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The Zambezi Society and The Biodiversity Foundation for Africa are working as partners within the African Wildlife Foundation's Four Corners TBNRM project. The Biodiversity Foundation for Africa is responsible for acquiring technical information on the biodiversity of the project area. The Zambezi Society will be interpreting this information into user-friendly formats for stakeholders in the Four Corners area, and then disseminating it to these stakeholders.

THE BIODIVERSITY FOUNDATION FOR AFRICA (BFA is a non-profit making Trust, formed in Bulawayo in 1992 by a group of concerned scientists and environmentalists. Individual BFA members have expertise in biological groups including plants, vegetation, mammals, birds, reptiles, fish, insects, aquatic invertebrates and ecosystems. The major objective of the BFA is to undertake biological research into the biodiversity of sub-Saharan Africa, and to make the resulting information more accessible. Towards this end it provides technical, ecological and biosystematic expertise.

THE ZAMBEZI SOCIETY was established in 1982. Its goals include the conservation of biological diversity and wilderness in the Zambezi Basin through the application of sustainable, scientifically sound natural resource management strategies. Through its skills and experience in advocacy and information dissemination, it interprets biodiversity information collected by specialists like the Biodiversity Foundation for Africa and uses it to provide a technically sound basis for the implementation of conservation projects within the Zambezi Basin.

THE PARTNERSHIP between these two agencies was formed in 1996 as a result of mutual recognition of their complementarity. They have previously worked together on several major projects, including the biodiversity component of IUCN's Zambezi Basin Wetland project and the evaluation of biodiversity in Tete province described in detail in the first Four Corners TBNRM Biodiversity Information Package.

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CHAPTER 6. MAMMAL FAUNA OF THE FOUR CORNERS AREA

F.P.D. (Woody) Cotterill

6.1 INTRODUCTION

The review given in this chapter covers all extant and historically extinct mammals occurring in the Four Corners Transfrontier area. When its historical context is considered, our current knowledge of this fauna has grown through surveys and ecological studies of selected species and assemblages that were carried out independently and piecemeal. Ecological studies have been biased toward the large mammals (especially in protected areas). Reference to all these studies has been made, but some information has undoubtedly been missed, especially that in unpublished reports. It is impossible at present to quantify the quality and scope of this grey literature.

The principal influences of habitat and faunal associations on the mammal composition are discussed. In addition, important influences on the evolution of this fauna are singled out and discussed. Knowledge is summarised for particular species considered to be of conservation, ecological or economic importance. First, though, the geographical and taxonomic scope of the mammals is discussed, with brief consideration of the criteria for determining the occurrence of a species in the region.

6.1.1 Geographical and Taxonomic Scope

Determination of the occurrence of a species within the Four Corners area (Appendix 6.1) has been derived from the principal summaries of knowledge. With the exception of large, obvious mammals, the criterion for inclusion has been a reliably identified museum specimen. The list is thus conservative as it excludes, for example, approximately five species of Chiroptera (bats) known from nearby localities, but is thought to be representative. Furthermore, many small mammals as currently listed are likely to comprise two or more species. Important records omitted include those from the Barotse floodplain and its surrounding miombo woodland (e.g. Cotterill 2000a), including species of small mammals which could well occur in the Zambian part of the area. There are an indeterminable number of species of small mammals (especially shrews and bats) the occurrence of which is based on very sparse data. Examples include *Laephotis botswanae*, *Kerivoula lanosa*, *Nycteris macrotis*, *Mimetillus moloneyi*, *Scotoecus hindei* and *S. albigula*, all of which are known from either a single specimen or occur near the northern boundary. Domesticated mammals are not considered.

The mammal fauna comprises at least 197 species, the majority of which (145 species, or 74%) are small-bodied (less than 10 kg in mass). The largest groups are rodents (47 species), bats (53 species) and insectivores (9 shrews and one hedgehog), which comprise 56% of the total for the area.

Besides the great disparity in geographical size of countries, factors such as habitat diversity, biogeographic affinities and evolutionary history influence these totals profoundly. Not least, the figures show important limitations in our knowledge of mammals (and in fact all biodiversity) in each of the five countries. The total species richness of mammals in the area probably exceeds 200, and species are likely to be more widespread than indicated in Appendix 6.1, especially for Angola.

6.1.2 Taxonomic Issues and Uncertainties

The taxonomic affinities of the majority of small and many large mammals are very uncertain. This acute deficiency in knowledge is surprising to many people, including the majority of biologists. Problems associated with imprecise taxonomic information are serious for both conservation and wildlife management - the impacts of such inaccurate information on reliable decisions about populations or habitats should not be underestimated.

Their taxonomy, in terms of what exactly what their constituent species are, is unresolved for many small carnivores and many genera of elephant shrews, bats, rodents and shrews. Others for which taxonomy awaits elucidation include primates, notably the baboons and vervet monkeys. For example, it is impossible at present to state with any confidence what actual species comprise the rodent genera *Cryptomys*, *Graphiurus* and *Mus*, or the bat genus *Scotophilus*. The musk shrews classified in the speciose genus, *Crocidura*, are even more problematic. There is also considerable uncertainty as to how many species of genets (*Genetta*) occur in south-central Africa.

The precise taxonomic affinities of both Roan and Sable antelopes require unequivocal elucidation, as does that of Blue wildebeest occurring in southwest and central Zambia. This situation means that we cannot state with certainty the precise identities of those populations found in SE Angola. These three antelope populations are currently perceived as no more than representatives of populations described in South Africa in the 19th century, but this hypothesis has yet to be tested by comparing all museum material together with molecular analyses. It is impossible to name many populations of African antelopes precisely, let alone define the ranges of described taxa with any confidence (Cotterill 2003a).

Higher level revisions of the Mammalia continue, and growth in interest in phylogenetic systematics over the past two decades suggests that radical changes in the taxonomy of all mammals will continue for some years to come, including the cats, Family Felidae (Wilson & Reeder 1993) and the Bovidae.

6.2 SOURCES OF KNOWLEDGE

6.2.1 Historical Aspects

This section first summarises the main sources of knowledge on mammals (natural history collections and publications), which constitute the main historical contributions in each of the five countries. In many respects, the relevance of much of this knowledge, where credible, increases with age, as shown by the information, albeit cursory and incomplete, on past distributions of some species in the 19th century and the impacts of phenomena such as the rinderpest pandemic of the 1890s.

The first published information on the mammals occurring in the region summarises observations made by the first European explorers. Collections focused on large mammals, and some publications included descriptions of new species (Spinage 1995). This literature also records important historical events, especially the rinderpest pandemic. In the 1870s Selous (1881, 1908) and Oates (1971) made the first collections of mammals from northern Matabeleland. Gibbons (1898, 1904) crossed NW Botswana and SW Zambia both before and after the rinderpest outbreak of 1896, and later wrote of the decimation of many populations of antelope that had been exceedingly abundant on the Shesheke Flats and in the area that today lies in the Chobe National Park. The importance today of this 19th century literature is that it is the only written information available about species which have declined greatly (especially Puku)

or become locally extinct (White rhinoceros) in the region. Particular cases are discussed in more detail below.

6.2.2 Taxonomic Diversity and Surveys

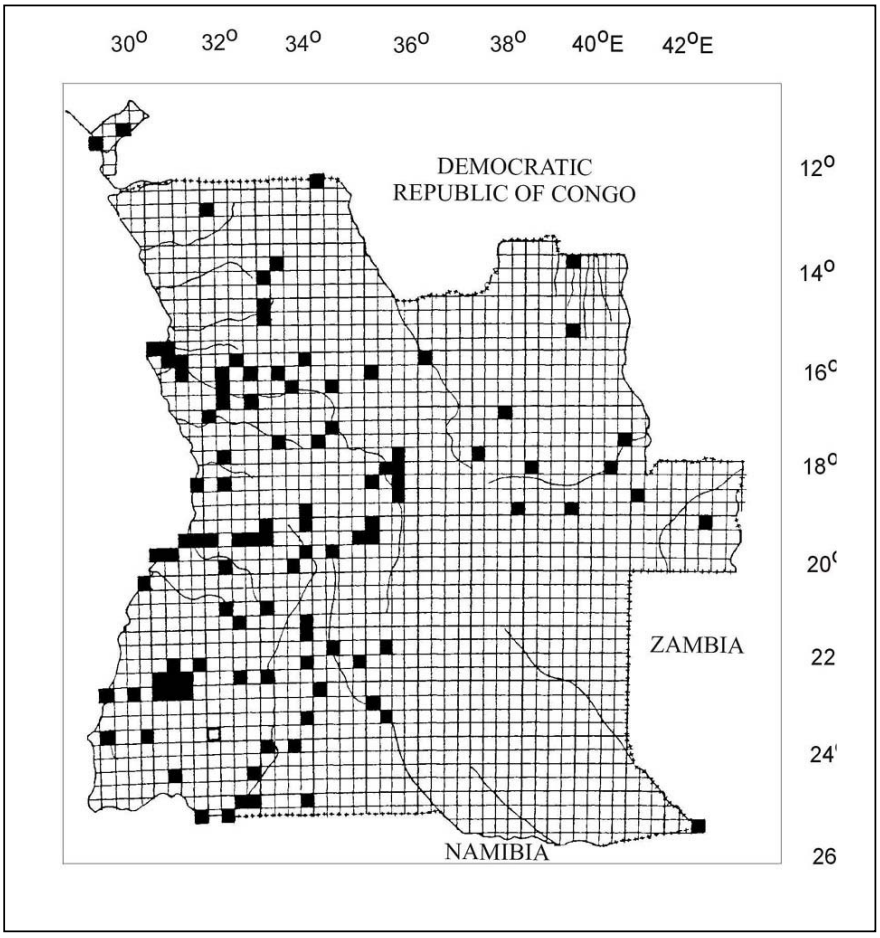
Smithers (1971), Ansell (1978) and Smithers and Wilson (1979) are principal sources of knowledge on which mammals occur in Botswana, Zambia and Zimbabwe, respectively. Hill and Carter (1941) summarise the little that is known about the mammals of Angola, while the mammals of the Caprivi Strip in eastern Namibia have been summarised by Griffin and Grobler (1991) and Brown and Jones (1994). There has also been more recent collecting and surveys of particular areas. This is discussed in the following country summaries.

Angola

The definitive review of the mammals fauna of Angola remains Hill and Carter (1941). They included specimens and records of A.S. Vernay and H. Lang who collected across south-central Africa. Specimens from the latter are preserved in the American Museum of Natural History, New York (AMNH) and in the Field Museum of Natural History, Chicago (FMNH).

Figure 6.1 indicates the distribution of bat specimens across the whole country showing there is virtually northing known from the eastern portion of Angola. This acute gap in knowledge also applies to other mammal groups.

Figure 6.1. Distribution of collecting sites of all known bat specimens (Chiroptera) from Angola showing an acute gap in knowledge, especially in the east of the country. Each marked quarter-degree square represents at least one specimen. After Crawford-Cabral 1989.



Botswana

The first major survey of mammals in the then Bechuanaland was that done by the Vernay-Lang Expedition (1930-1931), which collected mammal specimens across the territory including parts of Four Corners area. Collecting extended as far to the northeast as Kazungula in the then Southern Rhodesia (Smithers 1971, F.P.D. Cotterill unpublished data).

The principal source of information resides in the large collection built up during the Botswana Mammal Survey from 1964 to 1969, which involved the then Museums of Rhodesia in collaboration with the Mammal Section of the Smithsonian Institution, Washington DC. The latter provided fully-equipped teams over a period of three years (Smithers 1971). The approximately 100,000 mammal specimens collected are preserved either in the Natural History Museum, Bulawayo (NMZB) or in the National Museum of Natural History (USNM).

Multi-disciplinary expeditions by what is now the Natural History Museum of Zimbabwe began in the 1960s as part of the Botswana Mammal Survey. These continued through to the mid-1980s in collaboration with senior school natural history societies, when several trips focused on the Okavango Delta. This material, much of which has yet to be formerly reported upon, represents notable range extensions for some bat species (F.P.D. Cotterill, unpublished data). An important collection of Chiroptera from the Okavango Delta by A. Archer (partially reported upon in Archer 1977) is preserved in the Smithsonian in Washington DC, with just a few specimens in the Royal Ontario Museum (ROM) in Toronto. Some comparatively rare species have noteworthy ecological and life history data.

Namibia

Shortridge (1934) summarised the available information about the mammals of the then South West Africa, including the Caprivi Strip. The Bernard Carp Expedition of 1947, centred on the eastern section of the Caprivi Strip, involved biologists from the Kaffrarian Museum (King Williamstown), the Transvaal Museum (Pretoria) and the then National Museums of Southern Rhodesia. It was followed by an expedition by the Transvaal Museum (Haacke, Rautenbach & Kemp 1971). Both expeditions resulted in some important mammal specimens (Meester 1973).

More recent biological studies in the Caprivi (notably Brown & Jones 1994) include an assessment of the biogeography and conservation status of the mammals. There have been ecological studies on a few particular species; collecting and surveys continue (M. Griffin, pers. comm.).

Zambia

The definitive summary of knowledge remains the *Mammals of Zambia* (Ansell 1978), a reliable and comprehensive source on the taxonomy and biogeography of all mammals occurring in southwestern and central Zambia. Compared to elsewhere, the southwestern corner of the country is poorly surveyed. Collections of small mammals in the Choma and Kalomo districts in the 1990s provide important records of some bats.

Zimbabwe

A significant portion of the northwest corner of Zimbabwe is included within the Four Corners area, including Hwange National Park the mammal fauna of which was surveyed by Wilson (1975). This information and additional biogeographical records were collated by Smithers and Wilson (1979). Since 1982, there have been no less than five multi-disciplinary expeditions under the auspices of the Natural History Museum of Zimbabwe (Bulawayo) focusing on small mammals along the Zambezi upstream of Victoria Falls, in the Gwayi valley, the Matetsi Safari Area and in Kazuma Pan National Park.

6.2.3 Ecological Studies

Angola

There are no known studies on the ecology of mammals occurring in SE Angola. This is a glaring gap in our knowledge, underwritten by the nearly total lack of any biological specimens from this area.

Botswana

Ecological studies of mammals in Botswana have focused on large ungulates and carnivores (Hunter 1991). One exception is the monitoring of population dynamics of murids on the Chobe floodplain (Sheppe & Haas 1981), a study that extended from June 1971 to August 1972 (Sheppe 1972). Simpson (1974a, 1974b, 1974c) carried out a detailed ecological and behavioural study on bushbuck in the Chobe National Park, and also emphasized the adverse impacts of elephants on habitats and biodiversity in riparian habitats along the Chobe River (Simpson 1978). The ecological survey of NE Botswana by Child (1968) focused on large mammals including several antelope species, notably Common waterbuck, Red lechwe, Puku (Child 1975, Child & Von Richter 1969) and Tsessebe (Child, Robbel & Hepburn 1972). Games (1983) studied Sitatunga in the Okavango in some detail. The social behaviour of Grey-footed baboons, *Papio griseipes*, has been intensively studied in Moremi Game Reserve (Johnson 2003; Silk, Seyfarth & Cheney 1999). Some of these studies have formed part of control programmes of economically important hosts of epizootic diseases, especially trypanosomiasis (Hunter 1991) and foot and mouth disease (e.g. Falconer & Child 1975, Hunter 1991).

Elephants have been the subject of detailed study (e.g. Ben-Shahar 1996, Stokke 1999, Stokke & Du Toit 2002), while studies on predators have included ones on Spotted hyaena in Chobe NP (Cooper 1989, 1990), and on disease in large felids (Osofsky *et al.* 1996) and *Lycaon pictus* (Alexander *et al.* 1996). The Botswana National Parks department has maintained long term monitoring programmes censusing populations of large mammals within and around protected areas. Recent data for antelopes were included in an assessment of the conservation status of the antelopes of Botswana (Ross *et al*. 1998). There are currently several studies of predators and large ungulates, including an exhaustive monitoring of elephant movements and ecology (M. Chase, pers. comm.). A recent study by C.G. Hunter (1966) of regional changes of Buffalo focused on the population common to NE Botswana and NW Zimbabwe, demonstrating seasonal migrations in relation to predation, hunting pressure and resource availability.

Namibia

Important ecological and other studies on the mammals of the Caprivi are mostly in the form of reports or 'grey' literature of limited distribution, such as that by Brown and Jones (1994). Published studies include Child (1975), Williamson (1981), Griffin and Grobler (1991) and Schlettwein *et al.* (1991). There have been regular annual censuses of large mammal populations in protected areas (Mamili and Mudumu National Parks) in the Caprivi (Schlettwein *et al*. 1991).

Zambia

The major focus of ecological research in the Four Corners portion of Zambia has been on the Kafue National Park. Studies looked especially at antelopes in the 1960s (e.g. Hanks 1969a; Hanks, Stanley Price & Wrangham 1969), and on certain small mammals (Wrangham 1969). There have been important studies on the ecology of large species (including population dynamics), and these have been briefly reviewed in the management history of the Kafue NP (Mwima 2001). Species studied in some detail include Crawshay's waterbuck, elephant, Puku, Blue wildebeest, Oribi and Red lechwe. Other ecological surveys in the Kafue assessed predation (Mitchell, Shenton & Uys 1965) and animal movements, and the monitoring of large mammal

populations using road and aerial counts (Mwima 2001). There has been little, if any, research on mammals in SW Zambia since then, except for that by Tembo (1995).

Zimbabwe

The majority of ecological studies within the Four Corners area have been restricted to populations of large mammals, mainly in Hwange National Park. Most were carried out in the 1960s and 1970s; earlier studies are cited by Wilson (1975). The species were selected because of their relevance to ecology and management (elephant, hyaena) or conservation (White rhino, Painted hunting dogs). Fergusson (1990), for example, reviewed the population dynamics of Sable antelope, a key trophy species of management concern in Matetsi Safari Area.. Most studies have focused on elephants (e.g. Williamson 1975a, 1975b) and were conducted under the auspices of the Department of National Parks and Wildlife Management (DNPWM). They have been allied with regular censuses of large mammals, notably in Matetsi (Fergusson 1990). An important collation of research was presented at a conference at Hwange Safari Lodge in 1990; unfortunately these proceedings were not published (F. Robertson, pers. comm.).

Behavioural and ecological studies of large carnivores in and around Hwange NP have received more attention beginning in the 1990s. Subjects have included Black-backed and Side-striped Jackals (Loveridge & MacDonald 2001, 2002), Lion (A. Loveridge, pers. comm.), Spotted hyaena (Salnichi *et al*. 2001), and especially Painted hunting dogs (Davies 1993, Woodroffe & Ginsberg 1999a,1999b, Rasmussen 1999, Girman *et al*. 2001). Hyaena and Painted hunting dogs continue to be intensively studied, with a focus on the packs along the eastern and southern boundaries and in the northwest (Sinamatella and Robins camps).

The ecology and population dynamics of elephants have been intensively studied since the 1960s, and censuses continue, which also monitor other large mammals. The research has been allied with a revealing, long term taphonomic study of pachyderm mortality (Haynes 1993).

6.3 PRINCIPAL ASSEMBLAGES OF MAMMALS

The rich mammalian fauna of the Four Corners area owes its occurrence to several different factors. The main one is the contribution from different faunal elements comprising species associated with certain landscapes such as savanna woodlands (arid and mesic), grasslands, rocky hills and gorges (rupicolous), and wetlands. This last category includes large rivers (such as the Upper Zambezi), swamps (notably the Okavango) and riparian forests associated with these permanent water bodies. Mammals characteristic of each of these principal faunal elements are listed in Table 6.1.

The present-day habitat mosaic represents a transient stage when considered at evolutionary scales; one has to consider the evolutionary history of the landscape. As discussed in more detail below, climate change and drainage evolution through the Plio-Pleistocene have been major determinants of the modern biodiversity of the area.

6.3.1 Kalahari Savanna

The distributional limits of many desert species (southwest arid endemics) corresponds to the southern edge of the Okavango Delta and SW Makgadikgadi Pans. These include the gerbils, *Desmodillus auricularis* and *Gerbillurus paeba* (the latter reaches the southern end of Hwange NP), three small carnivores - Yellow mongoose, *Cynictis penicillata*, Black-footed cat, *Felis nigripes* and Cape fox, *Vulpes chama* - and Springbok, *Antidorcas melampus*. Red hartebeest, *Alcelaphus cama* rarely occurs to the east, with sporadic records from western Zimbabwe.

Table 6.1. Mammal species that show an association with the principal faunal elements in the Four Corners area.

Kalahari Arid Savanna	Dry Savanna Woodland	Mesic Miombo Woodland	Grassland	Wetland
Otocyon megalotis Bat-eared fox	*Paracynictis selousi* Selous mongoose	*Epomops dobsoni* Dobson's fruitbat	*Connachaetes taurinus* Blue wildebeest	*Pipistrellus rueppelli* Rueppell's bat
Suricata suricatta Suricate	*Giraffa camelopardalis* Giraffe	*Mops niveiventer* White-bellied free-tailed bat	*Damaliscus lunatus* Tsessebe	*Lutra maculicollis* Spotted-necked otter
Cynictis penicillata Yellow mongoose	*Tragelaphus strepsicerus* Greater kudu	*Papio kindae* Kinda baboon	*Redunca arundinum* Reedbuck	*Tragelaphus spekei Sitatunga*
Felis nigripes Black-footed cat	*Damaliscus lunatus* Tsessebe	*Genetta angolensis* Angolan genet	*Ourebia ourebi* Oribi	*Kobus leche* Red lechwe
Hyaena brunnea Brown hyaena	*Aepyceros melampus* Impala	*Dendrohyrax arboreus* Tree hyrax	*Thryonomys swinderianus* Greater canerat	*Kobus vardoni* Puku
Alcelaphus cama Red hartebeest	*Raphicerus campestris* Steenbok	*Sigmoceros lichtensteini* Lichenstein's hartebeest	*Pedetes capensis* Springhare	*Dasymys incomtus* Water rat
Antidorcas marsupialis Springbok	*Raphicerus sharpei* Sharpe's grysbok	*Heliosciurus gambianus* Gambian sun squirrel	*Dendromus melanotis* Grey climbing mouse	*Dendromus mesomelas* Chesnut climbing mouse
Xerus inaurus Ground squirrel	*Pronolagus randensis* Jameson's red rock rabbit	*Anomalurus derbianus* Scaly-tailed flying squirrel	*Dendromus nyikae* Climbing mouse	*Dendromus mystacalis* Lesser climbing mouse
Desmodillus auricularis Namaqua gerbil		*Zelotomys hildegardeae* Hildegarde's rat	*Arvicanthus niloticus*	
Gerbillurus paeba Hairy-footed gerbil			*Lemniscomys rosalia* Single-striped mouse	
Zelatomys woosnami Woosman's desert rat			*Rhabdomys pumilio* Striped mouse	

6.3.2 Mopane Savannas and Dry Miombo Woodlands

This faunal assemblage, which includes that in *Baikiaea* woodlands on Kalahari sands, accounts for the majority of mammal species occurring in the area. Species with a southern savanna distribution include Greater kudu, *Tragelaphus strepsiceros*, Sharpe's grysbuck, *Raphicerus sharpei* and Selous' mongoose, *Paracynictis selousi*.

6.3.3 Mesic Miombo Woodlands

Mammals associated with the mesic miombo woodlands of central and northern Angola, northern Zambia and Katanga in the Democratic Republic of Congo (DRC) only reach the northern periphery of the study area in the Kafue NP. Examples include the Gambian sun squirrel, *Heliosciurus gambianus* and Kinda baboon, *Papio kindae*. The Tree hyrax, *Dendrohyrax arboreus*, also reaches its southern distribution in S Zambia (Ansell 1978).

The southernmost occurrences (Jeffery, Bell & Ansell 1989) of two forest antelopes (Yellow-backed duiker, *Cephalophus silvicultor* and Blue duiker, *Philantomba monticola*) reflect more the availability of patches of evergreen thickets and gallery forest than mesic miombo woodland. These two species illustrate (as does the Tree hyrax) the influence of evergreen dry forest and thicket in augmenting species richness. The precise determinants for the southern limit of these species within and among mesic miombo woodland are difficult to identify. It is likely that this southern margin corresponds not only to these habitats but also to the former course of major wetlands, especially that of the palaeo-Chambeshi and palaeo-Kafue rivers. The former extent of the northeastern part of palaeo-Lake Makgadikgadi was probably an important determinant as (judged by the alluvium of the Machili Flats) this lake stretched back to be contiguous with the Kafue Flats (Cotterill 2003b).

6.3.4 Wetlands, Grasslands and Riparian Woodlands

Besides the dominance of wetlands, the overall habitat diversity in the Okavango Delta is of great significance in supporting a rich mammal fauna. Riparian forests and termitaria are particularly important microhabitats for small mammals. The southern portion of the study area corresponds to a local hotspot in southern Africa, where over 40 species of grazing mammals occur (Andrews & O'Brien 2000).

Grasslands in the area are either semi-arid habitats within Kalahari savanna, or are closely associated with wetlands along edges of the principal rivers and swamps. Important examples are Kazuma Pan and the Shumba Flats in NW Zimbabwe, utilized by grazing ungulates including Blue wildebeest and Tsessebe. These attract large predators, notably Painted hunting dog and Cheetah.

The richness of the small mammal fauna of these grasslands varies with respect to their association with perennial water. Close proximity to perennial water increases species richness (as in the Okavango and Linyanti). The shrews *Crocidura occidentalis* and *Suncus lixus*, are associated with wetlands and moist grasslands, as are many rodents including Water rat *Dasymys incomtus*, Groove toothed rat *Pellomys fallax*, vlei rats *Otomys* spp. and the climbing mice *Dendromus mystacalis* and *D. mesomelas*.

6.3.5 Rocky (Rupicolous) Habitats

Rupicolous mammals constitute another significant component of the mammal fauna, although rocky habitats are very patchy within the Four Corners area. The principal locations are in the northern section of Hwange NP (especially the hills from Sinamatella northwards across the Deka valley to the Gwayi and Zambezi). There are also rugged basalt hills and valleys downstream of Victoria Falls, extending either side of the Batoka gorge. This young drainage

system is characterised by numerous narrow gorges incised into the basalts and Karoo sandstones. Patchy rupicolous habitat extends across NW Zambia along the northern edge of the Gwembe rift. Granite outcrops are also found in parts of Choma District and in the Kafue NP. The Tsodilo Hills west of the Okavango provide similar habitat.

This rocky habitat has a distinctive associated fauna, including two species of hyraxes, *Procavia capensis* and *Heterohyrax ruddi*, Klipspringer *Oreotragus oreotragus*, Rock elephant shrew *Elephantulus myurus*, Jameson's red rock rabbit *Pronolagus randensis*, and several species of rupicolous rodents. Notable examples are the rock dormouse *Graphiurus platyops*, Namaqua rock rat *Aethomys namaquensis*, and Spiny mouse *Acomys spinosissimus*.

6.4 ECOLOGICAL AND EVOLUTIONARY PATTERNS AND DETERMINANTS

6.4.1 Ecological Determinants

In contrast to the eutrophic savannas of East Africa, much of the Four Corners area is semi-arid savanna (miombo and Kalahari sand woodlands) on dystrophic soils. Hence the area supports a comparatively low biomass of mammals (Coe, Cumming & Phillipson 1976, East 1984). As judged from densities of raptor nests in Hwange NP, primary productivity has been interpreted to be significantly greater on basalt soils as determined from the greater availability of small vertebrates and mammals as prey (Hustler & Howells 1990). This difference from the Kalahari sands could reflect other differences between the ecology of Kalahari sand and basalt habitats, for example grasses growing on basalt soils are more palatable. It remains to be established if primary production is in fact higher on the Kalahari sands (K. Dunham, pers. comm.).

The overall pattern of comparatively low mammal biomass changes in parts of the area, especially in the E Caprivi and NE Botswana. The network of wetlands, especially distributaries of the Okavango and Cubango rivers east of the Okavango Delta, are of great ecological significance, especially where surface water persists for long periods.

6.4.2 Mammals as Ecological Determinants

The ecological engineering activities of Hippotamus are important in maintaining and expanding aquatic habitats in the Okavango Delta, especially where they open up channels and thus facilitate water flow between channels and permanent lakes. These activities extend the area of permanent swamp (McCarthy, Ellery & Bloem 1998).

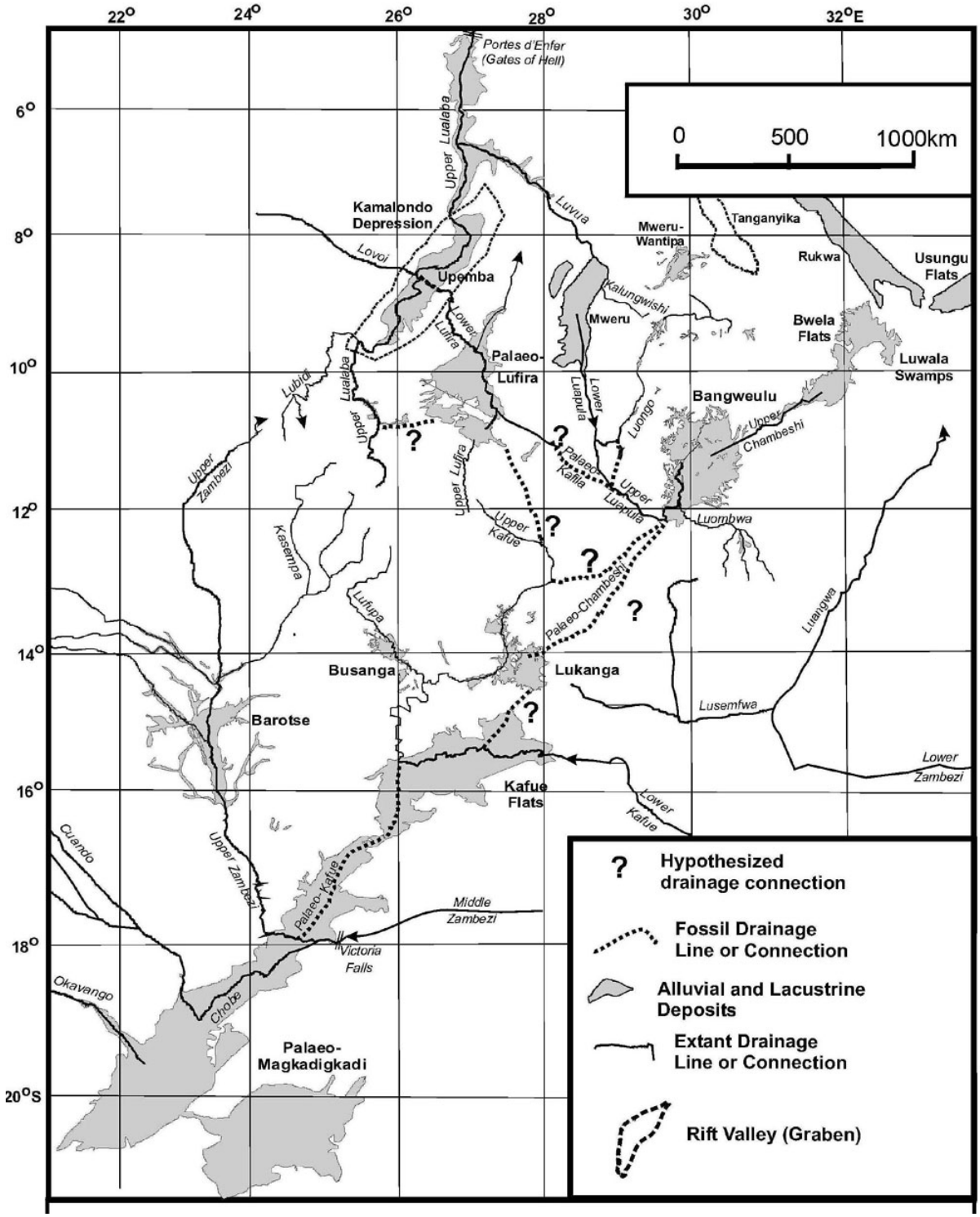
In addition to humans, elephants can be singled out as a major determinant of the functioning and structure of savanna landscapes. This especially applies to their activities in modifying habitat structure of woodlands (Cumming *et al.* 1997) and around localized water bodies (Haynes 1993).

6.4.3 Landscape Evolution

Landscape evolution in the Four Corners area has been profound (see Moore, Chapter 2), in that the drainage systems across south-central Africa have radically changed. This process began before the Miocene, with especially significant alterations of the Upper Zambezi and Okavango system through the Plio-Pleistocene. Of particular relevance was the existence of palaeo Lake Makgadikgadi through the Pleistocene. Its huge area was maintained in part by run-off from the present Upper Zambezi and the Okavango and Cubango rivers, which today flow into the Okavango and Chobe. Their inflows were significant, but the largest endoreic tributary of palaeo Lake Makgadikgadi was the palaeo-Chambeshi River, that flowed southwest from NE Zambia parallel with the Muchinga Escarpment, to terminate in the Kalahari basin (Figure 6.2). The most apparent signature of its importance is the vast alluvial deposits extending from NE Botswana

into SW Zambia that are contiguous with the present day Kafue Flats (Moore & Larkin 2001, Cotterill 2003b).

Figure 6.2. Extent of alluvial deposits in south-central Africa. Data collated from geological survey maps for Katanga, DRC and Zambia; extent of alluvium in NE Botswana modified from Moore & Larkin (2001). Adapted from Cotterill (2003e) and Broadley & Cotterill (2003).



The physical evidence is complemented by geographical distributions of particular wetland biota, for example vertebrates and Odonata, which occur in the drainage systems of both the Chambeshi and Upper Zambezi-Okavango (see reviews in Timberlake 2000). Interesting biogeographical patterns are evident in the otherwise anomalous discontinuities of many vertebrates, including several mammals (Cotterill 2003a, 2003b; Broadley & Cotterill 2003). A signature of this link is represented in distributions of those wetland species (including Sitatunga, Puku and Crawshay's waterbuck) that share a common southern distribution limit in the Okavango or Upper Zambezi, and are confined to upstream of Victoria Falls. In this respect, the distribution of the Spotted-necked otter *Lutra maculicolis* is also restricted to large wetlands. At least in south-central Africa, this species appears to have an Upper Zambezi distribution as it is absent from the Zambezi downstream of Katombora rapids. The last locality is noteworthy as two species of Otter (the other being the Clawless otter *Aonyx capensis*) occur sympatrically here.

The distribution pattern of lechwe is even more informative, as vicariance of the former palaeo-Chambeshi drainage in Zambia and SE Katanga is the most plausible explanation for speciation in these aquatic antelopes. Within the area only Red lechwe is confined to the Upper Zambezi drainage system, while the Kafue lechwe is endemic to the Kafue Flats where it occurred marginally within the Kafue NP (discussed below). The present pattern points to a formerly more contiguous distribution from the Okavango (palaeo-Makgadikgadi) extending northeast along the palaeo-Chambeshi to SE Katanga and Bangweulu (Cotterill 2000b, 2003c). The geologically recent connection of its wetlands with NE Zambia and Katanga is important in understanding the affinities of the extant biodiversity of the Four Corners area.

As mentioned above, several mammals in mesic miombo savanna have similar southern margin limits to their ranges, corresponding roughly to an axis extending southwest from the middle Kafue River north of the Gwembe rift to Kazungula. This boundary corresponds to the former course of the palaeo-Kafue and palaeo-Chambeshi rivers. Examples include Tree hyrax *Dendrohyrax arboreus*, Scaly-tailed flying squirrel *Anomalurus derbianus* and Gambian sun squirrel *Heliosciurus gambianus*. The relationships of some of these species, as shown in the primates, awaits clarification (Cotterill 2003a, 2003b, unpublished data).

An interesting, but still only partly researched, example is the molerats, *Cryptomys* spp. A hotspot of speciation is centred on the central Zambian plateau, extending west and southwest to the Upper Zambezi, where at least two species of localized distribution occur within the Four Corners area (Burda *et al*. 1999). The evolutionary history and taxonomy of these populations of molerats in Zambia are the subject of current research (P. Van Daele, pers. comm.). The most plausible mechanism for their vicariance involves geological determinants. It appears that drainage history has interacted with climatic changes through the Plio-Pleistocene to drive extensive speciation in these burrowing mammals. Likely mechanisms included changes in the extent and patchiness of Kalahari sands and alluvium and the varying geographical barriers in the form of large wetlands (Cotterill 2003b).

Tectonic activity which has been the ultimate causation of these geomorphological dynamics has been along the southwest edge of the East African Rift system. Repeated episodes of crustal flexure and vertical movements along NEE-SSW trending faults lines have broken and also reconnected major rivers. Headwater capture (in particular, the Mid-Zambezi capture of the Upper Zambezi) has been an especially significant mechanism. This was in turn an outcome of uplift and faulting of the landscape by tectonic activity, and has occurred comparatively recently in geological time. With respect to the evolution of the biota of the Four Corners area, radical

alterations of the drainage system since the Miocene (i.e. over the past 5 million years) have been profound (Moore & Larkin 2001; Moore, Chapter 2).

6.5 NOTABLE POPULATIONS OF LARGE MAMMALS, INCLUDING HISTORICAL EXTINCTIONS AND RANGE CONTRACTIONS

This section draws attention to particular species of large mammals which occur in large concentrations and/or are of conservation concern. Large populations, especially where they occur in dense concentrations, are of great ecological and economic significance.

6.5.1 Carnivores

The predators of Chobe National Park are comparatively well-studied, and are well-known internationally thanks to popular wildlife documentaries. This is especially true of lions and spotted hyaenas.

Lion, *Panthera leo*

Lions are a keystone predator in the Four Corners area. They are a popular trophy species, with significant quotas allocated each year in Matetsi and other hunting areas within northwest Zimbabwe. The Hwange Lion Project (http://www.wildcru.org/index.htm), carried out under the auspices of the Wildlife Conservation Research Unit, Department of Zoology, University of Oxford, began in 1999 and has continued into 2003. The main researcher, A. Loveridge, has been comparing the population and social dynamics of an exploited lion population with those of the protected population in Hwange NP.

Painted Hunting Dog, *Lycaon pictus*

Childes (1988) and Davies (1993) provide the principal information available about *Lycaon pictus* in NW Zimbabwe. Disease in this species has been investigated in Botswana (Alexander *et al.* 1996). There is no current or recently published information on this species from other countries within the area, but there have been two research and monitoring projects on the species centred in Hwange NP. These have studied packs around Sinamatella and Main Camp, and the latter population has continued to be monitored after Davies' (1993) study. The Four Corners area constitutes one of the most important protected areas in Africa for this highly mobile and threatened predator.

6.5.2 Ungulates

Elephant, *Loxodonta africana*

The distribution of elephant has changed profoundly in south-central Africa since the early 19th century, when it was widespread across the region (see Hoare, Chapter 14). Its modern distribution reflects a long history of persecution by humans. Latterly, competition and conflict between humans and elephants for habitat has increased, especially in the semi-arid areas of Zimbabwe (Smithers 1983). Nevertheless, the Four Corners area supports one of the largest populations in Africa, with high densities in NW Zimbabwe and in Chobe NP.

Black Rhinoceros, *Diceros bicornis*

Once widespread throughout the area, Black rhinos were nearly extinct in NE Botswana by the late 1960s. Their range had been reduced greatly since the early 1800s, and the population was much reduced by 1890. All recent records were concentrated in the northeast part of the country (Smithers 1971), where they moved between Botswana and the eastern Caprivi, and they are believed to have disappeared by 1974 (Skinner & Smithers 1990). The few remaining Black rhinos in Caprivi (east of the Kwando River) were translocated to safer habitat in the early 1990s (Brown & Jones 1994).

Historically, the black rhino was widespread in Zimbabwe, including in the northwest. Selous (1908) recorded it in the Deka valley and also, alongside White rhino, in the Dete vlei. A very few individuals persisted in the northern region of Hwange NP into the late 1950s. These were complemented by translocations of individuals from the Middle Zambezi, beginning in 1962 (Herbert & Austen 1972). The Sinamatella region of Hwange NP was proclaimed an Intensive Protection Areas (IPZ) in the late 1980s, and a significant number of Black rhinos were translocated into this area from the Middle Zambezi valley. Declining support and effectiveness of conservation in these IPZs is part of the recent crisis afflicting conservation of both species of rhino in Zimbabwe (Du Toit 2002).

There are historical records that Black rhino occurred throughout SW Zambia within the present study area (Ansell 1978), and the species was very common in parts of the southern region of Kafue NP until it was poached to extinction in the 1980s. Black rhino presumably also occurred in SE Angola. Previously, Ansell (1969) estimated that a total of 1200 Black rhino occurred in all of Zambia at that time, with approximately 130 individuals in Kafue NP.

White Rhinoceros, *Ceratotherium simum*

Although extinct from the region many years ago, White rhino had previously been widespread, certainly in W Zimbabwe (Selous 1908, Oates 1971, Herbert & Austen 1972) and across Botswana and Namibia. Shortridge compiled a detailed history of its decline in south-central Africa, and suggested it still occurred in southeast Angola, when they were "...'very rare' at Lujana (S.E. Angola) in the Tschbombe bush" (Shortridge 1934: 425). White rhino had already become extinct in Botswana between 1880 and 1890. The latter extirpation occurred within 20 years (Smithers 1971), and was part of the extermination of southern White rhino throughout its range (except Zululand) in the first three decades of the 20th century (Rookmaaker 2002). The species was reintroduced into the northeast of Hwange NP in 1966 and 1967, and the population had increased to 32 individuals by 1972. There was some dispersal out of this protected area; at least six individuals moved great distances west into Botswana and one was sighted near Khwaai River in 1971 (Herbert & Austen 1972). Ironically, the population of White rhino in Hwange NP was extirpated by poachers in 1993 (Rachlow 1998, Rachlow & Berger 1997). The northern region (Sinamatella) of Hwange is one of four IPZs for rhino in Zimbabwe.

White rhino were also reintroduced into Chobe NP, where they have persisted. There is no conclusive evidence that the species ever occurred in Zambia, although Ansell (1959) suggested it may have occurred between the Upper Zambezi and Mashi rivers on the SE Angolan border, including what is today the Sioma-Ngwezi National Park. If so, this species would also have occurred in SE Angola.

Two pairs of rhino were introduced from South Africa in the early 1960s to Kafue and Livingstone National Parks. The first attempt was unsuccessful, but a small population was established in Livingstone (Ansell 1978), although poached to extinction by 1989. A second population was established there in 1994 (K. Dunham, pers. comm). "It was quite unjustified to attempt introduction of an alien species to the Kafue National Park, but it would not be unreasonable to try and establish it eventually in the Sioma-Ngwezi National Park which lies within its putative original range" (Ansell 1978: 50). It should be emphasized that no evidence exists for former occurrence of White rhino east of the Zambezi in Zambia.

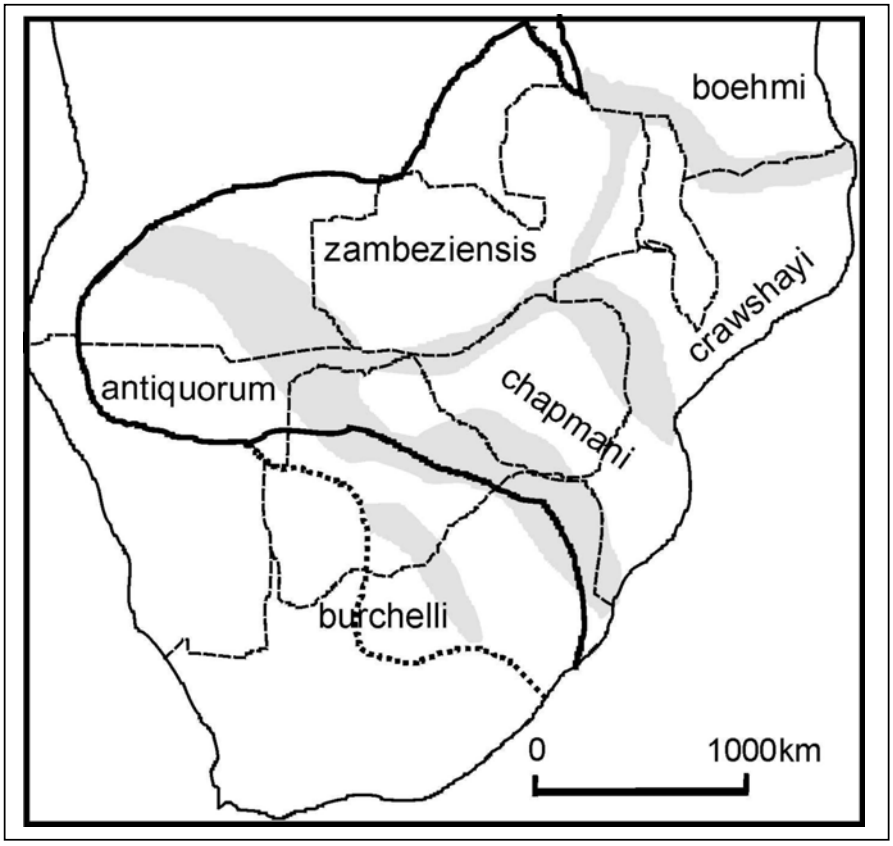
Burchell's Zebra, *Equus burchelli*

Burchell's zebra is widespread in the Four Corners area, and large populations have persisted in NW Zimbabwe and NE Botswana. Local movements occur within the region, apparently in response to patchy rainfall and the variable grass production that ensues (see Cumming, Chapter

13); Zebra are dependent on surface water. Large numbers of zebra and wildebeest moved between NE Botswana (Makgadikgadi) and the Kalahari, but these migrations have been disrupted by cattle fences (Smithers 1971).

This species is specifically distinct from the extinct Quagga, which only occurred south of the Vaal River in South Africa (Grubb 1993). It appears that three subspecies of Burchell's zebra occur in the study area; where their distributions intergrade in NE Botswana (Figure 6.3). These are *E. burchelli antiquorum* from the west and south, integrading with *E. b. chapmani* in central and NW Botswana and *E. b. zambeziensis* along the Zambezi River. The taxonomy of all zebras is still uncertain, and awaits a thorough study of museum material (Grubb 1981, 1993). In its inclusion of at least three genetically different populations of zebra, the Four Corners area illustrates how a large protected area can conserve the genetic diversity of a complex of closely related populations.

Figure 6.3. Distributions of the six subspecies of Burchell's zebra. The thick dotted line approximates the southern limit to modern distribution of zebra in southern Africa, where *Equus b. burchelli* is extinct. Modified from Grubb (1981).



Buffalo *Syncerus caffer*

This is an important species sold in trophy hunts, especially in Zambia and Zimbabwe. A recent study of changes in the regional distribution of Buffalo across NE Botswana and NW Zimbabwe demonstrated seasonal migrations in relation to predation, hunting pressure and resource availability (Hunter 1996, 1999; Hunter & Kerley 1999). There is significant conflict with humans in NE Botswana where buffalo exploit agricultural fields for dry season forage. The Kazuma depression is an important movement corridor in this landscape, and vehicle strikes on these animals are significant along the Kasane-Francistown road. Hunter & Kerley (1999)

suggested that this road should be modified to create an underpass (at least 80 m wide and 5 m high) across the depression, which would reduce costs (including human deaths) and equally maintain ecological functioning of the wetland across the larger landscape. Future threats to this buffalo population include prospective agricultural development north of the Kazuma depression in Botswana. Overall, the costs of such a scheme would be outweighed by the wildlife industry in this region (Hunter & Kerley 1999). Buffalo also have a bearing on other migratory species, including elephant and Tsessebe.

Roan Antelope, *Hippotragus equinus*
A relatively large population of Roan antelope has persisted in NE Botswana and was estimated to number 1360 in 1997 (Ross *et al*. 1998). Kafue NP has been the stronghold for the species in Zambia, "where it is locally quite common and probably numbers in the low thousands" (Jeffery *et* al. 1989). Roan antelope have declined in all areas, notably Namibia (Schlettwein *et al*. 1991) and Zambia, but the population in Botswana is comparatively healthy (Ross *et al*. 1998). The species was formerly abundant around Kazuma Pan National Park in Zimbabwe and a breeding population has been successfully established on Wildlive Game Farm, Kalomo in SW Zambia.

Sable antelope, *Hippotragus niger*
Healthy populations of Sable antelope have persisted in protected areas in Botswana, Zimbabwe and Zambia. Like buffalo, this antelope ranks high in economic importance, both for game ranching and as a trophy species. It has declined to very low numbers in Namibia (Schlettwein *et al.* 1991, Brown & Jones 1994). Sable is an important trophy animal, and both trophy quality and numbers declined in NW Zimbabwe through the 1980s (Fergusson 1990). Predation on calves and juveniles appeared to be one factor, and another was the artificial selective pressure of trophy hunting that targeted bulls with the largest horns (Ginsberg & Milner-Gulland 1994).

Waterbucks, *Kobus ellipsiprymnus, K. crawshayi, K. penricei*
At least three taxonomically distinct populations of waterbucks occur in the Four Corners area. Common waterbuck, *K. ellipsiprymnus*, occurs across NE Botswana into NW Zimbabwe (Smithers 1983), and Shortridge (1934) recorded this species in the East Caprivi. Crawshay's waterbuck, *K. crawshayi*, does not occur south or west of the Zambezi River (Ansell 1978, Cotterill 2000b, 2003b).

Griffin and Grobler (1991) recorded the presence of a few "Defassa waterbuck" *K. e. crawshayi* in the Zambezi area of the Caprivi between 1983-1987 (Cotterill 2000b). As originally stated by Shortridge (1934), and following Ansell (1972, 1978), these are better allocated to *K. penricei*. The species was considered extinct in the Caprivi by 1990, but the reason for its decline is not known (Schlettwein *et al*. 1991). Its occurrence in Namibia was considered to represent vagrants from Angola (Shortridge 1934, Skinner & Smithers 1990).

In many respects, this complex distribution of the three populations of waterbuck is congruent with the three subspecies of zebras, with their introgressive zones traversing the area.

Puku, *Kobus vardoni*
This reduncine antelope was formerly widely distributed across the wetlands of Zambia, including floodplains and dambos in the catchment of the Kafue and Upper Zambezi rivers, but their numbers and range declined radically through the 20th century (Ansell 1978, Rodgers 1984). Puku are now nearly extinct in the Caprivi (Schlettwein *et al*. 1991) and are endangered in Botswana. Stuart (1989) drew attention to their precarious status in southern Africa, with a highly localized distribution on the Chobe floodplain - the Puku Flats. Overall, reduncine populations have declined in the western Caprivi and certain species apparently occur marginally

(East 1989). Over the past 100 years, Puku numbers have declined greatly in the eastern Caprivi (Smithers 1983, East 1989), and their status is marginal and precarious in Namibia (Schlettwein *et al*. 1991). As of the 1980s, a relic population of approximately 50 animals persisted on the Chobe floodplain in Botswana (Smithers 1983, East 1989). F.C. Selous first visited the Puku Flats in 1874, and found them very numerous, but they were greatly disturbed by dense settlement in 1876 by refugees fleeing political turmoil in Barotseland, from which they have never recovered (Dollman 1921). Puku also declined to extinction on Impalila Island in the Caprivi after its settlement in 1958 (Child 1968). Today, this relict population persists in numbers of less than 100 (Ross *et al.* 1998). The status of Puku in Kafue NP appears to be stable (Jeffery *et al.* 1989) although there was loss of habitat for puku and other aquatic antelopes with the creation of Lake Itezhi-tezhi on the Kafue River when this impoundment was completed in 1975 (Mwima 2001).

Red Lechwe, *Kobus leche* and Kafue Lechwe, *K. kafuensis*

The Red lechwe, *K. leche*, was extremely numerous in the Four Corners region, especially in the Okavango and Linyanti (Shortridge 1934, Smithers 1971). As of the late 1980s, a population of over 4300 occurred in East Caprivi and 150-200 in West Caprivi (Linyanti Swamps and along the Mashi and Upper Zambezi rivers). It has been estimated that several thousand red lechwe occur in the Linyanti area of Botswana, and these migrate seasonally onto the Chobe floodplain (Williamson 1981, East 1989).

The largest south-central African species, Kafue lechwe *K. kafuensis*, is endemic to the Kafue Flats in central Zambia. It occurred throughout the Namwala Flats, from below the Itezhi-tezhi gorge on the Upper Kafue to the Kafue Gorge on the mid-Kafue. Hydroelectric dams have since been built in both gorges, with Itezhi-tezhi completed in 1975. Besides populations on private game ranches, two Vulnerable populations of *K. kafuensis* are now restricted to the Blue Lagoon and Lochinvar National Parks, divided by the Kafue Dam. As recorded by Pitman (1934), Kafue lechwe occurred in the Four Corners area early in the 20th century, and small herds persisted near Ngoma until at least December 1967 (Hanks 1969b). At that time, the species "only rarely ranges across the national park boundary on the Nkala river, east of Ngoma" (Hanks 1969b). Together with Black rhino, Kafue lechwe are one of the two species of mammals to have been driven to extinction within the Kafue NP. These local extinctions of Kafue lechwe and Black rhino in Zambia have occurred within the past three decades.

Sitatunga, *Tragelaphus spekei*

The Okavango and Linyanti Swamps support healthy populations of Sitatunga (Ross et al 1998), with approximately 4000 in the Okavango alone. The species has been studied by Games (1983, 1984) and Williamson (1986). It appears to cope with high hunting pressure in much of its range, but is threatened by drying out of its aquatic habitat caused by changes in hydrology (Ross 1992, Ross *et al*. 1998). The population along the Upper Kafue on the eastern edge of the Kafue NP was disrupted by the closure of the Itezhi-tezhi dam in the late 1970s, but a healthy population occurs in the Busanga Swamps northwest of the Kafue NP and adjacent Game Management Areas.

Tsessebe *Damaliscus lunatus*

Tsessebe antelope are endangered over much of their range, which has declined radically since the beginning of the 20th century (Cotterill 2003c, 2003d). Northeast Botswana remains a stronghold, where at least three major populations occur - in the Okavango, Savuti Marsh (Chobe NP) and in eastern Chobe along the Zimbabwe border. These populations numbered over 9000 in 1997, although numbers have declined locally in the Linyanti area (Ross *et al*. 1998). Originally widespread in the Caprivi, Tsessebe are now scarce in Namibia (Schlettwein *et al.*

1991, Brown & Jones 1994). They have declined greatly in W Zambia, and it is unclear whether any still occur in the southwest in Sioma-Ngwezi NP and adjacent parts of Angola. The population in NW Zimbabwe is migratory, moving in and out of Botswana and occurring seasonally in Kazuma and Matetsi. A population of 100 animals on the Shumba plains in Hwange NP had declined to less than 20 in 1997 (Anderson & Wilson 1998). The species is considered endangered in Zimbabwe, where formerly healthy populations have declined radically since 1999 following their widespread extirpation on commercial farms (Cotterill 2003d).

Selous (1881, 1908) observed that Tsessebe in the Caprivi calved in late September whilst the herds on the Mababe Flats (today in Chobe NP) calved in November. The same difference in the life histories of these populations was described by Child *et al*. (1972) in the late 1960s. This subtle difference may reflect a former geographical barrier between these populations, the most likely being palaeo-Lake Makgadikgadi in the late Pleistocene. However, the Linyanti and Chobe wetlands could well maintain this isolation today (Cotterill 2003d).

Oribi, *Ourebia ourebi*

The range and populations of this small antelope have declined greatly across southern Africa. It is very poorly represented in museum collections. Within the Four Corners area, Oribi occur in Kafue NP and apparently still exist in SE Angola. An important population persists on game ranches in the Choma District of Zambia (I. Bruce-Miller, pers. comm.). Their distribution is always localized as they are dependent on open grasslands. The greater extent of this habitat is in Zimbabwe but extends marginally into Botswana (East 1989; Ross *et al*. 1998).

Kazuma Pan supports an important population of Oribi (Anderson & Wilson 1998) that has always been small (estimated at under 100 individuals in the early 1970s, Wilson 1975). This population centred on the Kazuma depression should be considered Vulnerable. It would appear to represent *O. o. rutila* Blaine 1922, and is thus distinct from the species elsewhere in Zimbabwe, which was referred by Ansell (1972) to *O. o. hastata* (Peters 1852). The taxonomy of Oribi requires thorough review with respect to the many scattered populations; their phylogeography is currently being studied (J. Jansen Van Vuuren, pers. comm.).

6.6 WATER AVAILABILITY AND MOVEMENTS

The semi-arid climate of the Four Corners area makes for stochastic ecological conditions. In particular, surface water is a very patchy and ephemeral resource, its availability being determined by rivers and distributaries and episodes of rainfall which fill pans and pools. The drainage system in the Matetsi Safari Area and some northern areas of Hwange on basalt is more perennial. Surface water persists in the pools of the larger rivers (Bumbusie, Deka and Matetsi), which dry out only during severe droughts. There are also persistent springs and seeps in these landscapes. The long dambos (notably the Dete Vlei) in the catchments of the Gwayi River on Kalahari sand are particularly important features of the landscape along the eastern boundary of Hwange NP. Their heavy use by large mammals was first recorded by Selous (1881, 1908). Much of SW Zambia, much of NE Botswana and SE Angola lies on Kalahari sand; surface water is an especially and patchy resource. As has been shown in Hwange NP, the artificial supply of surface water creates a complicated situation of costs and benefits.

It appears that the movement of large mammals was formerly an important phenomenon between NE Botswana and the Central Kalahari (Child 1972, Smithers 1971, Cumming in Chapter 13). This occurred in response to the availability of key resources, especially fresh grass and water, the availability of which is determined primarily by variation in rainfall. The occurrence of

certain species across vast regions of the area can be described as transient as these large mammals move in relation to surface water availability. Although many mammals possess adaptations to prolonged water stress, the crux is in drier years when larger mammals move to available water or die (Lovegrove 1993). Management of surface water supplies is a critical issue in biodiversity conservation (Child 1972). It governs the distribution of elephants on a seasonal and daily cycle, especially as small calves struggle to commute long distances between feeding areas and drinking sites. As confirmed by Haynes (1993), the geography of water points becomes the major determinant of elephant density and habitat use when water is seasonally limiting. The resultant impacts on vegetation and terrestrial biodiversity are marked (Cumming *et al*. 1997).

6.7 CONSERVATION STATUS AND CONCERNS

6.7.1 Threatened Species and Habitats

Ten (or 5%) of the mammals occurring in the Four Corners area are classified as of global conservation concern (Appendix 6.1). Reasons for the vulnerability and declines of these species are complex. Three can be singled out: (i) diseases, (ii) direct depredations by humans, and (iii) loss of habitat. The impacts of unsustainable human offtakes of larger species coupled with landscape changes are illustrated in the Caprivi where many wetland species are threatened or are already locally extinct (Griffin & Grobler 1991).

The categories of conservation status are the officially recognized designations, which are misleading when one comes to consider many species occurring in the area. Species such as Oribi are vulnerable in all five countries, and except for parts of the Kafue NP, occur in only small and isolated populations. It and many other species are either Rare and/or Vulnerable. Furthermore, some species have declined significantly in some parts of their range (e.g. Tsessebe in Caprivi and Zimbabwe) although they may exist in healthy populations elsewhere within the area (Botswana in the case of Tsessebe). Many species of small mammal appear at risk of habitat changes driven by damage from elephants and humans, shown in N Zimbabwe for tree-roosting bats (Cumming *et al.* 1997).

The existing network of protected areas covers a wide range of the assemblages listed above; including wetlands, savannas and rupicolous habitats. It is not possible in this review to carry out a thorough gap analysis of how adequately protected mammal faunas are in terms of distributions of species with respect to habitats. A significant gap in its own right is the patchy knowledge of biodiversity. Patches of evergreen thickets and dryland forest are especially under-represented in the existing network of protected areas. Hence the Tree hyrax *Dendrohyrax arboreus* cannot be expected to persist over the long term within the area.

6.7.2 Diseases

The most infamous pandemic that decimated many bovids was the rinderpest which was widespread across Africa and greatly reduced many species in the region in 1896 (Gibbons 1898, 1904, Spinage 1962). Carnivore populations are susceptible to particular diseases, notably viral infections (Osofsky *et al*. 1996). Epidemics have greatly reduced populations of Lion and Painted hunting dogs (Woodroffe, Ginsberg & Macdonald 1997; Creel & Creel 2002) in East Africa. Feral and domestic dogs are a significant factor in the epidemology of rabies in parts of Africa, and the increased contact between wild carnivores and dogs has extirpated populations of the former (Alexander *et al*. 1993, 1996).

Certain murid rodents are carriers of the plague bacillus, *Yersinia pestis*, among many pathogens harmful to humans. The principal vectors are the House rat *Rattus rattus*, Multimammate mouse

Mastomys natalensis and, to a lesser extent, Bushveld gerbil *Tatera leucogaster*. The Multimammate mouse is a commensal species (De Graaf 1981, Smithers 1983). A major outbreak of bubonic plague occurred in Ngamiland in 1944, apparently associated with high flood levels in the Okavango delta (Davis 1946), and the disease is now endemic in the region with sporadic outbreaks (Smithers 1983). In addition to the more apparent diseases such as bilhzaria and malaria, bubonic plague needs to be considered in the development of urban centres and tourist resorts.

6.7.3 Introductions of Threatened And Extinct Species

Translocations of the two species of rhinoceros were described earlier. If protected areas in the Caprivi and elsewhere in the Four Corners area can be secured, than large mammals can be introduced. Candidates include Penric's waterbuck into the Caprivi, and Black and White rhinos into Sioma-Ngwezi NP in Zambia.

Any future translocations of organisms have to consider carefully the taxonomic and genetic affinities of the populations being introduced. This especially applies to ungulates. Introductions of mammals of populations from elsewhere in Africa (seen in the translocation of West African Roan antelope into South Africa, Matthee & Robinson 1999) is tantamount to introducing an alien species into an ecosystem. It is undesirable that short-term commercial concerns should override scientific and ecological realities (Castley, Boshoff & Kerley 2001). This concern is magnified in the Four Corners area for two reasons. One is the peripatric distributions of closely related species and populations, as shown by Burchell's zebra and waterbucks, a situation that dictates the need for thorough appraisals of which organisms are translocated where. Secondly, subtle differences between apparently very similar populations have evolved (for example, the differences in life histories of the Tsessebe in NE Botswana compared to those in the Caprivi), further emphasising the need to recognize that such populations have evolved adaptations to their particular environments.

6.8 MONITORING AND FUTURE STUDIES

Monitoring of mammal populations and assemblages is a complex subject. Many of these issues and techniques are detailed and discussed thoroughly by Wilson *et al*. (1996) and Jachmann (2001). Large mammal populations have been monitored within the principal protected areas of the Four Corners area for several decades. Considered overall, these efforts have been fragmentary and employed many different techniques and methods within the main themes of aerial, vehicle and walked transects. Surveys have also used either total counts of a selected population or indices of abundance. Censuses of elephants in Botswana and Zimbabwe are considered relatively reliable, and this is the most feasible (and often the only) species which can be counted from aircraft, especially in wooded savanna (Jachmann 2001).

6.8.1 Monitoring Large Mammals of High Conservation Concern

Overall estimates of small populations are invariably not sufficient as individuals need to be distinguished. Within the study area, costs and human resources decree that the most feasible approach is for game scouts to monitor animal activity (including usage of home ranges and key resources). Monitoring of large carnivores has relied on an observer's intimate knowledge of individuals, using photographs of pelage patterns (e.g. Painted hunting dog, G. Rasmussen, pers. comm.). A similar approach was utilized for Leopard in East Africa (Miththapala *et al*. 1989).

Specialized techniques are available to monitor mammals of high conservation concern such as rhinos using genetic signatures of individuals (microsatellite markers). This is feasible only for relatively small, highly dispersed populations (Cunningham *et al*. 2001). Techniques based on

automated analyses of footprints of black rhinos (as in Sinametella IPZ in Hwange by Jewell, Alibhai & Law 2001) are of dubious application, unless applied by experts in bushcraft (game scouts), who in any case routinely distinguish between individuals by eye at a glance.

6.8.2 Ecological Studies

The mammal fauna might appear well known, but all we know about the majority of species is that they occur in the area, and nothing more. This deficiency is especially true of nearly all the small mammals. One feasible approach to remedy this gap is to carry out intensive mark-recapture studies of small mammal assemblages in representative habitats. Such studies should be for at least two years, and employ standardized, comparable methods. The localities studied by Sheppe and Haas (1981) in Chobe should be revisited.

The primary objective of all these studies should be to establish the composition (species diversity) of the mammal assemblages, while species of economic, ecological and conservation concern can be singled out for more focused study. An important lesson from past research is to frame these studies within the context of the overall landscape, in which biodiversity is comphrehensively characterised (Cotterill 1995).

6.8.3 Biodiversity Surveys, Monitoring and Taxonomic Research

Southeast Angola is the obvious priority for a thorough survey of its biodiversity, which should include all vertebrates and not just mammals. Nevertheless, major gaps remain in all countries, as seen in the Caprivi where the presence of many listed species (Brown & Jones 1994) is based on extrapolation from neighbouring surveyed habitats and suspected knowledge of the habitat associations of a particular species. Only properly organized biodiversity surveys, which collate comprehensive biological collections, will remedy these deficiencies.

A more detailed research plan for the Four Corners area should consider the inauguration of a long-term and on-going biodiversity survey. Such a programme needs to choose target taxa (small mammals are an obvious candidate) under the direction of professional biologists with survey experience. A model is the Botswana Mammal Survey, in which conservation agencies and numerous individuals made substantial contributions. The aim should be to build comprehensive biological collections whose specimens are accompanied by detailed ecological data. Conservation authorities need to be shown the importance of such a long term, multi-disciplinary survey. One possible approach is to insist that safari operators with leases on state land participate in biodiversity surveys. If this became a mandatory requirement, it would do much to improve the knowledge of hunters and guides if they collected specimens of organisms besides charismatic large mammals.

A major obstacle to perform biodiversity surveys efficiently is the so-called Taxonomic Impediment (Hoagland 1996, Mims 2003). This is a global problem and afflicts virtually all museums and herbaria. There are too few taxonomic experts to identify specimens, and these posts are not being supported. The integrity of many of the world's natural history collections are in severe jeopardy. In this respect, one also has to acknowledge that the responsible agencies in the region, especially herbaria, National Museums of Botwana and Namibia, the Livingstone Museum and the Natural History Museum of Zimbabwe, will require major improvements in professional capacity to preserve and classify the large collections that will result from a full biodiversity survey. The key deficiency is insufficient taxonomic expertise, therefore funding for such a survey will have to include the cost of capacity building. All nations participating in the Four Corners TFCA initiative have signed and ratified the Convention on Biological Diversity which requires its members to survey their biodiversity scientifically.

The collation of comprehensive biological collections requires digital catalogues of their specimens and attributes as a prerequisite to their management, and especially to support research based on their attributes. These then provide valuable knowledge to multifarious queries on environmental concerns. A suite of manuals and electronic databases are particularly suited to improve the efficiency with which the primary data produced by biodiversity surveys can be synthesized (see Cotterill 1995). There are, however, no short shortcuts around the extinction of taxonomic resources (Cotterill 2002, Mims 2003).

6.9 MAMMAL CONSERVATION VALUES OF THE FOUR CORNERS TFCA

The occurrence of around 200 species of mammals in the Four Corners area shows the influence of habitat hetereogeneity, which in turn is a function of the complex evolutionary history of the landscapes of south-central Africa. The underlying reason for this diversity is the extremely large size of the landscape enclosed within this international conservation area. With respect to conservation of mammals, the Four Corners TFCA provides several benefits, which also confer significant costs for management.

Being a large area, the TFCA conserves genetic heterozygosity, as seen with many vertebrates where complexes of recently diverged populations or closely related species occur within the region. The inclusion of hybrid zones (as for zebras in NE Botswana, and also for Kinda and Grey-footed baboons in Zambia) is of equal value. These regions of active evolutionary change could provide potential buffers against habitat changes and other disturbances, especially diseases. Climatic change is an especially important consideration. One can argue that conservation of a species at the edge of its range (where they may be declining or are Vulnerable), is not worth the expense. Examples within the area include the two forest duikers. These highly threatened species may not persist without a large investment in anti-poaching, and perhaps will require maintenance and even restoration of their habitat. Can such an investment be justified? There are at least three sound reasons why it is important to conserve these less conspicuous and/or marginal habitats and species:

(a)**Peripatric Diversity and Intraspecific Variation**. Considered across its entire range, a species at the edge of its range may possess adaptations and genetic diversity which are not present in source populations or in the central population of the species. Based on the theory of population genetics (Meffe *et al*. 1997), genetic novelties may also accumulate more rapidly and become fixed in such smaller, peripheral populations where organisms are likely to encounter novel environmental challenges.

(b)**Habitat Hetereogeneity**. Habitats which constitute islands in the Four Corners TFCA are indeed geographically insignificant, marginal or very isolated, but they raise the beta and gamma diversity across the landscape. In addition to small hills and similar rupicolous habitats, one pertinent example is the evergreen thickets and forests in SW Zambia, including riparian fringes along the Kafue and Lufupa rivers in the Kafue NP. Another example is the islands of rocky habitat scattered across SW Zambia and in the Caprivi (e.g. Mushangara area).

(c)**Future Climatic and Habitat Change**. The edge effects associated with peripheral populations, in which local adaptations may have evolved in demes, may predispose such species and patchy habitats to accommodate climate change.

All these issues, both in this section and the previous discussion of monitoring and research, need to be evaluated and accommodated in a comprehensive research and management plan for the Four Corners TFCA. Any such plan will obviously have to prioritize investments in research

and management with respect to conservation problems, threats to biodiversity and ecological integrity and, especially, gaps in knowledge.

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Appendix 6.1. Mammals occurring in the Four Corners area, by country.
Data from Ansell (1978), East (1989), Hill & Carter (1942), Smithers (1971), Smithers & Wilson (1979). Taxonomy follows Wilson & Reeder (1993), with alterations from Groves (2001) and Kearney *et al*. (2002) for primates and vesper bats, respectively. Records for Namibia are conservative, being restricted to material evidence only; Brown & Jones (1994) list many species which are expected to occur, indicated by '?'. Conservation status and categories follow IUCN Red Data list 2003 (http://www.redlist.org), categories CR = Critical, EN = Endangered, VU = Vulnerable, DD = Data Deficient, LR/cd = Low Risk, conservation dependant, LR/nt = Low Risk, not threatened. These have been amended for the Four Corners area, where **R** = Rare, **V** = Vulnerable, **Ex** = Extinct, and apply to populations which occur marginally in the region or are confined to patchy habitat.

Taxon	**Conserv. status**	**Ang**	**Bot**	**Nam**	**Zam**	**Zim**
Order **INSECTIVORA** (shrews and hedgehogs)						
Family Soricidae						
Suncus lixus (Thomas 1898) Greater dwarf shrew	LR/nt **R**		+	?	+	
Crocidura cyanea (Duvernoy 1838) Reddish-grey musk shrew	DD		+	+	+	+
Crocidura flavescens (Geoffory 1827) Greater musk shrew	VU B1+2c				+	
Crocidura fuscomurina (Heughlin 1865) Tiny musk shrew	LR/nt		+	+	+	+
Crocidura silacea Thomas 1895 Lesser grey-brown musk shrew	DD				+	+
Crocidura hirta Peters 1852 Lesser red musk shrew	LR/nt	+	+	+	+	+
Crocidura mariquensis (A.Smith 1844) Swamp musk shrew	DD		+	+	+	+
Crocidura occidentalis (Pucheran 1855) Giant musk shrew	LR/nt		+	+	+	+
Crocidura turba Dollman 1910 Dollman's musk shrew	DD				+	
Family Erinaceidae						
Atelerix frontalis (A.Smith 1831) Southern African hedgehog	LR/nt **V**		+			+
Order CHIROPTERA (bats)						
Family Pteropididae						
Epomophorus crypturus Peters 1852 Peters' epaulatted fruit bat	LR/nt	+	+	+	+	+
Epomophorus gambianus Gray 1870 Gambian epaulatted fruit bat	LR/nt	+	+	+	+	+
Epomophorus wahlbergi (Sundevall 1846) Wahlberg's epaulatted fruit bat	LR/nt	+	+	?	+	+
Epomops dobsoni (Bocage 1889) Dobson's fruit bat	LR/nt **R**		+	?	+	+
Eidolon helvum (Kerr 1792) Straw-coloured fruit bat	LR/nt	+	+	+	+	+
Rousettus aegyptiacus (E.Geoffroy 1810) Egyptian fruit bat	LR/nt				+	+
Family Emballonuridae (tomb bats)						
Taphozous mauritianus E.Geoffroy 1818 Mauritian tomb bat	LR/nt		+	+	+	+
Taphozous perforatus E.Geoffroy 1818 Egyptian tomb bat	DD		+	+		
Family Molossidae (free-tailed bats)						
Tadarida aegyptiaca (E.Geoffroy 1818) Egyptian free-tailed bat	LR/nt		+	+	+	+
Tadarida fulminans (Thomas 1903) Madagascar large free-tailed bat	LR/nt				+	+
Tadarida ventralis (Heughlin 1861) Giant African free-tailed bat	DD					+
Mops midas (Sundevall 1843) Midas free-tailed bat	LR/nt		+	?	+	
Mops condylura (A.Smith 1833) Angola free-tailed bat	LR/nt		+	+	+	+

Taxon	Conserv. status	Ang	Bot	Nam	Zam	Zim
Mops niveiventer Cabrera & Ruxton 1926 White-bellied free-tailed bat	LR/nt				+	
Chaerephon ansorgei (Thomas 1913) Ansorge's free-tailed bat	LR/nt			?	+	+
Chaerephon bivittata (Heughlin 1861) Spotted free-tailed bat	LR/nt				+	+
Chaerephon chapini (J.A.Allen 1913) Long-crested free-tailed bat	DD		+	+		
Chaerephon pumila (Cretzschmar 1830) Little free-tailed bat	LR/nt		+	+	+	+
Chaerephon nigeriae Thomas 1913 Nigerian free-tailed bat	LR/nt		+	+	+	+
Family Hipposideridae (leaf-nosed bats)	LR/nt					
Cloeotis percivali Thomas 1901 Trident leaf-nosed bat	DD					+
Hipposideros caffer (Sundevall 1846) Sundevall's leaf-nosed bat	LR/nt	+	+	+	+	+
Hipposideros commersoni (E.Geoffroy 1813) Commerson's leaf-nosed bat	LR/nt **V**	+	+	+	+	+
Family Rhinolophidae (horseshoe bats)						
Rhinolophus clivosus Cretzschmar 1828 Geoffroy's horseshoe bat	LR/nt			?		+
Rhinolophus darlingi Andersen 1905 Darling's horseshoe bat	LR/nt		+	+	+	+
Rhinolophus fumigatus Rüppell 1842 Rüppell's horseshoe bat	LR/nt		+	+	+	+
Rhinolophus hildebrandti Peters 1878 Hildebrandt's horseshoe bat	LR/nt			?	+	+
Rhinolophus landeri Martin 1838 Lander's horseshoe bat	LR/nt				+	+
Rhinolophus denti Thomas 1904 Dent's horseshoe bat	LR/nt		+			
Rhinolophus simulator Andersen 1905 Bushveld horseshoe bat	LR/nt		?		+	
Rhinolophus swinnyi Gough 1908 Swinny's horseshoe bat	LR/nt **R**					+
Family Nycteridae (slit-faced bats)						
Nycteris hispida (Schreber 1774) Hairy slit-faced bat	DD		+	?	+	+
Nycteris macrotis Dobson 1876 Large-eared slit-faced bat	LR/nt **R**			?	+	+
Nycteris thebaica E.Geoffroy 1813 Egyptian slit-faced bat	LR/nt	+	+	+	+	+
Nycteris woodi K.Andersen 1914 Wood's slit-faced bat	LR/nt **R**					+
Family Vespertilonidae (vesper bats)						
Miniopterus schreibersi (Kuhl 1819) Schreiber's clinging bat	LR/nt		+	?	+	+
Laephotis botswanae Setzer 1971 Botswana long-eared bat	LR/nt **R**		+	+	+	+
Neoromicia rendalli (Thomas 1889) Rendall's serotine bat (ex. Eptesicus)	DD		+	?	+	
Neoromicia capensis (A.Smith 1929) Cape pipistrelle (ex Eptesicus)	LR/nt	+	+	+	+	+
Neoromicia melckorum (Roberts 1919) Melck's pipistrelle (ex Eptesicus)	DD		+	?		+
Neoromicia somalicus (Thomas 1901) Somali pipistrelle (ex Eptesicus)	LR/nt		+	+	+	+
Hysugo anchietai (Seabra 1900) Anchieta's pipistrelle (ex Pipistrellus)	VU A2c	+	+	?	+	+
Pipistrellus rusticus (Tomes 1861) Rusty bat	LR/nt	+	+	+	+	+
Pipistrellus kuhlii (Kuhl 1819) Kuhl's pipistrelle	LR/nt		+	?	+	+
Pipistrellus rueppelli (Fischer 1829) Rueppell's bat	LR/nt		+	+	+	+

Taxon	Conserv. status	Ang	Bot	Nam	Zam	Zim
Neoromicia nanus (Peters 1852) Banana bat	LR/nt		+	?	+	+
Pipistrellus sp.	DD				+	+
Glauconycteris variegata (Tomes 1861) Butterfly bat	LR/nt		+	+	+	+
Scotophilus viridis (Peters 1852) Lesser house bat	LR/nt	+	+	+	+	+
Scotophilus dinganii (A.Smith 1833) Yellow house bat	LR/nt	+	+	+	+	+
Scotophilus sp. House bat	DD				+	+
Nycteicinops schlieffeni (Thomas & Wroughton 1908) Schlieffen's bat	LR/nt	+	+	+	+	+
Kerivoula argentata Tomes 1861 Damara woolly bat	DD		+	?	+	+
Kerivoula lanosa (A.Smith 1847) Lesser woolly bat	DD		+	?		
Order PRIMATA (primates)						
Family Lemuridae						
Galagoides moholi A.Smith 1836 Lesser nightape	LR/nt	+	+	+	+	+
Otolemur crassicaudatus (E.Geoffroy 1812) Thick-tailed bushbaby	LR/nt				+	
Family Cercopithecidae						
Cercopethicus aethiops (Linnaeus 1758) Vervet monkey	LR/nt	+	+	+	+	+
Papio griseipes Pocock 1911 Gray-foot (chacma) baboon	LR/nt	+	+	+	+	+
Papio kindae Lönnberg 1919 Kinda (Katanga) baboon	LR/nt				+	
Order CARNIVORA						
Family Viverridae						
Civettictis civetta (Schreber 1776) African civet	LR/nt	+	+	+	+	+
Genetta angolensis Bocage 1882 Angolan genet	DD	+			+	+
Genetta genetta Linnaeus 1758 Small-spotted genet	DD	+	+	+	+	+
Genetta maculata (Gray 1830) Large-spotted genet (ex. G. tigrina)	DD		+	+	+	+
Family Mustelidae						
Aonyx capensis (Schinz 1821) Clawless Otter	LR/nt		+	+	+	+
Lutra maculicollis Lichtenstein 1835 Spotted-necked otter	VU A1c		+	+	+	M
Mellivora capensis (Schreber 1776) Honey badger	LR/nt	+	+	+	+	+
Poecilogale albinucha (Gray 1864) African striped weasel	LR/nt **R**		*	+	+	M
Ictonyx striatus Perry 1810 African striped polecat	LR/nt	+	+	+	+	+
Family Herpestidae						
Suricata suricatta (Schreber 1776) Suricate	LR/nt		+			
Paracynictis selousi (De Winton 1896) Selous' mongoose	LR/nt		+	+	+	+
Cynictis penicillata (G.Cuvier 1829) Yellow mongoose	LR/nt		+	?		+
Herpestes ichneumon (Linnaeus 1758) Large grey mongoose	LR/nt	+	+	+	+	+
Galerella sanguineus (Rüppell 1836) Slender mongoose	LR/nt	+	+	+	+	+
Rhynchogale melleri (Gray 1865) Meller's mongoose	LR/nt		+		+	
Ichneumia albicauda (G.Cuvier 1829) White-tailed mongoose	LR/nt	+	+	+	+	+
Atilax paludinosus (G.Cuvier 1829) Water mongoose	LR/nt	+	+	+	+	+
Mungos mungo (Gmelin 1788) Banded mongoose	LR/nt	+	+	+	+	+

Taxon	Conserv. status	Ang	Bot	Nam	Zam	Zim
Helogale parvula (Sundevall 1846) Dwarf mongoose	LR/nt	+	+	+	+	+
Family Canidae						
Otocyon megalotis (Desmarest 1822) Bat-eared fox	LR/nt		+	+		+
Canis adustus (Sundevall 1846) Side-striped jackal	LR/nt		+	+	+	+
Canis mesomelas (Schreber 1778) Black-backed jackal	LR/nt		+	+		+
Lycaon pictus (Temminck 1820) Painted hunted dog	EN C1	+	+	+	+	+
Vulpes chama (A.Smith 1833) Cape fox	LR/nt		+			
Family Felidae						
Caracal caracal (Schreber 1776) Caracal	LR/nt	+	+	+	+	+
Felis lybica Forster 1780 African wild cat	LR/nt	+	+	+	+	+
Felis nigripes Burchell 1824 Black footed cat	VU C2a(i)		+			
Leptailurus serval (Schreber 1776) Serval cat	LR/nt	+	+	+	+	+
Panthera leo (Linnaeus 1758) Lion	VU C2a(i)	+	+	+	+	+
Panthera pardus (Linnaeus 1758) Leopard	LR/nt **V**	+	+	+	+	+
Acinonyx jubatus (Schreber 1775) Cheetah	VU C2a(i)	+	+	+	+	+
Family Hyaenidae						
Crocuta crocuta (Erxleben 1777) Spotted hyaena	LR/nt	+	+	+	+	+
Hyaena brunnea Thunberg 1820 Brown hyaena	LR/nt	+	+	+		+
Proteles cristatus (Sparrmann 1783) Aardwolf	LR/nt	+	+	+	+	+
Order TUBULUDENTATA						
Orycteropus afer (Pallas 1776) Antbear, Aardvark	LR/nt	+	+	+	+	+
Order PROBOSCIDEA						
Loxodonta africana (Blumenbach 1797) Savanna elephant	EN A1b	+	+	+	+	+
Order HYRACOIDEA						
Dendrohyrax arboreus (A.Smith 1827) Tree hyrax	LR/nt **V**				+	
Heterohyrax ruddi (Wroughton 1910) Yellow-spotted hyrax	LR/nt					+
Procavia capensis (Pallas 1766) Rock hyrax	LR/nt					+
Order PERISSODACTYLA						
Diceros bicornis (Linnaeus 1758) Black rhinoceros	CR A2abc	**E**	**E***	**E**	**E**	**R**
Ceratotherium simum (Burchell 1817) White rhinoceros	NT	**E**	**E**	**E**	**R**	**R**
Equus burchelli (Gray 1824) Burchell's zebra	DD	+	+	+	+	+
Family Suidae						
Potamochoerus porcus (Linnaeus 1758) Bushpig	LR/nt	+	+	+	+	+
Phacochoerus aethiopicus (Pallas 1776) Warthog	LR/nt	+	+	+	+	+
Hippopotamus amphibius Linnaeus 1758 Hippopotamus	LR/cd **V**	+	+	+	+	+
Order ARTIODACTYLA						
Family Giraffidae						
Giraffa camelopardalis angolensis Lydekker 1903 Angolan giraffe	LR/cd	+	+	+	+	+
Family Bovidae						
Tribe Tragelaphini						

Taxon	Conserv. status	Ang	Bot	Nam	Zam	Zim
Syncerus caffer (Sparrman 1779) Buffalo	LR/nt	+	+	+	+	+
Tragelaphus strepsicerus (Pallas 1776) Greater kudu	LR/nt	+	+	+	+	+
Tragelaphus scriptus (Pallas 1776) Chobe bushbuck	LR/nt	+	+	+	+	+
Tragelaphus spekei Speke 1863 Sitatunga	LR/nt **V**	+	+	+	+	+
Taurotragus oryx (Pallas 1776) Eland	LR/nt	+	+	+	+	+
Tribe Cephalophini						
Cephalophus silvicultor (Afzelius 1815) Yellow-backed duiker	LR/cd **R**				+	
Philantomba monticola (Thunberg 1789) Blue duiker	LR/cd **R**				+	
Sylvicapra grimmia (Linnaeus 1758) Grey duiker	LR/nt	+	+	+	+	+
Tribe Reduncini						
Redunca arundinum (Boddaert 1785) Common reedbuck	LR/cd	+	+	+	+	+
Kobus crawshayi P.L.Sclater 1894 Crawshay's waterbuck	LR/cd				+	
Kobus ellipsiprymnus (Ogilby 1833) Common waterbuck	LR/cd	+	+	+	+	+
Kobus penricei Rothschild 1895 Penric's waterbuck	LR/cd **V**	+	+	+	?	
Kobus leche Gray 1850 Red lechwe	LR/cd **V**	+	+	+	+	
Kobus kafuensis Haltenorth 1964 Kafue lechwe	VU D2 **Ex**				+	
Kobus vardoni (Livingstone 1857) Puku	LR/cd **V**	**E**?	+	+	+	**E**
Tribe Hippotragini						
Hippotragus equinus (Desmarest 1804) Roan antelope	LR/nt **V**	+	+	+	+	+
Hippotragus niger (Harris 1838) Sable antelope	LR/nt	+	+	+	+	+
Oryx gazella (Linnaeus 1758) Gemsbok	LR/cd		+			+
Tribe Alcelaphini						
Connachaetes taurinus (Burchell 1823) Blue wildebeest	LR/cd	+	+	+	+	+
Damaliscus lunatus (Burchell 1823) Tsessebe	LR/nt **V**	+	+	+	+	+
Alcelaphus cama (Pallas 1776) Red hartebeest	LR/cd	+	+	+		+
Sigmoceros lichtensteini (Peters 1849) Lichtenstein's hartebeest	LR/cd	+			+	
Tribe Antilopini						
Antidorcas marsupialis (Zimmerman 1780) Springbok	LR/nt		+			
Tribe Aepyceroni						
Aepyceros melampus (Lichtenstein 1812) Impala	LR/nt	+	+	+	+	+
Tribe Neotragini						
Oreotragus oreotragus (Zimmerman 1783) Klipspringer	LR/cd **V**		+		+	+
Ourebia ourebi (Zimmerman 1783) Oribi	**V**	+	+	+	+	+
Raphicerus campestris (Thunberg 1811) Stenbuck	LR/nt	+	+	+	+	+
Raphicerus sharpei Thomas 1897 Sharpe's grysbuck	**V**		+		+	+
Order RODENTIA						
Thryonomys swinderianus (Temminck 1827) Greater canerat	LR/nt	+	+	+	+	+
Thryonomys gregorianus (Thomas 1894) Lesser canerat	DD				+	
Family Bathyergidae						
Cryptomys damarensis (Ogilby 1838) Damara molerat	LR/nt	+	+	+	+	+

Taxon	Conserv. status	Ang	Bot	Nam	Zam	Zim
Cryptomys kafuensis Burda et al. 1999 Kafue molerat	DD				+	
Cryptomys sp. molerat (Livingstone environs)	DD				+	
Family Hystricidae						
Hystrix africaeaustralis Peters 1852 Porcupine	LR/nt	+	+	+	+	+
Family Sciuridae (squirrels)						
Anomalurus derbianus (Gray 1842) Scaly-tailed flying squirrel	LR/nt **V**				+	
Heliosciurus gambianus (Ogilby 1835) Gambian sun squirrel	LR/nt **V**				+	
Paraxerus cepapi (A.Smith 1836) Tree squirrel	LR/nt	+	+	+	+	+
Xerus inaurus (Zimmermann 1780) Ground squirrel	LR/nt		+			
Family Peditidae						
Pedetes capensis (Forster 1778) Springhare	LR/nt	+	+	+	+	+
Family Graphiuridae (dormice)						
Graphiurus murinus (Desmarest 1822) Woodland dormouse	LR/nt	+	+	+	+	+
Graphiurus platyops Thomas 1897 Rock dormouse	LR/nt			+	+	+
Family Muridae (rats and mice)						
Saccostomys campestris Peters 1846 Pouched mouse	LR/nt	+	+	+	+	+
Dendromus mystacalis Heughlin 1863 Lesser climbing mouse	LR/nt		+		+	+
Dendromus melanotis A.Smith 1834 Grey climbing mouse	LR/nt	+	+	+	+	+
Dendromus mesomelas (Brants 1827) Chestnut climbing mouse	LR/nt	+	+	+		
Dendromus nyikae Wroughton 1909 Climbing mouse	LR/nt				+	
Steatomys krebsi Peters 1852 Kreb's fat mouse	LR/nt		+	+	+	+
Steatomys pratensis Peters 1846 Fat mouse	LR/nt		+		+	+
Steatomys parvus Rhoads 1896 Tiny fat mouse	LR/nt		+		+	+
Otomys angoniensis Wroughton 1906 Angoni vlei rat	LR/nt				+	
Otomys maximus Roberts 1924 Large vlei rat	LR/nt		+	+	+	+
Desmodillus auricularis (A.Smith 1834) Namaqua gerbil	LR/nt		+			
Gerbillurus paeba (A.Smith 1836) Hairy-footed gerbil	LR/nt		+			+
Tatera valida (Bocage 1890) Bocage's gerbil	LR/nt	+			+	
Tatera brantsi (A.Smith 1836) Brants' gerbil	LR/nt	+	+	+	+	+
Tatera leucogaster (Peters 1852) Bushveld gerbil	LR/nt	+	+	+	+	+
Mus musculus Linnaeus 1758 House mouse (introduced)	LR/nt				+	+
Mus minutoides A.Smith 1834 Pygmy mouse	LR/nt	+	+	+	+	+
Mus indutus (Thomas 1910) Desert Pygmy mouse	LR/nt	+	+	+	+	+
Mastomys coucha (A.Smith 1836) Multimammate mouse	LR/nt	+	+	+	+	+
Mastomys natalensis (A.Smith 1834) Natal multimammate mouse	LR/nt	+	+	+	+	+
Mastomys shortridgei (St Leger 1933) Shortridge's mouse	LR/nt		+	+		
Rattus rattus (Linnaeus 1758) House rat (introduced)	LR/nt	+	+	+	+	+
Thallomys paedulcus (Sundevall 1846) Tree rat	LR/nt	+	+	+	+	+
Dasymys incomtus (Sundevall 1847) Water rat	DD	+	+	+	+	+
Aethomys namaquensis (A.Smith 1834) Namaqua rock rat	LR/nt		+	+	+	+

Taxon	**Conserv. status**	**Ang**	**Bot**	**Nam**	**Zam**	**Zim**
Aethomys chrysophilus (De Winton 1897) Red veld rat	LR/nt		+	+	+	+
Pellomys fallax (Peters 1852) Groove-toothed rat	LR/nt		+	+	+	+
Lemniscomys rosalia (Thomas 1904) Single-striped mouse	LR/nt	+	+	+	+	+
Arvicanthus niloticus (Desmarest 1822)	LR/nt				+	
Rhabdomys pumilio (Sparrmann 1784) Striped mouse	DD		+			
Zelotomys hildegardeae (Thomas 1902) Hildegarde's rat	LR/nt				+	
Zelatomys woosnami (Schwann 1906) Woosnam's desert rat	LR/nt		+			
Grammomys dolichurus (Smuts 1832) Woodland rat	LR/nt	+	+	+	+	
Acomys spinosissimus (Peters 1852) Spiny mouse	LR/nt				+	+
Order PHOLIDOTA (pangolins)						
Manis temminckii Smuts 1832 Pangolin	LR/nt **V**	+	+	+	+	+
LEPORIDAE (hares and rabbits)						
Lepus saxatalis F.Cuvier 1823 Scrub hare	LR/nt	+	+	+	+	+
Lepus capensis Linnaeus 1758 Cape Hare	LR/nt		+			
Pronolagus randensis Jameson 1907 Jameson's red rock rabbit	LR/nt					+
MACROSCELIDAE (elephant shrews)						
Petrodomus tetradactylus Peters 1846 Four-toed elephant shrew	LR/nt					
Elephantulus brachyrhynchus (A.Smith 1836) Short-snouted elephant shrew	LR/nt	+	+	+	+	+
Elephantulus intufti (A.Smith 1836) Bushveld elephant shrew	LR/nt		+			
Elephantulus myurus Thomas & Schwann 1906 Rock elephant shrew	LR/nt					+
TOTAL = 197 species		**91**	**149**	**118**	**162**	**150**