it is important to monitor the condition of the animals in Tembe during this time to determine whether the current stocking density of the greater kudu is satisfactory. In order to keep the greater kudu population in Tembe at its current level, 156 to 234 individuals will have to be removed annually based on an expected population growth rate of 20 to 30%, whether this is through predation, culling, live capture for translocation or other causes (Bothma *et al*. 2002).

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CHAPTER 9

HABITAT PREFERENCE AND STATUS OF THE RED DUIKER IN TEMBE ELEPHANT PARK, SOUTH AFRICA

INTRODUCTION

The red duiker is a member of the family Bovidae and the tribe Cephalophini (Grubb 1993). This tribe includes small to medium-sized, cover-dependent antelope showing little sexual dimorphism (Estes 1997). The colloquial name comes from the rich red-coloured pelage of representatives of the species from KwaZulu-Natal, South Africa. Smith first described it scientifically in 1834 (Skinner & Smithers 1990). Most duikers live in forests, although some have adapted to more open, swampy or mountainous areas (Kingdon 1997). Duikers are exclusive to Africa and today virtually every indigenous African forest and woodland is occupied by at least one species of duiker (Estes 1997; Kingdon 1997). The red duiker is associated with indigenous forests, forest clumps and dense thickets (Mills & Hes 1997). All the cephalophines are classified as frugivores, being animals with a diet consisting of > 70% fruits and little or no monocotylodons (Gagnon & Chew 2000).

In distribution, the red duiker is confined to the indigenous forests along the east coast of Africa (Mills & Hes 1997). In southern Africa the red duiker occurs naturally in eastern Mozambique, the Lebombo Mountains in Swaziland, in indigenous forests in the KwaZulu-Natal province, and isolated populations on the escarpment of the Mpumalanga province of South Africa (Mills & Hes 1997). The red duiker is still widespread and common, although rarely seen over most of its range despite intensive hunting and trapping for the bush meat trade (Kingdon 1997). Although the red duiker used to be classified as Rare in the South African Red Data Book (Smithers 1986), it is currently classified as being of Least Concern, implying that the species is widespread and abundant (Friedmann & Daly 2004). There is, however, debate about this classification as there has been a considerable decrease in the population of the red duiker since the last assessment in 1986. The red duiker could possibly be elevated to the Near Threatened category based on the fact that there are fewer than 10 000 mature individuals left in the South African population, which is restricted to only four locations (Friedmann & Daly 2004).

Knowledge of the habitat preference, ecological requirements and conservation status of large herbivores is basic to any management programme for a reserve and a pre-requisite to determine stocking densities and possible translocations (Dekker *et al*. 1996). Stocking density is the area of land allocated per animal unit (Tainton 1999). The optimal stocking density of various species depends on the available habitat, the quality of the habitat and the objectives of use (Van Rooyen *et al*. 1996). In conservation areas, one of the primary objectives is to maintain viable populations of all the animal species present. The fact that most species are linked to major vegetation types help in understanding their distribution patterns (Pienaar 1974).

In the present study, we tested the hypothesis that the red duiker responded to the variables in its physical habitat in proportion to its availability within the Tembe Elephant Park. If the red duiker showed a preference of use for certain vegetation types, then the suitability of different areas can be determined for the red duiker by evaluating the physical characteristics of the preferred vegetation types. More accurate stocking densities can then also be determined based on the habitat preferences of the red duiker. The objective of the present study was therefore to gather information on the habitat preference and conservation status of the red duiker within the park. This information is crucial for the effective management of the population within the park and neighbouring areas.

METHODS

The methods presented below are restricted to the broad outlines of the methods employed. For a more detailed description of the methods, please refer to the general methods in chapter 3.

Habitat preference

Road counts of the spatial distribution of the red duiker were done in Tembe from December 2002 to November 2003. The study area was surveyed four times per month for a full year. All the observations were documented on a field form and the closest coordinates of the position of an observed red duiker was determined by using geographic positioning equipment (GPS). All the data were captured on a computer database for further analysis.

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simultaneous confidence intervals around the proportion of the red duiker recorded in each vegetation type (Beyers *et al*. 1984; Allredge & Ratti 1992; Pienaar *et al*. 1992).

Direct observations of feeding were also made to identify the preferred height and plant species that were being browsed by the red duiker in Tembe. Plant species were identified either while the animal was actually feeding, or by site inspection once it had moved on. If a plant species could not be identified in the field, a sample was taken for later identification. Feeding records were taken during diurnal activity only.

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An aerial survey that was done in October 2003 was used to determine the current population status of the red duiker in Tembe. The overall aim of the survey was to derive trends and estimates of the large herbivore populations in Tembe that would be useful for management decisions and would stand as a record of abundance for future trend analyses. Total aerial counts and transect distance sampling counts were used to estimate the number of red duiker in Tembe and to calculate trends in the population from 1993 to 2003 (Matthews 2004).

RESULTS

Habitat preference

In all, 938 observations on the red duiker were recorded during the study period. It was most often found in the Sand Forest/Grassland Mosaic (31.9% of observations) and Open Woodland (30.4%), less often in the Closed Woodland/Thicket Mosaic on sand (19.3%) and Closed Woodland on clay (14.2%), and least often in the *Acacia borleae* Shrubland/Bush Clump Mosaic on clay (2.9%) and Sparse Woodland (1.4%). The red duiker was never found in the Hygrophilous Grassland, Muzi Swamp or Old Lands (Table 13). The Chi-square goodness-of-fit test for the overall data set showed a significant difference ($\chi^2 = 73.868$; $p \leq 0.05$; $df = 8$) in use versus availability for the different vegetation types in Tembe. The preference index of use of vegetation types by the red duiker in Tembe indicated vegetation types 1, 2 and 3 as being preferred for use, vegetation types 4, 5, 6, 8 and 9 as not being used and vegetation type 7 as being used in the same ratio as its proportional occurrence (Table 14).

Based on 37 feeding observations, 28 plant species were utilised by the red duiker in Tembe (Table 15). Generally, the fallen leaves, fruit and new shoots of the food plants were consumed. The browsing height was predominantly from 100 to 300 mm above the ground. Using the number of times that a red duiker was observed feeding on a particular species as a measure of the frequency of consumption,

Table 13. Vegetation types in Tembe Elephant Park, South Africa, their respective sizes (km²), proportion of the available habitat, proportion of use by the red duiker and preference index of use by the red duiker from December 2002 to November 2003.

Number	Vegetation type	Size (km²)	Percentage of available habitat (*A*)	Percentage of use (*U*)	Preference index (*P*)
1	*Acacia borleae* Shrubland/Bush Clump Mosaic on clay	2.3	0.7	2.9	0.759
2	Closed Woodland/Thicket Mosaic on sand	51.8	15.0	19.3	0.223
3	Closed Woodland on clay	8.7	2.5	14.2	0.824
4	Hygrophilous Grassland	6.7	2.0	0.0	-1.000
5	Muzi Swamp	3.4	1.0	0.0	-1.100
6	Old Lands	0.6	0.2	0.0	-1.000
7	Open Woodland	91.5	26.6	30.4	0.125
8	Sand Forest/Grassland Mosaic	164.8	47.8	31.8	-0.336
9	Sparse Woodland	14.4	4.2	1.4	-0.667

Table 14. The preference of use of the vegetation types in Tembe Elephant Park, South Africa by the red duiker from December 2002 to November 2003 ($\alpha = 0.05$; $k = 9$; $Z_{1-\alpha/2k} = 2.75$).

Vegetation type*	Percentage of habitat	Chi-square contribution	Confidence interval	Habitat use
1	0.7	6.9	$0.014 \leq p_1 \leq 0.044$	Prefer
2	15	1.2	$0.158 \leq p_2 \leq 0.228$	Prefer
3	2.5	54.8	$0.111 \leq p_3 \leq 0.173$	Prefer
4	2.0	2.0	$0.000 \leq p_4 \leq 0.000$	Not used
5	1.0	1.0	$0.000 \leq p_5 \leq 0.000$	Not used
6	0.2	0.2	$0.000 \leq p_6 \leq 0.000$	Not used
7	26.6	0.5	$0.263 \leq p_7 \leq 0.345$	No pattern
8	47.8	5.4	$0.276 \leq p_8 \leq 0.360$	Not used
9	4.2	1.9	$0.003 \leq p_9 \leq 0.025$	Not used
Total	100	73.9	-	-

*Vegetation type numbers corresponds with Figure 5 in chapter 2, and Table 13.

Table 15. The percentage occurrence of various plant species in the diet of the red duiker based on 37 feeding observations from December 2002 to November 2003 in Tembe Elephant Park, South Africa.

Plant species	Actual observations	Percentage of occurrence
Acacia burkei	2	5.4
Afzelia quanzensis	3	8.1
Boscia foetida	1	2.7
Bridelia cathartica	1	2.7
Carissa tetramera	2	5.4
Combretum molle	1	2.7
Coddia rudis	1	2.7
Croton gratissimus	1	2.7
Deinbollia oblongifolia	1	2.7
Dichrostachys cinerea	1	2.7
Euclea natalensis	1	2.7
Gardenia volkensii	1	2.7
Grewia caffra	1	2.7
Grewia microthyrsa	1	2.7
Gymnosporia senegalensis	1	2.7
Hymenocardia ulmoides	1	2.7
Londolphia kirkii	2	5.4
Margaritaria discoidea	1	2.7
Ochna barbosae	1	2.7
Plumbago zeylanica	1	2.7
Pteleopsis myrtifolia	2	5.4
Rhus gueinzii	1	2.7
Salacia leptoclada	1	2.7
Strychnos madagascariensis	2	5.4
Strychnos spinosa	3	8.1
Tabernaemontana elegans	1	2.7
Terminalia sericea	1	2.7
Uvaria caffra	1	2.7

Afzelia quanzensis (8.1%) and *Strychnos spinosa* (8.1%) were the most commonly eaten plants (Table 15). During field observations the red duiker was often observed feeding underneath these and other large trees.

Population status

During the total area aerial count, 191 red duiker were recorded in 182 groups. Based on the distance sample estimate this indicated a population of 714 individuals, which is the current estimate for the red duiker population in Tembe (Matthews 2004). Population trends appear to indicate an increase in the population of red duiker from a total area aerial count of 54 individuals in 1993 to the 191 in 2003 (Figure 16).

DISCUSSION

Habitat preference

The red duiker in Tembe showed a preference of use for the *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, the Closed Woodland/Thicket Mosaic on sand and the Closed Woodland on clay. No observations of the red duiker were ever recorded in the Hygrophilous Grassland, Muzi Swamp or Old Lands and these vegetation types were clearly not being used. The Sand Forest/Grassland Mosaic and the Sparse Woodland were also not being used often, and the Open Woodland was used in proportion to its availability.

The *Acacia borleae* Shrubland/Bush Clump Mosaic on clay occurs next to marshy areas and clay-based thickets associated with the Muzi Swamp. In structure, this vegetation type varied from areas of dense vegetation to thickets that were associated with termitaria (Matthews *et al*. 2001). Of all the observations of the red duiker, only 2.9% were in this vegetation type that comprised < 1% of the total available habitat.

The Closed Woodland/Thicket Mosaic on sand occurs on the dune crests, slopes and interdune depressions throughout Tembe and could be distinguished based on plant density, which in most cases varied from closed to semi-closed crown gaps and a canopy that varied from approximately 8 to 12 m in height. Of all the observations of the red duiker, 19.3% were in this vegetation type.

The Closed Woodland on clay occurs on clay-rich duplex soils that were normally associated with bottomlands of dunes (Matthews *et al*. 2001). Although this vegetation type only covered 2.5% of the surface area of Tembe, 14.2% of the observations of the red duiker were made there. The presence of dense vegetation

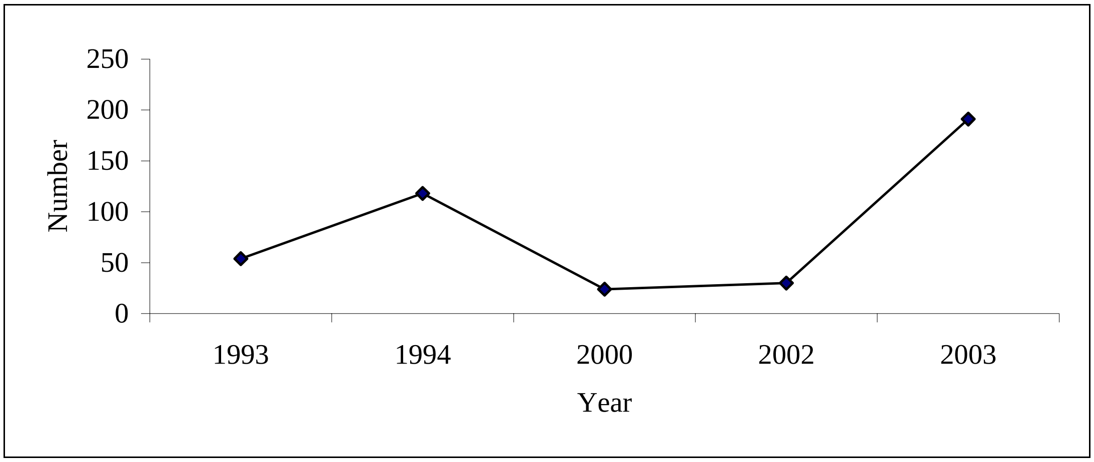

Figure 16: Aerial survey of the red duiker as based on total counts conducted in Tembe Elephant Park, South Africa from 1993 to 2003. Source: Matthews *et al*. (2004).

or thickets seemed to play an important role in the distribution of the red duiker and its preference towards certain vegetation types in Tembe.

Structurally, the Hygrophilous Grassland was classified as open grassland with scattered woody shrubs that occurs adjacent to the Muzi Swamp and around marshy areas associated with sand. The Muzi Swamp comprised of reed beds of the extensive Muzi Swamp system that crosses the eastern side of Tembe and extends northwards to Maputo Bay in Mozambique (Matthews *et al*. 2001). The open nature of the Hygrophilous Grassland, Muzi Swamp and Old Lands were most likely the reason why the red duiker did not use these vegetation types in Tembe.

Even though the red duiker was often recorded in the Sand Forest/Grassland Mosaic and Sparse Woodland, no preference of use was shown towards these vegetation types. The Sand Forest/Grassland Mosaic was the largest vegetation type in Tembe and was mostly associated with dunes (Matthews *et al*. 2001). Although this vegetation type had the highest occurrence of red duiker in Tembe (31.9%), the overall density of the red duiker was low because of the size of this vegetation type. The Sand Forest/Grassland Mosaic was structurally classified as forest, interspersed with grassland. The Sparse Woodland mainly occurs on flat areas between dunes, but also to a lesser degree on dune slopes and crests throughout Tembe. This vegetation type was a grassland characterised by an abundance of shrub species. It produces annual leafy and flowering shoots from a perennial, underground woody rootstock. The lack of sufficient cover also seemed to limit the use of the Sparse Woodland by the red duiker in Tembe.

The Open Woodland was the second largest vegetation type in Tembe and occurs on dune crests, slopes and interdune depressions throughout the park. Although the red duiker reached its second highest occurrence (30.4%) in this vegetation type, it was used in the same ratio as its proportional occurrence in Tembe.

The habitat of ungulates provides them with food, water and cover, and the feeding style of each species is therefore of primary importance in determining its preferred habitat. All the cephalophines have diets that include a large amount of fruits and little or no monocots (Gagnon & Chew 2000). According to Bowland (1997) the red duiker feeds on leaves, flowers and fruit freshly fallen from forest canopy trees, and it seldom actively browses live plant material. In Tembe, however, it was often observed browsing on the new leaves and shoots of small shrubs. The red duiker will venture beyond forest margins to forage, but retreats to cover at the slightest disturbance. Dense vegetation types with thickets and interspersed perennial pans on clay-rich soils were consistently selected for use over vegetation types with an open structure and a well-developed grass layer on more sandy soils.

Population status

The population of the red duiker in Tembe is currently estimated at 714 individuals, which is most likely an underestimate because of the counting technique used (Matthews *et al*. 2001). There is no single comprehensive counting technique that is suitable for counting all animal species. Knowledge of the habitat requirements of the animals to be counted is essential before any count should be attempted (Bothma 2002). As a result of the behavioural response of the red duiker to flee more readily when disturbed, drive counts proved to be a reliable counting technique in other areas (Bowland 1990). The nature of the vegetation in Tembe, as well as the presence of dangerous wildlife, however, limits the use of this technique within the park. It is recommended that road strip counts be used to supplement the aerial counts for the red duiker in Tembe in order to get a more reliable estimate of its conservation status. Population trends do, however, appear to indicate an increase in the number of individuals from 1993 to 2003 and there is at present no threat of a decline for the red duiker population in Tembe.

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CHAPTER 10

HABITAT PREFERENCE AND STATUS OF THE SUNI IN TEMBE ELEPHANT PARK, SOUTH AFRICA

INTRODUCTION

The suni is a member of the family Bovidae and the tribe Neotragini or dwarf antelopes (Estes 1997). Von Dueben first described it scientifically in 1846 from a specimen collected from Chapani Islet, 3 km from Zanzibar, Tanzania (Skinner & Smithers 1990; Grubb 1993). In distribution, the suni is confined to the eastern parts of the African continent from the False Bay Park in the KwaZulu-Natal province of South Africa, north to the Marsabit area in Kenya (Skinner & Smithers 1990). Two subspecies of suni are recognised, *Neotragus moschatus livingstonianus* that occurs from north-eastern Zimbabwe northwards, and *Neotragus moschatus zuluensis* that occurs in the Sand Forests of the northern parts of the KwaZulu-Natal province of South Africa, southern Mozambique and the south-eastern parts of Zimbabwe (Friedmann & Daly 2004). Other members of this tribe occurring in southern Africa are the klipspringer *Oreotragus oreotragus*, Damara dik-dik *Madoqua kirkii*, oribi *Ourebia ourebi*, steenbok *Raphicerus campestris*, grysbok *Raphicerus melanotis* and Sharpe's grysbok *Raphicerus sharpei* (Skinner & Smithers 1990; Grubb 1993).

The majority of sightings of the suni are of solitary animals, although they do occur in pairs or family groups consisting of a male and female with her offspring. Male and female suni share a territory but live relatively independent within that area. Males are, however, mutually exclusive in terms of range use and will actively defend their range. While the territories of males have well defined borders with very little overlap, those of females are usually situated entirely within the territory of a male. Both male and female suni show a tendency to undertake exploratory trips to neighbouring territories, presumably for breeding or to investigate the presence or absence of neighbouring animals. The suni make use of communal middens on which both male and female animals deposit their dung. Counts of these middens can be used in order to give a crude estimate of the relative density of suni in different areas. Glandular secretions from facial glands are sometimes used to demarcate territories by being deposited as a black, tarry substance on small twigs within the territory (Lawson 1986; Skinner & Smithers 1990).

The suni is generally associated with Sand Forest, coastal lowland and dune forest, pallid sand bushveld, and closed canopy woodland with a high stem density of shrubs in the understory and a low ground cover (Friedmann & Daly 2004). It is independent of drinking water and obtains its moisture requirements from the food consumed (Skinner & Smithers 1990). Based on its diet, the suni is classified as a browser, being an animal with a diet that includes > 70% dicotyledonous plant material (Gagnon & Chew 2000). It is partial to freshly fallen leaves, and when captive animals were given a choice between leaf litter and fresh browse, a distinct preference was shown towards the former (Lawson 1986).

Knowledge of the habitat preference, ecological requirements and conservation status of large herbivores is basic to any management programme for a reserve and a pre-requisite to determine stocking densities and possible translocations (Dekker *et al*. 1996). In conservation areas, one of the primary objectives is to maintain viable populations of all the animal species present. The fact that most species are linked to major vegetation types help in understanding their distribution patterns (Pienaar 1974). In the KwaZulu-Natal province of South Africa, the suni has disappeared outside formally protected areas due to the destruction of its habitat and excessive hunting. Within protected areas, where poaching and excessive hunting is low, numbers are, however, also decreasing (Lawson 1986). Based on its restricted distribution range, decline in habitat area and quality and the declining population numbers, the suni is currently classified as Vulnerable in the South African Red Data Book, implying that it is considered to be facing a high risk of extinction in the wild (Friedmann & Daly 2004).

In the present study, we tested the hypothesis that the suni responded to the variables in its physical habitat in proportion to its availability within the Tembe Elephant Park. If the suni showed a preference of use for certain vegetation types, then the suitability of different areas could be determined for the suni by evaluating the physical characteristics of the preferred vegetation types. The objective of the present study was therefore to gather information on the habitat preference and conservation status of the suni within the park. This information is crucial for the effective management of the population within the park and neighbouring areas.

METHODS

The methods presented below are restricted to the broad outlines of the methods employed. For a more detailed description of the methods, please refer to the general methods in chapter 3.

Habitat preference

Road counts of the spatial distribution of the suni were done in Tembe from December 2002 to November 2003. The study area was surveyed four times per month for a full year. All the observations were documented on a field form and the closest coordinates of the position of an observed suni was determined by using geographic positioning equipment (GPS). All the data were captured on a computer database for further analysis.

A measure of habitat preference for the suni was obtained by comparing patterns of habitat use with habitat availability within the study area. The Index of Jacobs (1974) was then used to calculate a preference index of use (*P*) for each vegetation type. The preference index only provided a ratio of habitat use to habitat availability and was not based on a statistical test. This was overcome by performing a Chi-square goodness-of-fit test. When a significant difference in use versus availability was detected, a Bonferroni *Z*-statistic was used to determine which vegetation types were used more or less often than expected by constructing 95% simultaneous confidence intervals around the proportion of the suni recorded in each vegetation type (Beyers *et al*. 1984; Allredge & Ratti 1992; Pienaar *et al*. 1992).

Population status

An aerial survey that was done in October 2003 was used to determine the current population status of the suni in Tembe. The overall aim of the survey was to derive trends and estimates of the large herbivore populations in Tembe that would be useful for management decisions and would stand as a record of abundance for future trend analyses. Total aerial counts and transect distance sampling counts were used to estimate the number of suni in Tembe and to calculate trends in the population from 1993 to 2003 (Matthews 2004).

RESULTS

Habitat preference

A total of 69 observations were recorded during the study period. The suni was most often found in Sand Forest/Grassland Mosaic (40.4% of observations), Closed Woodland/Thicket Mosaic on sand (24.6%) and Closed Woodland on clay (23.2%%) and less often in Open Woodland (11.6%). The suni was never recorded in *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, Hygrophilous Grassland, the Muzi Swamp, Old Lands or Sparse Woodland (Table 16). The Chi-square goodness-of-fit test for the overall data set showed a significant difference (χ^2= 195.183; $p \leq 0.05$; $df = 8$) in use versus availability for the different vegetation types in Tembe. The preference index of use of vegetation types by the suni in Tembe indicated vegetation type 3 as being preferred for use, vegetation types 1, 4, 5, 6, 7 and 9 as not being preferred and vegetation types 2 and 8 as being used in the same ratio as its proportional occurrence (Table 17).

Population status

During the total aerial count, 23 suni were recorded in 19 groups. Due to the small sample size, no distance sample estimate could be made for the suni population in Tembe (Matthews 2004). Actual trends do, however, appear to indicate an increase in the suni population from a total aerial count of 2 individuals in 1993 to the 23 in 2003 (Figure 17).

DISCUSSION

Habitat preference

In Tembe the suni showed a preference of use for the Closed Woodland on clay. No observations of the suni were ever recorded in the *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, Hygrophilous Grassland, Muzi Swamp, Old Lands or Sparse Woodland and these vegetation types were clearly not being used. The Open Woodland was also not being used often and no preference of use was thus indicated towards this vegetation type. The Closed Woodland/Thicket Mosaic on sand and the Sand Forest/Grassland Mosaic was used by the suni in proportion to its availability within Tembe.

Table 16. Vegetation types in Tembe Elephant Park, South Africa, their respective sizes (km²), proportion of the available habitat, proportion of use by the suni and preference index of use by the suni from December 2002 to November 2003.

Number	Vegetation type	Size (km²)	Percentage of available habitat (*A*)	Percentage of use (*U*)	Preference index (*P*)
1	*Acacia borleae* Shrubland/Bush Clump Mosaic on clay	2.3	0.7	0.0	-1.000
2	Closed Woodland/Thicket Mosaic on sand	51.8	15.0	24.6	0.390
3	Closed Woodland on clay	8.7	2.5	23.2	0.892
4	Hygrophilous Grassland	6.7	2.0	0.0	-1.000
5	Muzi Swamp	3.4	1.0	0.0	-1.000
6	Old Lands	0.6	0.2	0.0	-1.000
7	Open Woodland	91.5	26.6	11.6	-0.564
8	Sand Forest/Grassland Mosaic	164.8	47.8	40.6	-0.152
9	Sparse Woodland	14.4	4.2	0.0	-1.000

Table 17. The preference of use of the vegetation types in Tembe Elephant Park, South Africa by the suni from December 2002 to November 2003 ($\alpha = 0.05$; $k = 9$; $Z_{1-\alpha/2k} = 2.75$)

Vegetation type*	Percentage of habitat	Chi-square contribution	Confidence interval	Habitat use
1	0.7	0.7	$0.000 \leq p_1 \leq 0.000$	Not used
2	15	6.1	$0.103 \leq p_2 \leq 0.389$	No pattern
3	2.5	171.4	$0.092 \leq p_3 \leq 0.372$	Prefer
4	2.0	2.0	$0.000 \leq p_4 \leq 0.000$	Not used
5	1.0	1.0	$0.000 \leq p_5 \leq 0.000$	Not used
6	0.2	0.2	$0.000 \leq p_6 \leq 0.000$	Not used
7	26.6	8.5	$0.010 \leq p_7 \leq 0.222$	Not used
8	47.8	1.1	$0.243 \leq p_8 \leq 0.569$	No pattern
9	4.2	4.2	$0.000 \leq p_9 \leq 0.000$	Not used
Total	100	195.2	-	-

*Vegetation type numbers correspond with Figure 5 in chapter 2, and Table 16.

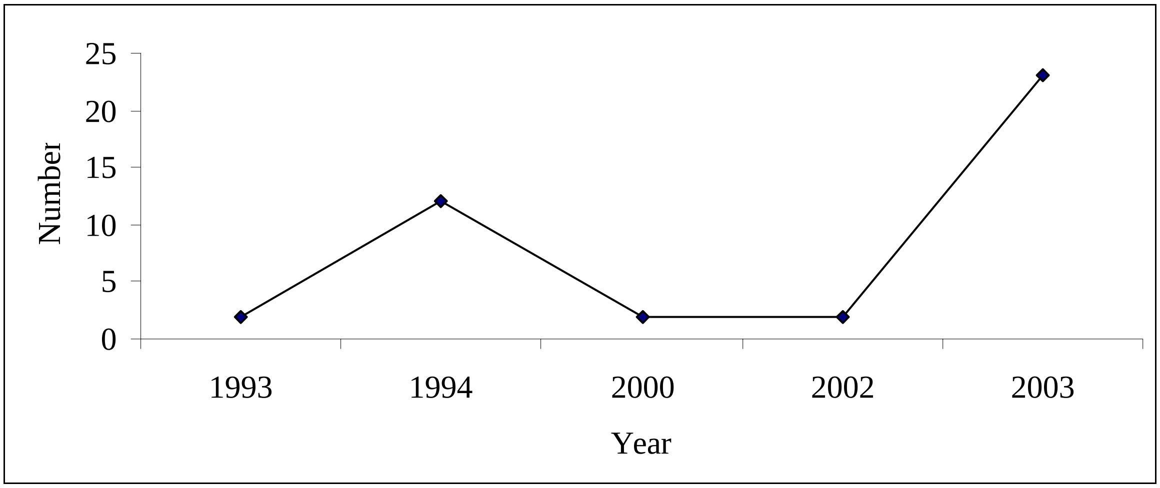

Figure 17: Aerial survey of the suni as based on total counts conducted in Tembe Elephant Park, South Africa from 1993 to 2003. Source: Matthews *et al*. (2004).

The Closed Woodland on clay occurs on clay-rich duplex soils that are normally associated with the bottomlands of the dunes and the edges of the Muzi Swamp. Perennial pans were also found throughout this vegetation type and it contained few grass species. The structure of the Closed Woodland on clay varied from areas of dense vegetation to thickets associated with termitaria (Matthews *et al*. 2001). The fact that the suni generally prefers a closed canopy with a high stem density of shrubs in the understory and a low ground cover was therefore probably the reason why this vegetation type was preferred for use by it (Friedmann & Daly 2004). Although this vegetation type only covered 2.5% of the surface area of Tembe, 23.2% of observations of the suni were made there.

The *Acacia borleae* Shrubland/Bush Clump Mosaic on clay occurs next to marshy areas and clay-based thickets associated with the Muzi Swamp. In structure this vegetation type varied from areas of dense vegetation to thickets that were associated with termitaria. Both the Hygrophilous Grassland and the Muzi Swamp have a grassland structure with no abundant trees or thickets present. The Muzi Swamp consists of reed beds in an extensive swamp system that crosses the eastern side of Tembe and extends northwards to Maputo Bay in Mozambique. The Sparse Woodland mainly occurs on flat areas between the dunes, but also to a lesser degree on the dune slopes and crests throughout the park. It was a type of grassland that was characterised by an abundance of shrub species that produced annual leafy and flowering shoots from a perennial, underground woody rootstock. The suni thus clearly avoids vegetation types with an open structure and a well-developed grass layer, but extensive patches of thicket vegetation with a closed canopy appears to be essential for their presence. Although some thicket vegetation does occur in the *Acacia borleae* Shrubland/Bush Clump Mosaic on clay, the small size of these patches most probably prevented them from being used by the suni.

No preference of use was shown towards the Open Woodland, which was the second largest vegetation type in Tembe and occurs on the dune crests, slopes and interdune depressions throughout the park (Matthews *et al*. 2001). This vegetation type was characterised by a good grassy layer interspersed with a few tall trees of approximately 8 to10 m in height. Although the suni was observed within this vegetation type, it was never found in the open areas but in the transitional zone towards a more closed woodland or thicket vegetation type.

The Closed Woodland/Thicket Mosaic on sand occurs on the dune crests, slopes and the interdune depressions throughout Tembe and could be distinguished based on plant density, which in most cases varied from closed to semi-closed crown gaps and a canopy that varied from approximately 8 to 12 m in height. This vegetation type covered 15% of Tembe, and 24.6% of the observations of the suni were made there.

The Sand Forest/Grassland Mosaic was the largest vegetation type in Tembe and was mostly associated with the dunes. This vegetation type was structurally classified as a forest that was interspersed with grassland (Matthews *et al*. 2001). The grasslands there were open with few to no trees and shrubs, and it gradually acquired a more open woodland character further away from the Sand Forest. Although the Sand Forest/Grassland Mosaic had the highest density (40.6% of all observations) of the suni in Tembe, its large size caused the overall density of the suni to be low.

Although the Closed Woodland/Thicket Mosaic on sand and Sand Forest/Grassland Mosaic vegetation types were not preferred for use by the suni in Tembe, both vegetation types are suitable to sustain them there. The habitat of ungulates provides them with food, water and cover and the feeding styles and need for cover of each species are therefore of primary importance in determining their preferred habitat. Dense vegetation types with a closed structure and well-developed understory were consistently selected for use by the suni in Tembe over more open vegetation types.

Population status

No estimate for the population of the suni in Tembe could be made from the total aerial count (Matthews *et al*. 2001). Although total aerial counts from a helicopter are generally an acceptable option, there is no single comprehensive counting technique that is suitable for counting all animal species. Knowledge of the habitat requirements of the animals to be counted is essential before any count should be attempted (Bothma 2002). Due to the secretive nature of the suni and the fact that it is only found in dense vegetation types, it is recommended that road strip counts be used to supplement the counts for the suni in Tembe so as to get a more reliable estimate of its conservation status. Lawson (1986) also recommended doing a simple midden count index at intervals of five years in order to assess the suni population. The nature of the vegetation in Tembe, as well as the presence of dangerous wildlife does, however, limit the use of this technique within the park. In Tembe, 22 530 ha of suitable habitat for the suni (vegetation types 2, 3 and 8) are available, although only the Sand Forest areas in vegetation type 8 is used by them at present. By doing a simple midden count index in each of the suitable habitat types, a reliable first estimate will, however, be obtained for the suni population in Tembe.

Despite the limits of the counting technique used, population trends appear to indicate an increase in the number of suni in Tembe from 1993 to 2003. Monitoring of changes in the structure of vegetation within the suitable habitat is, however, important for the conservation of the suni in Tembe. The population numbers of competitive herbivores like the nyala should also be kept sufficiently low in order not to have a negative influence on the vegetation and thus the survival of the suni.

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CHAPTER 11

CONCLUSIONS

The present study has shown that the Tshanini Community Conservation Area not only has the potential to contribute significantly towards biodiversity conservation in the heterogeneous Maputaland Centre of Plant Endemism, but that it will also serve as an example for conservation-based community development in South Africa. It is the first reserve of its kind to be established in a ward of a tribal area in the northern parts of the KwaZulu-Natal province of South Africa through the initiative taken by the local people themselves. This is a huge step forward for conservation in South Africa, given the current negative attitude of the rural people towards conservation. However, the success of such ventures will require structures to promote initiatives that will support their establishment and maintain their long-term sustainability. We can ill afford to lose any chance to promote conservation in South Africa where the highest known concentration of threatened plants and the highest extinction estimates for any area in the world are found (Wynberg 2002).

With the huge and still growing population of the world, especially in developing countries, and the resultant decrease in natural resources, the environment is becoming increasingly more important in development planning. Whereas middle and top management staff involved in conservation activities to a certain extent realize the need for community involvement as a valid conservation activity, they do not really understand how to go about it (Els & Bothma 2000). Most of these managers are natural scientists that have not been trained in people management skills necessary to be involved in, or to facilitate rural development. They most certainly are also not trained to be involved in the development of capacity at grass roots level in communal communities. However, although all conservation staff should today clearly have a degree of knowledge and expertise to deal with conservation-based community development in the ordinary run of their duties, it is unrealistic to expect them to be fully qualified in what is essentially a separate field of expertise. The answer to the seeming contradiction in the focus of wildlife conservation and rural development, therefore, must lie in the development of wildlife management programmes based on multi-disciplinary and multi-institutional interaction. These interactions will have to harness the scientific knowledge and skills found outside the natural sciences in the social sciences (Els & Bothma, 2000).

An integrated approach incorporating both conservation and human development needs is required. Such an approach should emphasise the value of existing conservation areas and view parks as a central component of conservation strategies (Bruner *et al.* 2001; McKinney 2002), from which to promote the sustainable development of rural communal areas surrounding these sites (Editorial 2003), while establishing buffer zones around protected areas. Since the eradication of poverty is an indispensable requirement for sustainable development, the alleviation of poverty in areas surrounding protected areas will contribute largely towards the required future integrated approach. Developing countries like South Africa face the challenge of achieving economic growth and poverty alleviation without causing environmental degradation (UNDP 2003).

Core conservation areas like the Tembe Elephant Park cannot be the main driving force behind the sustainable development of rural communal areas surrounding the park, but instead should be used to promote environmental education and to do appropriate research on the ecosystem. There are basically two types of wildlife management: active management and passive management. Active management involves the manipulation of wildlife and their habitat, while passive management involves the prevention of any human influence. Only active management should be applied on a relatively small extensive wildlife production system or nature reserve that has been fenced. No natural area should be managed without an ecological management plan in place. The aim of an ecological management plan is to give scientifically based advice regarding the management options and recommendations. This will allow a sustainable use of a ranch or reserve without deterioration of the environment.

Both the nyala and the impala are highly adaptable and competitive and occur in relatively high numbers within the Tembe Elephant Park. Although they do not compete directly with one another in all the vegetation types within the park, with the nyala showing a preference for dense vegetation types and the impala showing a preference for vegetation of intermediate density, one of the two does, however, show a preference for every vegetation type that is preferred by every other herbivore in the present study. Either the nyala or the impala is thus competing with every other herbivore within the preferred vegetation type of that particular species within the park. Population numbers of both the nyala and the impala should therefore be kept sufficiently low in order not to have a negative influence on the vegetation or the survival of less competitive ungulates in the park. Although the herbivores are separated in terms of feeding height, the opening up of the vegetation by the nyala and the impala will have a negative influence on wildlife like the red duiker and the suni, which prefer dense vegetation with a closed structure. Population trends for all the ungulates in the present study do, however, appear to indicate an increase in the number of individuals from 1993 to 2003 and there is at present no immediate threat of a decline in numbers for any of these populations within the Tembe Elephant Park.

No herbivore in the present study showed a preference for the Sand Forest/Grassland Mosaic vegetation type although the suni and the Burchell's zebra did use it in proportion to its availability within the park. Burchell's zebra was observed feeding on the grassland areas in this vegetation type, but it seldom entered the Sand Forest. Although the Sand Forest/Grassland Mosaic had the highest density (40.6% of all observations) of the suni in Tembe, its large size caused the overall density of the suni to be low. The destruction of the Sand Forest in the Tembe Elephant Park will thus have a negative effect on the survival of the suni, especially since this is the only vegetation type in the park where the suni occurs without competition from other herbivores like the nyala, impala or red duiker. None of the target herbivores in the present study appears to have a destructive effect on the Sand Forest within the park.

Key aspects of wildlife and their habitat should be monitored so that trends are noted in time, and management adjustments can be made accordingly. This is known as active adaptive management. It is of great importance to monitor the vegetation for changes at specific intervals in order to keep the stocking rate of wildlife at an optimum capacity, without detriment to the environment (Bothma 2002). Social behavioural patterns also play a key role in determining how different animal species utilise their habitat and therefore play an important part in determining the densities in which different animal species are found in a specific area. In sub-optimal conditions, the social structure of animal populations may be affected to such an extent that it can lead to a decline in numbers or even cause extinction (Joubert 2002). It is thus important to protect a viable portion of the preferred habitat of every target species within a reserve, and to keep competition with rare species to a minimum for the long-term survival of the regional biodiversity.

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