CHAPTER 1

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Identifying and targeting species and ecosystems in critical need of conservation action requires clearly established priorities, particularly in the context of increasing financial and logistical constraints (Master 1991; Mace 1995; Stein et al. 1995; Dunn et al. 1999). Prioritisation of conservation action for species and ecosystems has become standard practise in the field of conservation biology (Mehlman et al. 2004). In many cases, the prioritisation process serves two basic purposes. First, it helps to identify and document species most in need of conservation attention, and second, it provides an index of the state of degradation of biodiversity. Although related, the identification of species conservation priorities and the assessment of species extinction risk (Fitter & Fitter 1987) are two different and confounded processes (Rodríquez & Rojas-Suárez 1996). The category of threat simply provides an assessment of the extinction risk under certain conditions, whereas a system for assessing priorities for action will include numerous other conservation action-related factors such as costs, logistics, chances of success, and other biological characteristics (IUCN 2003a). However, conservation prioritisation has mainly focused on taxa that are rare and threatened with extinction (Master 1991; Freitag & van Jaarsveld 1997; Dunn et al. 1999).

Conservationists argue that the earth is embarking on a mass extinction phase similar in magnitude to those that occurred during the Permian and Cretaceous Periods (Smith et al. 1993). Approximately 680 vertebrates have been recorded as extinct since the early 1600s (Smith et al. 1993; Magin et al. 1994; IUCN 2003a), while approximately 3500 (6%) of extant vertebrates are listed as threatened (IUCN 2003a). Of these vertebrates, mammals are considered to represent a highly threatened Class with approximately 23.6% deemed threatened with extinction in the near future (IUCN 2003a). Currently, 24 of the 26 mammalian Orders of the world include threatened taxa. The highest proportions of globally threatened mammals are in the Orders Proboscidea (100%), Perrisodactyla (70.6%), Hyracoidea (42.9%), Primates (38.6%), and Insectivora (35.0%) (IUCN 2003a). While these numbers are indeed alarming, there are still many other Orders of vertebrates, invertebrates, and plants that have a much higher proportion of threatened taxa, such as the Order Hymenoptera (94%) of the Class Insecta (IUCN 2003a).

Red Data Books and Red Lists

The growth of public awareness in the problem of the decline and possible extinction of taxa originated in the early 1960s with the development of The World Conservation Union (IUCN) Red Data Book concept pioneered by Sir Peter Scott (Magin et al. 1994). The first ever threatened categories used in the Red Data Book and Lists were published in 1966 and assessed mammals on a global basis (Smithers 1986; Gärdenfors 2001). Since then the Red List classification scheme has been universally accepted to the extent that it has been applied across a wide taxonomic spectrum (Colyvan et al. 1999).

However the pre - 1994 categories were qualitative, subjective, and simple with regard to data requirements (Todd & Burgman 1998). The 1994 IUCN Red List categories and criteria (version 2.3) marked a shift from the qualitative Red Data Book categories to a more quantitative Red List approach developed by the IUCN (IUCN 1994, 2001). More recently, the Red List categories and criteria were reviewed and some modifications were introduced (IUCN 2001). The Red List approach assesses each taxon's threat status by using one to eight threat categories determined by a review of its conservation status throughout the taxon's distributional range (Figure 1). Three of these categories include Critically Endangered (CR), Endangered (EN), and Vulnerable (VU), which are collectively known as the Threatened category. These categories broadly reflect the different levels of the risk of extinction (IUCN 1994) based on a variety of criteria. The quantitative risk assessment criteria are based on five sets of decision rules comprising one or more attributes connected by logical "*and/or*" statements (Keith et al. 2000). The attributes addressed include: 1) rates of decline (rule A); 2) distribution/range size in conjunction with fragmentation, meta-population structure, continuing decline, and extreme fluctuations (rule B); 3) population size in conjunction with continuing decline (rule C); 4) population size only (rule D); and 5) probability of extinction (rule E) (IUCN 2001).

Regional Assessments

The 1994 and 2001 IUCN Red List categories and their definitions were primarily developed for global scale assessments. However, regional and local conservation agencies require regional threat assessments in order to provide baseline data to allow comprehensive decisions to be made with regard to relevant conservation and management programmes. Consequently, a protocol has recently been

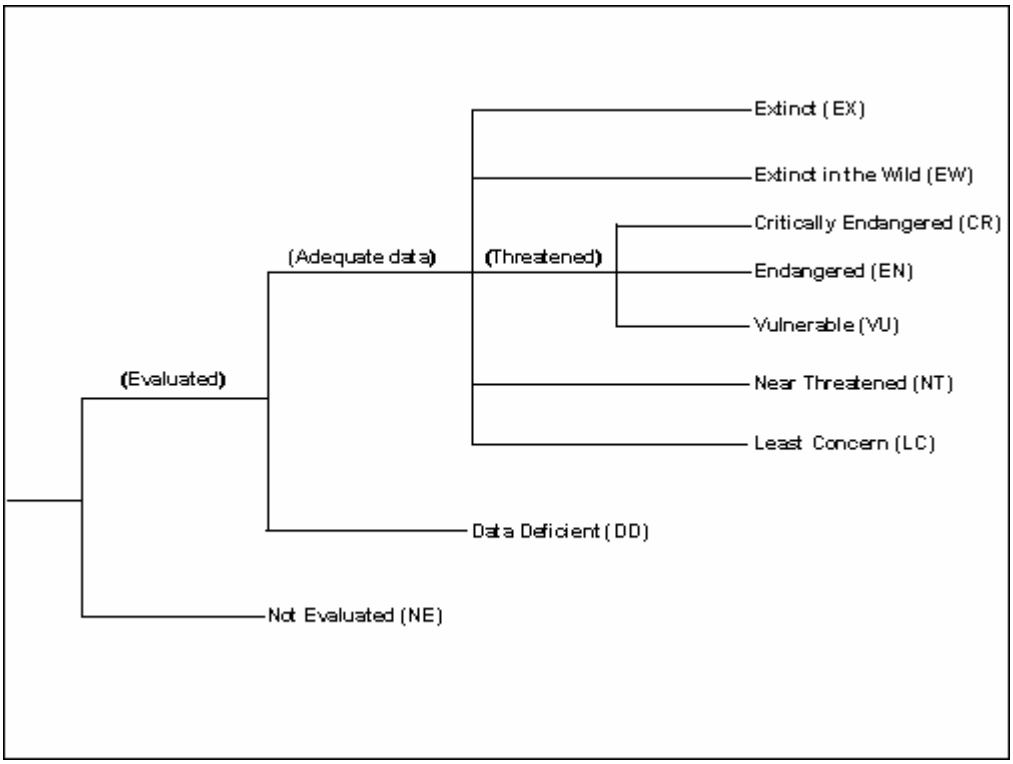

Figure 1. Structure of the 2001 IUCN Red List criteria.

released ("*Guidelines for application of IUCN Red Data List criteria at regional levels*") for determining how the global Red List categories and criteria may be applied on a regional scale (IUCN 2003b).

The Red List categories, therefore, provide a widely used method for high-lighting taxa under high risk of extinction at both the global and regional scales. These Red List assessments are based on considerable ecological knowledge defined by strict sets of criteria that are supported by decision rules based on thresholds of parameters such as distributional ranges, population sizes, and life histories (IUCN 2001; Lamoreux et al. 2003). Consequently, the IUCN Red List assessments have played an increasingly prominent role in guiding conservation activities, and are regularly included in conservation prioritisations or assessments (IUCN 2003a; Mehlman et al. 2004).

South African Mammal Red Data Book

In the 1970s, the IUCN Red Data Book concept was first applied at a national level in South Africa by Meester (1976), and subsequently, Skinner et al. (1977), and focussed on small and large mammals, respectively. Subsequently, these were followed by a Red Data Book by Smithers (1986) who implemented the then IUCN categories of threat which used broad definitions for five threatened categories, of which only two, namely, Vulnerable (V) and Endangered (E), directly indicated the likelihood of extinction (Statterfield 1996). However, these IUCN threat categories are considered to be subjective and may not accurately reflect the actual risks of extinction (Mace & Lande 1991).

Since the 1994 inception of the new IUCN Red List Categories and Criteria, the IUCN has assessed over 4500 mammalian taxa based on the Red List categories and criteria on a global scale. This process provides a global assessment of mammalian taxa that occur in the country under consideration. For South Africa, 110 marine and terrestrial mammals have thus far been assigned some IUCN Red List categories based on the relevant criteria at a global scale (IUCN 2003a).

More recently (2002), the South African non-governmental organization (NGO), the Endangered Wildlife Trust (EWT) initiated a workshop based on the Conservation Assessment and Management Plan (CAMP) approach (Friedmann & Daly 2004) to assess 295 South African mammals according to the latest IUCN categories and criteria at a national level (Friedmann & Daly 2004). This assessment high-lighted the conservation status of 57 mammalian taxa that are highly threatened with extinction at

either the Critically Endangered (CR), Endangered (EN), or Vulnerable (VU) categories (Friedmann & Daly 2004).

Conservation Assessment

The availability of three different Red List and Red Book assessments that span nearly 18 years, as well as two generations of IUCN assessment categories and criteria allows for the analysis of South African mammalian taxa that have been high-lighted as threatened with extinction. The global and regional information provides an opportunity to undertake an objective evaluation of the threats facing a taxon at both a national and/or a global scale (Gärdenfors 2001). Such an evaluation can also facilitate the inclusion of region-specific threat levels into conservation prioritisation exercises but also with reference to global assessments (Master 1991; Mace 1995; Hilton-Taylor et al. 2000). The likelihood of assigning different threat categories to taxa when using regional and global assessments has rarely been examined (Gärdenfors 2001). Consequently, South Africa, with Red List assessments at both the global and regional scales, offers an ideal opportunity to explore the implications of different scale assessments for identifying taxa at risk of extinction.

Additional Measures of Conservation Prioritisation

Conservation prioritisation based on risk of extinction as the sole indicator of a taxon's conservation priority is considered to be inadequate (Masters 1991; Mehlman et al. 2004). Various other components, such as endemism, ecological specialization, phylogenetic diversity, and a series of threat variables are also considered to be important in determining vulnerability to extinction and subsequently, in conservation prioritisation exercises (Burke & Humphrey 1987; Lande 1993; Dobson, Yu & Smith 1995; Cardillo & Bromham 2001). By incorporating as much information as possible in the assessment of a taxon's conservation priority, the likelihood of a more accurate classification may be increased (Harcourt & Parks 2003; Knapp et al. 2003), so long as the variables used do not overly complicate the prioritisation process (Harcourt & Parks 2003; Knapp et al. 2003).

Conservation assessments do not only rely on a taxon's susceptibility to threat (i.e., risk of extinction or Red List assessments), but also on the nature and intensity of the threat itself (Reed 1992; Harcourt & Parks 2003). It is possible that the inclusion of additional explicit criteria of threat may improve the process of assessing threat. A variety of anthropogenic demographic components and their

effect on different flora and fauna, and their disposition to become extinct, have been extensively investigated (Kerr & Currie 1995; Thompson & Jones 1999; Liu et al. 2003). Generally, these studies suggest a relationship between continental rates of habitat, taxon disappearance, and human-induced activities (Ceballos & Ehrlich 2002; Harcourt & Parks 2003, Luck et al. 2003).

Consequently, the present investigation attempts to address questions on the relationship between anthropogenic variables and measures of mammalian richness and their potential use in the assessment of threats to terrestrial mammals across their distributional ranges in South Africa. The study focuses on terrestrial mammals because of the relatively general lack of information on marine mammals. The use of regional IUCN Red List assessments (Friedmann & Daly 2004) which provide an assessment of extinction risks of taxa, in conjunction with various measures of anthropogenic impact, may allow for more informed decisions on the conservation of South African mammals at a national scale (Hannah et al. 1994; Sisk et al. 1994; Harcourt & Parks 2003).

The conservation value of a taxon in conservation priority planning is also considered to be of critical importance. Conservation values are usually equated to a taxon's geographic distribution and taxonomic uniqueness, such as endemism and phylogenetic distinctiveness. While there are a variety of approaches for determining the conservation value of a taxon (Vane-Wright, Humphries, & Williams 1991; Crozier 1992; Faith 1992; Heard & Mooers 2000), the scarcity of comprehensive information has led to a search for alternative measures for identifying unique taxa (Polasky et al. 2001; Rodrigues & Gaston 2002). Consequently, in order to gain an insight into the implementation of conservation prioritisation of South African mammal taxa, a modified Regional Priority Score (RPS) (Freitag & van Jaarsveld 1997; Mills et al. 2001; Reyers 2004) approach for identifying conservation priorities was reviewed in the current study.

Freitag and van Jaarsveld (1997) proposed RPS as a taxon-specific priority scoring technique for conservation priority-setting for at a regional scale. They suggested a method where regional taxa were scored in order of regional conservation importance according to a number of different but complementary rarity, vulnerability, and irreplaceability criteria (Freitag & van Jaarsveld 1997). Their priority scores consisted of the following four components: 1) Relative Vulnerability (RV) which equates to estimates of vulnerability to extinction based on Red Data Book or Red List assessments; 2) Regional Occupancy (RO) measures which estimates the regional extent of taxa 3) Relative Endemism

(RE) measures which equates to the proportion of the taxon's distributional range falling within the area under consideration; and 4) Relative Taxonomic Distinctiveness (RTD) which represent simple measures of taxonomic diversity. These four components have since been used to rank taxa in order of regional conservation importance (Freitag, van Jaarsveld & Biggs 1997; Reyers 2004).

Apart from the four components included by Freitag and van Jaarsveld (1997) in their regional analysis, the present investigation also incorporates additional information in the national RPS assessment for South African terrestrial mammals. Available information on vulnerability (i.e., extinction, probability and occupancy), irreplaceability value (i.e., endemism and taxonomic distinctiveness), as well as additional measures such as human interaction (which include human density and body size) that are considered to measure some form of threat were used in the present study.

Phylogenetically distinct taxa are generally considered to be of a higher conservation value than those with close genetic relatives. However, the general lack of all-inclusive and wide-ranging phylogenies has led to a search for alternative measures for identifying distinct species (Polasky et al. 2001). With the availability of comprehensive ordinal phylogenies (for example Primata (Purvis 1995), Chiroptera (Jones et al. 2002), Carnivora (Bininda-Emonds, Gittleman & Purvis 1999), Insectivora (Greyner & Purvis 2003), and the Lagomorpha (Stoner et al. 2003)), the present investigation attempts to address questions of whether measures of "simple" taxon's richness could function as a proxy in the absence of more comprehensive measures of phylogenetic diversity in regional conservation prioritisation exercises. To this end, the recently published phylogenies of members of two extant Orders, namely, the Chiroptera (Jones et al. 2002) and the Carnivora (Bininda-Emonds et al. 1999) allowed for such an assessment.

Conservation Prioritisation

The philosophy of conservation biology, which initially focused almost exclusively on the prioritisation and conservation of species, has also changed (Pressey et al. 1993; Lombard 1995; Entwistle et al. 2000; Margules & Pressey 2000; Ginsberg 2001). The conservation of single taxa was usually justified through the use of flagship and umbrella taxa approaches which were in turn extrapolated to the broader protection of ecosystems and sympatric taxa (Simberloff 1998; Leader-

Williams & Dublin 2000). The subsequent shift in focus towards 'systems' and 'biodiversity' have reinforced area selection procedures for conservation purposes (Freitag et al. 1997). Selecting areas of high endemism (hot spots) (Mittermeier et al. 1998), complementarity, as well as iterative conservation value-based and representation algorithms (Pressey et al. 1993; Freitag et al. 1997) came to the fore-front in area prioritisation and conservation processes.

Current systematic conservation planning incorporates explicit goals, quantitative targets, prioritisation of various biodiversity features of high significance as well as using rigorous criteria (Margules & Pressey 2000; van Jaarsveld et al. 2003). To this end, various systematic conservation-planning techniques, such as C-Plan software (New South Wales National Parks & Wildlife Service 2001) and Marxan software (Ball & Possingham 2000) have been developed, and are being widely used and implemented by decision-makers to review the consequences of land-use decisions across planning regions.

Some of the better known conservation planning projects in South Africa, includes projects on the National Biodiversity Strategy Action Plan (NBSAP), the Cape Action Plan for the Environment (CAPE), the Succulent Karoo Ecosystem Plan (SKEP), and the Sub-tropical Thicket Ecosystem Planning (STEP) (Balmford 2003; Cowling et al 2003; Driver et al. 2003; Rouget et al 2004). In its use and implementation, systematic conservation assessment relies on six essential steps (see Margules & Pressey 2000; Driver et al 2003), the first of which involves "*the identification or prioritisation of species, vegetation type, future land use pressures or other measures to use as surrogates for overall biodiversity*" (Driver et al. 2003). This step is the most relevant to the current study as it relies on the selection of threatened and priority taxa.

Equally, at a national level, the selection of threatened and priority taxa contribute to the requirements of Part 2 of Chapter 5 under "*Threatened or Protected Ecosystems and Species – Protection of threatened or protected species"* in the new South African National Environmental Management: Biodiversity Act 2004. Provisions of this part of the Act requires the listing of: "*(a) critically endangered species, being any indigenous species facing an extremely high risk of extinction in the wild in the immediate future; (b) endangered species, being any indigenous species facing a high risk of extinction in the wild in the near future, although they are not a critically endangered species; (c) vulnerable species, being any indigenous species facing an extremely high risk of extinction in the*

wild in the medium-term future, although they are not a critically endangered species or an endangered species; and (d), protected species, being any species which are of such high conservation value or national importance that they require national protection, although they are not listed in terms of paragraph (a), (b) or (c)."

Even though the terminology used by the Act is similar to that used by the IUCN Red List threatened categories, it is no way nearly as comprehensive in assessing and highlighting the extinction risk and threat to taxa as the Red List process (IUCN 2001; Chapter 2). Of particular relevance is that the IUCN Red Listing process could facilitate and high-light taxa that would be listed under parts *a*— *c* of the Act. In order to assist in the identification of protected species of high national importance or of high conservation value as outlined in part *d* above, an Orange List approach (Victor & Keith 2004) was adopted in the present investigation. The Orange List approach attempts to accommodate taxa that would have been categorised as Rare (R), Insufficiently Known (K), and Indeterminate (I) in the pre-1994 IUCN Red List system of determining threat status, but excluded under the current Red List categories and criteria (IUCN 1994, 2001).

The rationale behind the Orange List approach was neither to address the problems of priority-setting for conservation purposes nor to replace the functionality of the Red Listing process. It rather intended to provide lists from which conservationists and decision-makers could prioritise what to conserve according to all factors that need to be considered in biological conservation exercises, such as financial feasibility, practicality, and urgency (Master 1991; Mace 1995).

Similarly, a Green Data Species List (Keith & van Jaarsveld 2002) concept was developed because capacity constraints, such as financial and logistical support, and uncertainties faced by national regulatory, enforcement, and border control agencies because of increasing management and active enforcement of escalating numbers of conservation-related instruments. These instruments include the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), IUCN Red Data Lists, and the pending invasive species regulations. It may, therefore, be imperative to support calls for a radical shift in the traditional approaches to the management of threatened species such as Red Data and/or CITES listings, and the maintenance of the integrity of biological systems such as the control of potentially invasive species. This should perhaps include the establishment of Green Data Species Lists as proposed by Imboden (1987) which may represent a

reciprocal list of taxa that are not threatened (i.e., not Red Listed), not affected by trade (i.e., not CITES listed), or pose little threat of invasion according to importing authorities.

Aims of Study

In order to facilitate and improve regional conservation practice for South African mammals, a better understanding of various conservation assessment techniques may be imperative. This may allow an insight into the value and applicability of various conservation assessment tools for prioritising mammals at a regional scale. By incorporating relevant source data into various well-established conservation and priority setting techniques, this may in turn offer an opportunity to explore the conservation priorities of South African mammals.

Objectives of Study:

To this end, the present investigation, therefore, includes the following four objectives:

1. To explore the implications of different scale assessments for high-lighting South African mammal taxa at risk of extinction by using regional and global Red List and Red Data Book assessments;

2. To assess whether various measures of human-induced activities can function as proxies of threat to South African mammals that could in turn be used in conservation priority-setting exercises;

3. To assess whether relevant priorities for conservation can be determined for South African mammals based on measures of vulnerability, irreplaceability, and threat; and

4. To assess if a simple measure of taxonomic distinctiveness can be an effective surrogate for measures of phylogenetic diversity in the absence of comprehensive phylogenies, and to evaluate whether the inclusion of measures of more comprehensive phylogenetic diversity can alter the conservation priorities of South African mammals.

Key Research Questions and Study Outline:

In order to achieve the objectives in the present study, the following key research questions followed by the relevant study outline were addressed:

> **Key Research Question I:** Do the quantitative Red List categories and criteria provide an insight to into the risk of threats faced by South African mammals at a regional scale?;
>
> **Key Research Question II:** Do regional Red List assessments for South African mammals differ from those based on global Red List assessments?

These two key research questions are addressed in the first part of this study (Chapter 2) and are directed towards investigating and comparing South African mammals according to their respective regional and global World Conservation Union (IUCN) Red List and Red Data Book assessments. This included the use of the 1986 regional Red Data Book assessments (Smithers 1986), 2003 global IUCN Red List assessments of species occurring within the borders of South Africa (IUCN 2003a) as well as the latest regional Red List assessment (Friedman & Daly 2004). This part of the study allowed an investigation of the nature and extent of the qualitative and quantitative IUCN assessments over an 18-year period from 1986 to 2004 (Smithers 1986; IUCN 2003a; Friedman & Daly 2004).

> **Key Research Question III:** Can different measures of human-induced activities provide relevant information on threat to allow for more inclusive priority assessment for South African mammals to be made?

This key research question is addressed in Chapter 3 and is directed at assessing the relationship between six human activity variables (see section: Data utilized in study) and the recent regional Red List assessment (Friedmann & Daly 2004). In addition, the relationship between anthropogenic variables and measures of mammalian richness, and their potential use in the assessment of threats to South African mammals are investigated. This part of the study focuses on terrestrial South African mammals because of the general lack of quantifiable spatial data for marine mammals. Although both natural and anthropogenic threats may be important in assessing a taxon's risk of extinction (Kerr & Currie 1995), only limited threat data have been included in previous quantitative risk assessments.

Key Research Question IV: Would the inclusion of measures of vulnerability, irreplaceability, and threat in conservation priority assessment techniques allow for a simplified, region-specific conservation priority-setting for South African mammals?

This key research question is addressed in Chapter 4 and is directed towards assessing the conservation priorities allocated to a range of South African terrestrial mammals when measures considered to be related to vulnerability (IUCN Red List assessments and occupancy data), irreplaceability (endemism and taxonomic distinctiveness), and threat (body mass and human density) are included in the analysis. An additional focus is also directed at assessing the effect of including body mass and a human density index in a priority exercise.

Key Research Question V: Can a simple measure of taxonomic distinctiveness act as potential surrogates for measures of phylogenetic diversity in the conservation assessment of South African mammals?

This key research question is addressed in Chapter 5 and is directed at assessing whether a simple measure of taxonomic diversity can be used as a proxy for measures of phylogenetic diversity in high-lighting taxa of regional conservation priority. In this part of the study, members of the Orders Chiroptera and Carnivora from South Africa are used as a case study because of the availability of their published phylogenies and their representation of a large proportion of South African terrestrial mammals.

Key Research Question VI: Do current conservation assessment techniques adequately incorporate relevant information for an inclusive conservation assessment of South African mammals?

This research question is addressed in Chapters 6 and 7 and is directed at the different facets and limitations of current conservation prioritisation processes. Conforming to the demands of the new South African Biodiversity Act of 2004, as well as the inherent short-comings of many conservation assessment techniques, two conceptual frameworks are proposed to circumvent potential limitations.

Data Utilised in Study

Mammal taxonomy

Broadly, the entire study is based on extant South African mammals and following the Friedman and Daly (2004) taxonomy established in 2002, the taxonomic framework of Wilson and Reeder (1993) and augmented by that of Taylor (2000) for the Order Chiroptera. For taxa with taxonomic discrepancies between authorities, taxon specialists working on the specific problematic groups were consulted (see Friedmann & Daly 2004). While this study acknowledges the recently published taxonomic framework of Bronner et al. (2003), this study follows the taxonomy used by the recent regional Red List assessment by Friedmann and Daly (2004) (based on the taxonomy used by the Conservation Assessment and Management Plan for the Mammals of South Africa (Friedmann et al. 2002)) in order to facilitate comparisons between the present study and previous work.

Red Data Book, Red List, and distribution data.

The regional Red Data Book (RRDB) assessments were extracted from Smithers (1986) and Mugo et al. (1995), while the global IUCN Red List assessments (GRL) included information from the 2003 global Red List assessment (IUCN 2003a). The recent regional Red List assessment (RRL) by Friedman and Daly (2004) was included in all relevant regional Red List assessments throughout the study. Subsequent analyses (Chapters 3 – 5) focused on terrestrial taxa for which relevant spatial distributional, biological and threat data were available. Mammal distributional data were obtained from distributional presence records from various natural museums in South Africa and electronic range maps (Freitag & van Jaarsveld 1995; Keith 2004). All spatial data were generalised to a common resolution at the quarter degree square (QDS) level representing an area of 25 x 25 km (or 625km^2) (Freitag & van Jaarsveld 1995).

Regional Priority components

Components used in Chapters 4 and 5 included: 1) Relative Vulnerability (RV) based on the regional IUCN Red List assessment of Friedmann and Daly (2004); 2) Relative Occupancy (RO) based on presence data from natural history museum distributional records (Freitag & van Jaarsveld, 1995; Keith 2004); 3) Relative Endemism (RE) based on the level of endemism following Freitag and van Jaarsveld

(1997); 4) Relative Taxonomic Distinctiveness (RTD) following methodology as proposed by Freitag and van Jaarsveld (1997); 5) Relative Body Mass (RBM) based on average body weights (in grams) for each species; and 6) Relative Human Density based on the average human population per QDS derived from magisterial human population data (Central Statistical Service 1998). To facilitate analysis in Chapter 5, information on phylogenetic diversity was were extracted from comprehensive ordinal phylogenies for bats (Jones et al. 2002) and carnivores (Bininda-Emonds et al. 1999), while taxonomic distinctiveness values were calculated as described by Freitag and van Jaarsveld (1997). More precise methodologies and other sources of data are outlined in the relevant chapters.

Anthropogenic Data

Six anthropogenic variables were used in Chapter 2. These included: 1) human population density; 2) human change; 3) poverty; 4) affluence; 5) urbanization; and 6) land transformation and degradation. The main sources for information on human population density, human change, poverty, and affluence included magisterial district data (Central Statistical Service 1995, 1998), while all land-cover and transformation data were collated from the National Land-Cover database (Fairbanks & Thompson 1996). These data were also converted to a spatial scale at the QDS level in order to conform to mammal distributional data.

Rationale of Study

It is anticipated that the utilization of a wide range of approaches of assessing/prioritising mammals as adopted in the present study may extend our understanding of the methods that are most comprehensive in identifying priority species. It is also anticipated that the approaches adopted in the present study may also further our understanding towards the development of a more encompassing list of priority mammals for South Africa to allow for relevant conservation decisions to be made. Of particular importance is that the approaches used in the present study may not only be relevant for South African mammals, but may also be applied to other regions worldwide, as well as to a wide range of other taxonomic groups within both the animal and plant kingdoms.

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