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Estimated spatial requirements of the medium- to large-sized mammals, according to broad habitat units, in the Cape Floristic Region, South Africa

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Conservation planning in the Cape Floristic Region (CFR) of South Africa, a recognised world plant diversity hotspot, required information on the estimated spatial requirements of selected medium- to large-sized mammals within each of 102 Broad Habitat Units (BHUs) delineated according to key biophysical parameters. Spatial requirement estimates were derived for 19 omnivore and carnivore species, following a review and extrapolation of extant information. The estimates for 23 herbivore species were derived from a simple spreadsheet model based on forage availability estimates and the metabolic requirements of the species in question; this analysis incorporated adaptations of the agriculture-based Large Stock Unit (LSU) or Animal Unit approach. The LSU approach has various shortcomings but given the virtual absence of information on forage availability (quantity, quality and seasonality) for indigenous herbivores in the CFR, it provides the only extant measure of the influence of key biophysical factors on this parameter, especially at a regional scale. The outcomes of the exercise, *viz.* densities (hectares/animal), are presented here; these should be considered as testable hypotheses and a cautious 'management by hypothesis' approach should be adopted in their use. This information can be used to guide both conservation planning activities and practical conservation management decisions.

Keywords: forage production, species assemblages, herbivore densities, conservation planning, conservation management

Introduction

Information required for conserving biological diversity includes, *inter alia*, the distributions and ecological requirements of species (McNeely *et al.* 1990). The strategic placement of protected areas is necessary to capture maximum biological diversity but this can only be done by conservation planners on the basis of solid inventory data on biological diversity, i.e. distribution and abundance of species in time and space.

The Cape Floristic Region (CFR) of South Africa, a region of exceptional plant diversity and one of the world's six floral kingdoms (Cowling and Holmes 1992, Goldblatt 1978), encompasses three of southern Africa's centres of plant endemism (Cowling and Hilton-Taylor 1997). This globally recognised biodiversity hotspot (Myers 1990), covering some 90 000km^2, is currently the focus of a strategic conservation planning exercise (Cowling *et al.* 1998). The implementation of this exercise in the spatially extensive CFR accords with recent emphasis on the need for conservation biology principles to be applied to large spatial scales (May 1994). The spatial requirements of the mammals of the CFR ares considered to be a key component of the conservation planning exercise in this region.

The medium- to large-sized mammals were selected as 'target' species (*sensu* Wilcox 1982) for the CFR exercise because it is likely that if their minimum area requirements are met, adequate survival conditions can be simultaneously met for other biota. In this regard, many of the medium- to large-sized mammals qualify as 'umbrella' species (*sensu* Wilcox 1982) since their minimum area requirements are likely to be at least as comprehensive as those for the remainder of the community. Mammals with a large body size (e.g. some ungulates) or which occupy a high trophic level (e.g. carnivores) are regarded as good candidates for target species acting as 'umbrella' species. The concept of umbrella species acting as surrogates for biodiversity in conservation planning exercises is reviewed by Caro and O'Doherty (1999).

An additional consideration for determining minimum area requirements for preserving biological diversity is that of the estimation of minimum viable populations (MVP) for 'target' species (Wilcox 1982, Soulé 1987). The MVP is a set of specifications concerning the size and structure of the populations comprising a species that is necessary to provide a margin of safety from extinction. The MVP for a species can be translated into the minimum area requirements by determining the amount and type of habitat that will satisfy the MVP. In view of this, it is essential that realistic estimates of the spatial requirements of each the selected species in the CFR be obtained.

The focus of the present study is on the medium- to large-sized mammals because their distributions and spatial requirements are better known, or can be better estimated, than those of other mammal species in the CFR.

Given an inadequate understanding, and lack of detailed information, on the spatial requirements of the larger mammals of the CFR, a pragmatic approach is required to obtain data, at the appropriate scale and coverage, for achieving the overall objectives of the planning exercise. This approach is described in detail by Boshoff *et al.* (2001). The present paper provides the detailed outcomes of the spatial requirement component of that study.

Approach and methods

The information on the estimated spatial requirements for the 42 species in question is presented at the level of the 102 Broad Habitat Units (BHUs) which are the biodiversity entities for the conservation planning component of the CFR project (Figures 1a and 1b). These BHUs were identified on the basis of coincident patterns of geology, topography, climate and vegetation (Cowling and Heijnis 2001).

The 42 indigenous terrestrial mammal species included in this study are those with a mass greater than *ca.* 2kg (cf Chew 1978), which are most prominent in the landscape, and whose populations can be relatively easily managed. Two species that fall into this category, namely the hippopotamus *Hippopotamus amphibius* and the Cape clawless otter *Aonyx capensis*, have been excluded from this study since they occur exclusively in aquatic habitats and their associated riparian areas; the riparian habitat was not mapped as a separate habitat unit by Cowling and Heijnis (2001).

The estimated spatial requirements provided here generally refer to the period prior to arrival of the European settlers, in what is now the CFR, in the mid 17th century. Therefore, they represent a situation where the patterns and processes exhibited by the mammals of the region were presumably still intact, and are therefore of practical use in present-day pristine or near-pristine landscapes.

The occurrence of a species within a BHU was defined according to three categories (after Boshoff *et al.* 2001):

- BHUs with the potential to sustain significant resident (i.e. present all year round and breeding) populations,
- BHUs which may be used on an ephemeral (i.e. seasonal) basis, or which may carry small populations in habitat refugia (patchy basis), and
- BHUs where the species is unlikely to occur, except perhaps for vagrants or during rare and short incursions.

The estimated spatial requirements refer exclusively to those BHUs where the species is likely to occur, on a 'resident' or 'ephemeral/patchy' basis.

Domestic herbivores, maintained by Khoi pastoralists in the period prior to European settlement, have not been taken into account in this analysis, owing to the lack of information on their distributions, nomadic movements and densities.

Omnivores and carnivores

The overall lack of information from the CFR precluded a BHU-specific approach to estimating the spatial requirements of the omnivores and carnivores. Consequently, the CFR was treated as a homogeneous unit for this purpose, and therefore the estimated spatial requirements for each species in this category apply throughout the entire CFR.

Estimates of the spatial requirements of each species in each BHU were extrapolated from a comprehensive review of available published information on densities, social structures, breeding units, territory sizes and home ranges; for the sake of brevity, details and information sources have been omitted from this paper. Published ecological information for the CFR is available for only four of the 19 species in this category, little of which deals specifically with spatial requirements in more than one habitat type in the CFR. Consequently, estimates based on the interpretation and extrapolation of information on the relevant species from other biomes in South Africa, mainly the Nama-Karoo, Grassland and Savanna biomes (*sensu* Low and Rebelo 1996), were used for many of the species.

A conservative approach to the estimation of the spatial requirements of the omnivores and carnivores in the CFR was adopted because of the naturally, and relatively, low herbivore carrying capacity (Teague 1999) and a very poor understanding of the ecology of the species concerned. This was achieved by (a) usually adopting the lowest densities or largest territories or home ranges provided in the literature, (b) using the home range when territory size is not known, (c) basing, in appropriate cases, the estimates only on the sizes of the territories or home ranges of breeding adults; in these cases effective densities may be higher when non-territorial individuals (e.g. sub-adults, immatures and juveniles) are taken into account, and (d) reducing the densities in the ephemeral/patchy habitats to 20% of those calculated for the 'core' habitats.

Herbivores

In the general absence of data on the spatial requirements for herbivores in the CFR, we took a pragmatic approach in the derivation of the necessary estimates. This comprises a spreadsheet model, based on forage availability estimates and the metabolic requirements of the mammal species in question. This analysis incorporated adaptations of the agriculture-based Large Stock Unit (LSU) approach. A LSU is the equivalent of a steer with a mass of 450kg and a mass gain of 500g per day on grass pasture with a mean digestible energy concentration of 55%; to maintain this, 75 megajoules of metabolisable energy per day is required (Meissner 1982). The concept of the LSU, or AU (Animal Unit), was developed for the livestock industry to determine grazing capacity (e.g. Anon 1985) and has been defined as 'the area of natural vegetation (ha) required to to carry a single LSU for the normal grazeable period without deterioration of the grazing or the soil' (Edwards 1981). The LSU approach has been used in North America (e.g. Flinders 1988, Robinson and Bolen 1989, Heady and Child 1994) and in Australia (e.g. Landsberg *et al.* 1992) to standardise measures for both livestock and wildlife, including an assessment of foraging pressure.

The various sequential components of the model are described in detail in Boshoff *et al.* (2001); space precludes repetition here. Briefly, these steps involve the following:

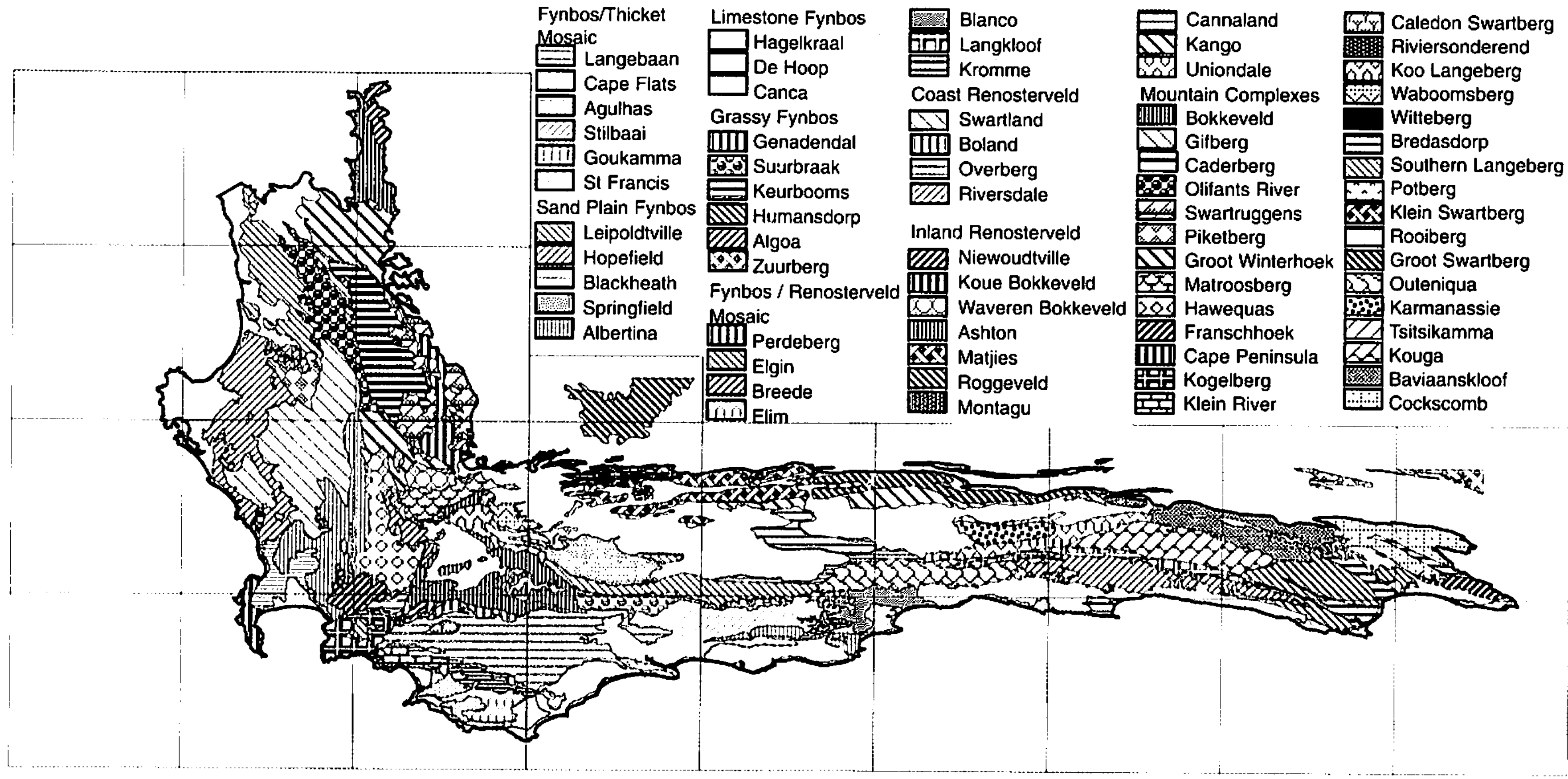

Figure 1a: Broad Habitat Units for the Fynbos Biome in the planning domain for the Cape Floristic Region, used as the basis for estimating the spatial requirements of the medium- to large-sized mammals (reproduced with permission from Cowling and Heijnis 2001)

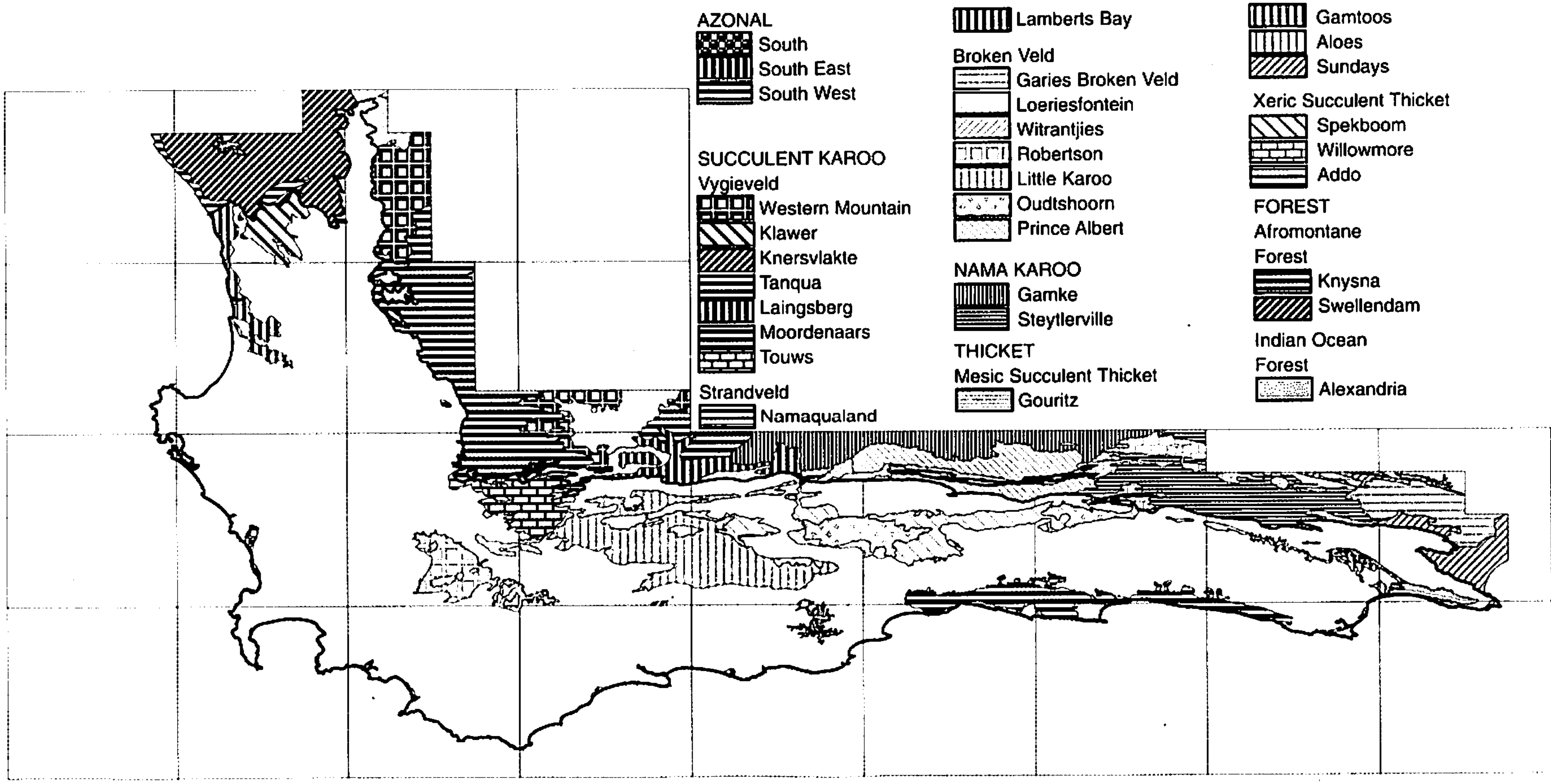

Figure 1b: Broad Habitat Units for the Forest, Nama-Karoo, Succulent Karoo and Thicket biomes, and for the Azonal categories, in the planning domain for the Cape Floristic Region, used as the basis for estimating the spatial requirements of the medium- to large-sized mammals (reproduced with permission from Cowling and Heijnis 2001)

- allocation of each species to one of four foraging guilds (see Appendix 2),
- estimation of the LSU equivalents of each species (see Appendix 2),
- adjustment of the potential agricultural carrying capacity (expressed as hectares per LSU),
- allocation of the available forage within each BHU to each of the foraging guilds,
- allocation of the available forage to the individual species within the foraging guilds, within each BHU,
- adjustment for seasonality and patchiness of occurrence,
- calculation of the total numbers of individuals of each species within each BHU, and
- calculation of the estimated spatial requirements (i.e. hectares per individual) of each species within each BHU.

It is not practical, at the scale of this study, to provide information at the age class level. However, the various age classes have been taken into account in the calculation of the LSU equivalents (e.g. Meissner 1982). Although the porcupine is predominantly a herbivore, we have treated it as an omnivore and excluded it from the spreadsheet model, since it does not easily fit the conventional grazer/browser classification.

Results

Omnivores and carnivores

The estimates of the spatial requirements for the omnivores and carnivores, for all the BHUs in which they occur (see Boshoff and Kerley 2001), exhibit a wide range of densities in both ephemeral/patchy and core (resident) habitats (Table 1). The vervet monkey has potentially the highest density in both habitat types (6 and 3ha/individual), whereas the cheetah and the leopard have the lowest (33 480 and 18 600ha/individual, and 18 000 and 10 000ha/individual, respectively) (Table 1).

Herbivores

The wide range of estimated spatial requirement values for herbivore species that occur throughout, or largely throughout, the CFR is noteworthy (Appendix 1); this can be expected given the range in forage production in BHUs. More specifically, the predicted densities are, in general, relatively low in the western BHUs and relatively high in the eastern ones. This is taken to reflect a decline in forage productivity from east to west in the region.

In the case of the two megaherbivores — African elephant (Kerley and Boshoff 1997) and black rhinoceros (Adcock 1994) — social constraints have not been violated by the spreadsheet model's predictions. A general minimum spatial (social) requirement of 200ha/animal has been suggested for the black rhinoceros (see Hall-Martin and Knight 1994). Sixty four of the 66 rhino values in the model represent densities lower than 200ha/animal, some of these in habitats where densities higher than 200ha/animal are potentially feasible in terms of forage quantity and quality. The remaining two density values, of 151 and 158ha/animal, are not substantially different from 200ha/animal.

With the exception of one species in the Thicket Biome (kudu; see Discussion), the spatial requirements derived from the model were corroborated for those herbivore species for which published information is available, thereby

Table 1: Estimated spatial requirements for selected medium- to large omnivores, insectivores and carnivores in (a) ephemeral/patchy and (b) resident occurrence categories in the Cape Floristic Region. See text and Boshoff *et al.* (2001) for assumptions and calculations. Scientific names in Appendix 2

Species	Calculation	Estimated density (ha/individual) Ephemeral/Patchy	Resident
Chacma baboon	Cape Point Nature Reserve: 1 troop of 80 uses 3 400ha	77	43
Vervet monkey	25/troop, 8 troops required for 200 individuals at ca. 80 ha/troop	6	3
Porcupine	Family group of 8 individuals; group home range of 400ha		50
Aardwolf	Males and females share territories of up to 1 000ha	900	500
Brown hyaena	Clan of 8 members has territory size of about 25 000ha	5 625	3 125
Spotted hyaena	A clan of 15 would require territory of around 40 000ha	5 760	3 200
Cheetah	Est. home range for 5 animals (2 male, 3 female) at 100 000 ha, with 75% overlap. 50 animals = 100 000 + 25% for 10 iterations	33 480	18 600
Leopard	One pair requires a home range of about 20 000ha	18 000	10 000
Lion	A pride of 10 animals (adults, sub-adults and young) may require a territory of about 50 000ha	9 000	5 000
Caracal	Pairs have overlapping (by up to 20%) home ranges of about 6 600ha	4 752	2 640
African wild cat	One pair has a home range of approximately 250ha	225	125
Small spotted cat	Males and females have overlapping (ca 20%) territories of about 900ha. Thus, one pair has a territory of about 1 500ha	1 350	750
Serval	Males and females occur in home ranges of up to 3 000ha, taking overlap into account		1 500
Bat-eared fox	Density of three animals/100ha	60	34
Wild dog	Take mean pack size of 13 animals and mean pack home range of 45 000 ha. Overlapping accounted for		3 450
Cape fox	Only information for hunting range (up to 500ha); overlapping home ranges. Say one pair needs 750ha	675	375
Black-backed jackal	Territory/home range of about 2 000ha/pair	1 800	1 000
Honey badger	Male and female have overlapping home ranges of about 10 000ha	9 000	5 000
Aardvark	Est. home ranges for one male and one female of 7 500ha		3 750

indicating that realistic values were generated (Boshoff *et al.* 2001). A sample of the predicted values, in relation to actual data, is provided in Table 2; the species included in this Table are ones for which some information is also available from the CFR. The values in Table 2 have been derived from specific studies in high quality habitats (e.g. conservation areas) and therefore reflect relatively high-density situations.

Discussion

The spatial requirement data generated by the model described here can be used, in conjunction with distributional data (cf. Boshoff and Kerley 2001), for conservation planning for large mammals in the CFR. Specifically, these data can be used to determine the size, shape and location of the protected areas required to achieve demographically and genetically viable populations, in evolutionary terms, of each species in a multi-species assemblage (Kerley *et al.* submitted). These data also provide useful information for guiding conservation management decisions, for example, determining species assemblages and potential carrying capacities of herbivores in protected areas and private wildlife operations.

The model predicts, in addition to the spatial requirements for each species within a BHU, the proportions (based on numbers of individuals) between species (Boshoff *et al.* 2001). It should be emphasised, though, that for each BHU the current model predicts a potential 'full-house' situation, with regard to community structure, and it assumes that the natural habitat is intact throughout a BHU. However, the model can be manipulated to provide data for only the remaining pristine, or near-pristine, habitat, and for selected species only, in a particular BHU. The primary assumption of the model is that herbivore spatial requirements are determined, on an overall basis, by forage production.

We emphasise that the information provided here describes potential species assemblages for each BHU, and for pristine or relatively pristine habitat conditions (i.e. prior to European settlement; hence the inclusion of the long extinct [since 1800] blue antelope). Habitat transformation or species unavailability (on the market) may dictate that only certain species may be introduced by a landowner, following a comprehensive ecological evaluation of the land in question. In such cases, a re-allocation of forage resources, by manipulating the spreadsheet model, will be necessary.

We recognise, however, that the model greatly oversimplifies the highly complex intra-specific and inter-specific mammal interactions, as well as the equally complex animal-plant relationships. The influence of seasonality introduces further complexities. There are, however, no viable alternatives when working at this scale, and with so little ecological information available for the species concerned. This exercise has therefore assisted in identifying gaps, and hence directions for research, in our understanding of the processes structuring mammal assemblages in the CFR (Boshoff *et al.* 2001). The development of appropriate potential carrying capacity indices, in relation to ecosystem theories and principles, is still the subject of debate (Peel *et al.* 1998). These authors review a number of approaches, including the agricultural (LSU) approach, and state that all of them have various shortcomings.

Boshoff *et al.* (2001) emphasise that the use of the LSU concept to provide estimates of forage production, and ultimately potential carrying capacities, for multi-species stock grazing systems, let alone wildlife, have not been fully investigated (e.g. Hardy 1996, Meissner 1996, Peel *et al.* 1998). Due to a number of influences, the use of LSUs can be, even for domestic livestock predictions, difficult to calculate and interpret (Meissner 1982, Peel *et al.* 1998). In addition, estimated potential carrying capacity derived from the LSU approach will, in practice, show much variation due to, e.g., local variation within habitats (e.g. surface water availability, soil depth, texture), rainfall amount and seasonality, drought incidence, etc. These problems are exacerbated in the CFR where agricultural carrying capacities are notoriously difficult to calculate (H Lindemann, Department of Agriculture, pers. comm.). Nevertheless, the LSU concept is, with reservations and adaptations, considered to be sound and 'there is sufficient evidence that (this) approach has been more acceptable than almost any other approach elsewhere' (Meissner 1996).

Given the reservations expressed about the applicability of the LSU concept in agricultural terms, it is apparent, for similar reasons, that its application to multi-species communities of indigenous ungulates, which could comprise grazers, mixed feeders, and browsers, may be problematic (Hardy 1996, Peel *et al.* 1998, Robinson and Bolen 1989). It can be accepted that in the CFR, as will be the case elsewhere, there will be some resource partitioning, especially in the browser component, and some competition, especially in the grazer component, and that population structure (sex ratio, age class) will also influence any calculations. The inability of the LSU approach to deal with the issue of ecological separation in a multi-species indigenous ungulate community led to the quantification of the overlap in ungulate resource use in a savanna habitat, and the incorporation of indices of overlap into substitution ratios for calculating

Table 2: Sample of comparisons between the predictions of the spatial requirements model and available empirical data (from Boshoff et al. 2001). Empirical data from CFR in italics. Scientific names in Appendix 2.

Mammal species	Empirical data(ha/animal)	Predictions from the model (ha/animal)
Blue duiker	0.5–1 (Apps 1996); *5.5–8 (Hanekom and Wilson 1991); 1.8–11 (Von Gadow 1978)*	3–14
Common duiker	Mean = 17; as low as 20–50 recorded (Allen-Rowlandson 1986)	8–135
Klipspringer	*11–15 (Norton 1980)*	6–428
Grysbok	*1.3–9.4 (Manson 1974)*	6–456
Grey rhebok	15–152 (Ferreira 1984); *15 (Beukes 1987)*; 44–57 (Mentis 1978)	26–2 340
Bushbuck	20 (Allen-Rowlandson 1986); *14–20 (Seydack 1984); 33 (Odendaal and Bigalke 1979); 77 (Stuart-Hill and Danckwerts 1988)*	12–1 699

carrying capacities (Dekker 1997). However, owing to a paucity of information for the CFR on utilisation of graze and, particularly, browse resources, a refined version of the LSU approach, or an approach accommodating grazer/browser differences (cf Peel *et al.* 1998) could not be attempted beyond the guild approach in the present study. However, Dekker (1997), in a bushveld study, suggested that if substitution ratios are based on metabolic mass only, without consideration to ungulate species specific differences in resource utilisation, carrying capacity could be underestimated by as much as 63%. An equivalent value for the CFR is not known but should our use of metabolic mass only lead to an underestimate of browsers, this would support our conservative approach to estimating potential carrying capacities in this region.

In some agricultural studies using the LSU concept, 'carrying capacity' is assumed to be the sum of the grazing capacity and browsing capacity (e.g. Stuart-Hill and Aucamp 1993). Even though, based on ecological feeding separation theories, it could be anticipated that more animal equivalents could be carried per unit area in a multi-species game system, compared to a domestic stock system, the current view is that more conservative figures should be adopted for game carrying capacities (Grossman *et al.* 1999). The conservative approach adopted in this study therefore accords with current thinking (cf Boshoff *et al.* 2001).

The LSU concept permits ready comparison of stocking rates between areas, regardless of the species occurring, and is a convenient base for calculating optimal carrying capacities and combinations of species in the commercial exploitation of indigenous ungulates (Mentis 1977). Grossman *et al.* (1999), whilst suggesting the conversion of LSUs to game species as a way of obtaining carrying capacity guidelines, caution that, for a number of reasons, these conversions must be applied with circumspection. Although the LSU approach provides only a broad index of the potential carrying capacity for game in a given area or habitat, it is considered a practical gauge for comparing different habitat types (Van Rooyen *et al.* 1996).

Notwithstanding the reservations about its applicability, the LSU concept, or adaptations of it, has been widely applied, through the use of the indigenous herbivore equivalents of agricultural LSUs, in South Africa for estimating potential carrying capacities of indigenous ungulates on game ranches and nature reserves (e.g. Berry 1975, Mentis and Duke 1976, Mentis 1977, Collinson and Goodman 1982, Meissner 1982, Trollope 1990, Van Rooyen *et al.* 1996, Grossman *et al.* 1999). Given the virtual absence of information on forage availability (quantity, quality and seasonality) for indigenous herbivores in the CFR, the LSU approach provides the only extant measure of the influence of key biophysical factors on this parameter, especially at this scale (Boshoff *et al.* 2001). There remains, however, a need to obtain good information on how the forage reserve is shared within and between herbivore species, and the role of other ecological factors.

It is to be hoped that at least some of the effects of community and population structure will be mitigated by the highly conservative approach that has been adopted in estimating spatial requirements by using the LSU concept as a guideline. Given that the agricultural carrying capacity is often more akin to an 'economic stocking rate' (Caughley 1983), the adjusted carrying capacities used for the indigenous herbivores in the present study could be closer to the 'ecological stocking rate', i.e. the natural limit of a population set by resources in a particular environment (e.g. food, space, cover), which is more appropriate when dealing with large indigenous herbivores (Caughley 1983). This, however, needs to be evaluated and tested in the case of the CFR. An alternative to the LSU approach for calculating potential carrying capacities is the use of a standing crop biomass of animals, as an index of carrying capacity. In savanna regions, often exhibiting high rainfall and nutrient rich soils, primary production and animal density are generally positively correlated with mean annual rainfall (Coe *et al.* 1976). However, soil type influences and further complicates this relationship, even in the savannas, and the biomass of large ungulates can be as much as 20 times lower on nutrient poor soils (Fritz and Duncan 1994). The fact that savannas with nutrient rich soils support different kinds of vegetation and also different types and densities of herbivores from those with nutrient poor soils has been emphasised by Bell (1982). Given the high regional variation in rainfall and soil type (providing generally nutrient poor soils), and presumably primary productivity, in the CFR, this approach was not attempted in the present study.

It is important that the estimates derived by this study be treated as hypothetical guidelines at this stage. Thus, any management action based on these estimates should be considered experimental, should be tested through adaptive management strategies and should be closely monitored. The need to test indigenous herbivore spatial requirement estimates in practice, and to adapt them in the light of field experience, has been mentioned elsewhere (Trollope 1990). In addition, the final carrying capacities for these herbivores should be conservative, in order to cope with unfavourable conditions (Trollope 1990). We thus advocate a 'management by hypothesis' approach, with assumptions and predictions being explicitly tested. A major advantage of the estimates presented here is that the predictions are quantitative and can be modified as these ideas are tested, allowing adaptive management principles and actions to be employed. The concepts of 'management by hypothesis' and 'adaptive management' are a generally accepted approach to dealing with management challenges associated with a paucity of information (e.g. Macnab 1983, May 1991, Bowman 1995).

Despite the fact that the conversion of carrying capacities for domestic ungulates into estimates of spatial requirements for indigenous ungulates can be problematic, and that most of the estimates of spatial requirements for viable populations are based heavily on the interpretation and extrapolation of data and information from outside the CFR, it is considered that realistic values, which can be meaningfully used for conservation planning in the CFR, have been generated (Boshoff *et al.* 2001). This is supported by the general congruence between model-generated densities and empirically observed densities of these herbivores (Table 2).

Based on the density information in Allen-Rowlandson (1980), the model appears to overestimate the spatial requirements for the kudu (Boshoff *et al.* 2001). The reasons for this are not understood but may be related to the species' feeding ecology. This aspect requires further investigation. One of the useful products of the model is the identification of such discrepancies, i.e. between our ecological understanding of a species and predictions and empirical observations on that species.

It needs to be emphasised that even though the model has attempted to address the issue of seasonality for certain species (by reducing the amount of allocated forage), it will be unwise to keep a nomadic or migratory species in a single BHU on a year-round basis. This is because there may be other ecological factors that need to be taken into account, for example, presence of surface water, seasonal food availability and possible negative effects on threatened plants through selective foraging (Boshoff *et al.* 2001). This concern is addressed more specifically at private landowners wishing to re-introduce normally nomadic or migratory species to their land. A good example is the eland; it may be sedentary in certain areas but highly nomadic in others (Skinner and Smithers 1990).

The use of the LSU as a basis for estimating spatial requirements and potential carrying capacities for indigenous herbivores is not novel, and has been invoked in various counties, e.g. South Africa, United States of America, Australia (see earlier). However, there has been a tendency to use this approach only at a local level, e.g. for small (<10 000ha) private reserves and game ranches, and, occasionally, small (<20 000ha) conservation areas. As far as can be established, it has not been used for conservation planning at a regional scale approaching that of the CFR study (9 million ha). Implementation at this scale introduces new challenges and assumptions. Furthermore, the LSU approach, as applied to private game ranches, is normally used to estimate high carrying capacities for maximum game production, whereas the approach in the present study has been to estimate low carrying capacities, i.e. non-production oriented. It is contended that the LSU-based approach is, notwithstanding its inherent constraints, appropriate at a regional scale but not necessarily at the scale of individual protected reserves and game ranches; in the case of the latter categories, additional ecological parameters need to be addressed when estimating spatial requirements and potential carrying capacities (see also Boshoff *et al.* 2001).

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Appendix 1: Potential species assemblages and estimated spatial requirements (hectares per animal) for the medium to large herbivores in each Broad Habitat Unit (BHU) in the Cape Floristic Region. See text and Boshoff *et al.* (2001) for assumptions and calculations. Adjusted agricultural stocking rates given (as ha/LSU) in brackets after primary BHU names. BHUs listed according to biome. Scientif names in Appendix 2

BHU	Herbivore spp.	Ha/animal
AZONAL		
Dune Pioneer		
South West (270)	Steenbok	720
	Grysbok	38
South (270)	Bushpig	149
	Steenbok	1 080
	Grysbok	74
	Bushbuck	161
South East (270)	Bushpig	149
	Steenbok	1 080
	Grysbok	74
	Bushbuck	161
FYNBOS BIOME		
Fynbos/Thicket Mosaic		
Langebaan (40)	African elephant	7 413
	Black rhinoceros	413
	Burchells zebra	2 640
	Red hartebeest	156
	Common duiker	23
	Klipspringer	280
	Steenbok	240
	Grysbok	15
	Grey rhebok	800
	Eland	2 880
Cape Flats (40)	African elephant	7 413
	Black rhinoceros	406
	Burchells zebra	2 640
	Red hartebeest	148
	Common duiker	22
	Steenbok	192
	Grysbok	15
	Eland	2 880
Agulhas (37.5)	African elephant	7 043
	Black rhinoceros	396
	Bontebok	86
	Red hartebeest	4 218
	Common duiker	22
	Klipspringer	319
	Steenbok	274
	Grysbok	14
	Bushbuck	593
	Grey rhebok	1 140
	Eland	2 736
Stilbaai (26)	African elephant	498
	Black rhinoceros	442
	Bushpig	39
	Red hartebeest	2 886
	Bontebok	1 638
	Blue duiker	8
	Common duiker	24
	Klipspringer	255
	Steenbok	218
	Grysbok	16
	Grey rhebok	780
	Bushbuck	35
	Eland	2 808
Goukamma	African elephant	383
(19.5)	Black rhinoceros	336
	Bushpig	30
	Red hartebeest	740
	Blue duiker	6
	Common duiker	18
	Steenbok	144
	Grysbok	12
	Bushbuck	26
	Eland	2 160
St Francis (9.1)	African elephant	173
	Black rhinoceros	151
	Bushpig	14
	Red hartebeest	333
	Blue duiker	3
	Common duiker	8
	Steenbok	65
	Grysbok	5
	Bushbuck	12
	Eland	972
Sand Plain Fynbos		
Leipoldtville (48)	African elephant	8 896
	Black rhinoceros	542
	Burchells zebra	6 336
	Red hartebeest	374
	Common duiker	30
	Springbok	480
	Steenbok	20
	Grysbok	256
	Gemsbok	10 752
	Eland	3 456
Hopefield (48)	African elephant	8 896
	Black rhinoceros	542
	Burchells zebra	6 336
	Red hartebeest	374
	Common duiker	30
	Springbok	480
	Steenbok	20
	Grysbok	256
	Gemsbok	10 752
	Eland	3 456
Blackheath (40)	African elephant	4 942
	Black rhinoceros	451
	Burchells zebra	5 280
	Red hartebeest	296
	Common duiker	25
	Steenbok	16
	Grysbok	213
	Eland	1 920
Springfield (24)	African elephant	2 965
	Black rhinoceros	271
	Red hartebeest	190
	Bontebok	3 024
	Common duiker	15
	Steenbok	10
	Grysbok	128
	Grey rhebok	1 440
	African buffalo	5 136
	Eland	1 152
Albertinia (39)	African elephant	4 819
	Black rhinoceros	584
	Burchells zebra	542
	Red hartebeest	309
	Bontebok	4 914
	Common duiker	32
	Steenbok	21
	Grysbok	21
	Grey rhebok	2 340
	African buffalo	16 692
	Bushbuck	563
	Eland	1 872
Limestone Fynbos		
Hagelkraal (48)	African elephant	17 792
	Black rhinoceros	588
	Cape mnt zebra	4 032
	Red hartebeest	245
	Bontebok	139
	Common duiker	32
	Klipspringer	305
	Steenbok	21
	Grysbok	21
	Grey rhebok	960
	African buffalo	6 848
	Eland	6 912
De Hoop (48)	African elephant	17 792
	Black rhinoceros	596
	Cape mnt zebra	4 032
	Red hartebeest	245
	Bontebok	139
	Common duiker	33
	Klipspringer	367
	Steenbok	22
	Grysbok	22
	Grey rhebok	960
	African buffalo	6 848
	Bushbuck	681
	Eland	6912
Canca (45)	African elephant	16 680
	Black rhinoceros	559
	Cape mnt zebra	3 780
	Red hartebeest	230
	Bontebok	130
	Common duiker	30
	Klipspringer	344
	Steenbok	20
	Grysbok	20
	Grey rhebok	900
	African buffalo	6 420
	Bushbuck	638
	Eland	6 480
Grassy Fynbos		
Genadendal	African elephant	6 116
(32.5)	Black rhinoceros	10 890
	Cape mnt zebra	215
	Burchells zebra	3 267
	Red hartebeest	183
	Bontebok	104
	Common duiker	12
	Klipspringer	9
	Steenbok	396
	Grysbok	8
	Grey rhebok	50
	African buffalo	365
	Bushbuck	78

Appendix 1 cont.

BHU	Herbivore spp.	Ha/animal
	Eland	2 376
Suurbraak(26)	African elephant	4 819
	Black rhinoceros	8 580
	Cape mnt zebra	169
	Burchells zebra	2 574
	Red hartebeest	144
	Bontebok	82
	Common duiker	25
	Klipspringer	19
	Steenbok	312
	Grysbok	16
	Grey rhebok	39
	African buffalo	288
	Bushbuck	676
	Eland	1 872
Keurbooms(26)	African elephant	4 819
	Black rhinoceros	8 580
	Cape mnt zebra	169
	Burchells zebra	2 574
	Red hartebeest	96
	Common duiker	30
	Klipspringer	24
	Steenbok	312
	Grysbok	20
	Grey rhebok	26
	African buffalo	288
	Bushbuck	676
	Eland	1 872
Humansdorp (19.5)	African elephant	3 707
	Black rhinoceros	6 600
	Cape mnt zebra	130
	Burchells zebra	1 980
	Red hartebeest	111
	Common duiker	26
	Klipspringer	21
	Oribi	21
	Steenbok	18
	Grysbok	18
	Grey rhebok	30
	African buffalo	221
	Bushbuck	520
	Eland	1 440
Algoa (18.2)	African elephant	3 336
	Black rhinoceros	5 940
	Cape mnt zebra	117
	Burchells zebra	1 782
	Red hartebeest	100
	Common duiker	24
	Klipspringer	19
	Oribi	19
	Steenbok	16
	Grysbok	16
	Grey rhebok	27
	African buffalo	199
	Bushbuck	468
	Eland	1 296
Zuurberg (20.8)	African elephant	3 892
	Black rhinoceros	6 930
	Cape mnt zebra	137
	Burchells zebra	2079
	Red hartebeest	117
	Common duiker	25

BHU	Herbivore spp.	Ha/animal
	Klipspringer	19
	Steerbok	252
	Grysbok	16
	Grey rhebok	32
	African buffalo	232
	Bushbuck	546
	Eland	1 512
	Mountain reedbuck	41
Fynbos/Renosterveld Mosaic		
Perdeberg (144)	African elephant	17 792
	Black rhinoceros	2 155
	Cape mnt zebra	1 814
	Red hartebeest	2 131
	Common duiker	118
	Klipspringer	91
	Steenbok	960
	Grysbok	78
	Grey rhebok	576
	Eland	6 912
Elgin (112.5)	African elephant	13 962
	Black rhinoceros	1 691
	Cape mnt zebra	1 424
	Red hartebeest	1 730
	Bontebok	14 238
	Common duiker	92
	Klipspringer	72
	Steenbok	753
	Grysbok	61
	Grey rhebok	468
	Eland	5 424
Breede (98)	African elephant	12 108
	Black rhinoceros	1 467
	Cape mnt zebra	1 235
	Red hartebeest	1 450
	Common duiker	80
	Klipspringer	62
	Steenbok	653
	Grysbok	53
	Grey rhebok	392
	Eland	4 704
Elim (98)	African elephant	12 108
	Black rhinoceros	1 827
	Cape mnt zebra	1 235
	Red hartebeest	2 176
	Bontebok	1 235
	Common duiker	100
	Klipspringer	78
	Steenbok	66
	Grysbok	66
	Grey rhebok	588
	Bushbuck	1 699
	Eland	4 704
Blanco (78)	African elephant	5 189
	Black rhinoceros	522
	Cape mnt zebra	706
	Bushpig	411
	Red hartebeest	414
	Common duiker	28
	Klipspringer	22
	Steenbok	224
	Grysbok	19
	Grey rhebok	112

BHU	Herbivore spp.	Ha/animal
	African buffalo	1 198
	Bushbuck	41
	Eland	2 016
Langkloof (93.6)	African elephant	17 421
	Black rhinoceros	1 723
	Cape mnt zebra	3 553
	Burchells zebra	3 722
	Bushpig	1 379
	Red hartebeest	1 439
	Common duiker	94
	Klipspringer	73
	Oribi	3 948
	Steenbok	63
	Grysbok	63
	Grey rhebok	389
	African buffalo	6 035
	Eland	6 768
Kromme (11.7)	African elephant	2 224
	Black rhinoceros	264
	Cape mnt zebra	4 536
	Burchells zebra	328
	Bushpig	176
	Red hartebeest	184
	Common duiker	14
	Klipspringer	11
	Oribi	504
	Steenbok	10
	Grysbok	10
	Grey rhebok	50
	African buffalo	531
	Bushbuck	21
	Eland	864
Coast Renosterveld		
Swartland (96)	African elephant	53 376
	Black rhinoceros	606
	Cape mnt zebra	8 064
	Burchells zebra	445
	Red hartebeest	254
	Common duiker	33
	Springbok	2 880
	Steenbok	419
	Grysbok	419
	Grey rhebok	1 920
	Gemsbok	10 752
	Eland	20 736
Boland (96)	African elephant	53 376
	Black rhinoceros	886
	Cape mnt zebra	8 064
	Burchells zebra	445
	Red hartebeest	249
	Common duiker	48
	Springbok	2 880
	Steenbok	419
	Grysbok	32
	Grey rhebok	1 280
	Eland	20 736
Overberg (75)	African elephant	27 800
	Black rhinoceros	692
	Cape mnt zebra	9 450
	Burchells zebra	683
	Red hartebeest	488
	Bontebok	277

Appendix 1 cont.

BHU	Herbivore spp.	Ha/animal
	Blue antelope	1 153
	Common duiker	38
	Steenbok	327
	Grysbok	25
	Grey rhebok	1 716
	African buffalo	1 107
	Eland	10 800
Riversdale (70)	African elephant	25 947
	Black rhinoceros	646
	Cape mnt zebra	8 820
	Burchells zebra	637
	Red hartebeest	357
	Bontebok	203
	Common duiker	35
	Steenbok	305
	Grysbok	23
	Grey rhebok	1 400
	African buffalo	1 033
	Eland	10 080
Inland Renosterveld		
Niewoudtville (62.4)	African elephant	12 927
	Black rhinoceros	1 044
	Cape mnt zebra	781
	Burchells zebra	818
	Red hartebeest	688
	Common duiker	57
	Springbok	25
	Klipspringer	44
	Steenbok	465
	Grysbok	38
	Grey rhebok	186
	Gemsbok	1 042
	Eland	5 022
Koue-bokkeveld (76.5)	African elephant	16 055
	Black rhinoceros	1 296
	Cape mnt zebra	970
	Burchells zebra	1 016
	Red hartebeest	570
	Common duiker	71
	Springbok	31
	Klipspringer	55
	Steenbok	578
	Grysbok	47
	Grey rhebok	154
	Eland	6 237
Waveren-bokkeveld (64)	African elephant	13 344
	Black rhinoceros	1 078
	Cape mnt zebra	806
	Burchells zebra	845
	Red hartebeest	474
	Common duiker	59
	Springbok	26
	Klipspringer	46
	Steenbok	480
	Grysbok	39
	Grey rhebok	128
	Eland	5 184
Ashton (56)	African elephant	11 676
	Black rhinoceros	943
	Cape mnt zebra	706
	Burchells zebra	739
	Red hartebeest	414
	Common duiker	51
	Springbok	630
	Klipspringer	40
	Steenbok	420
	Grysbok	34
	Grey rhebok	112
	Eland	4 536
Matjies (62.4)	African elephant	12 927
	Black rhinoceros	1 279
	Cape mnt zebra	781
	Burchells zebra	818
	Red hartebeest	459
	Common duiker	70
	Springbok	698
	Klipspringer	54
	Steenbok	47
	Grysbok	47
	Grey rhebok	124
	Eland	5 022
Roggeveld (85)	African elephant	17 723
	Black rhinoceros	1 753
	Cape mnt zebra	1 071
	Burchells zebra	1 122
	Red hartebeest	944
	Common duiker	96
	Springbok	956
	Klipspringer	74
	Steenbok	64
	Grysbok	64
	Grey rhebok	255
	Gemsbok	1 428
	Eland	6 885
Montagu (105.6)	African elephant	22 101
	Black rhinoceros	2 223
	Cape mnt zebra	1 336
	Burchells zebra	1 399
	Red hartebeest	784
	Common duiker	121
	Springbok	1 193
	Klipspringer	94
	Steenbok	81
	Grysbok	81
	Grey rhebok	212
	Kudu	8 586
	Eland	8 586
Cannaland (75.6)	African elephant	15 846
	Black rhinoceros	1 594
	Cape mnt zebra	991
	Burchells zebra	1 038
	Red hartebeest	562
	Common duiker	87
	Springbok	855
	Klipspringer	68
	Steenbok	58
	Grysbok	58
	Grey rhebok	152
	African buffalo	24 396
	Kudu	6 156
	Eland	6 156
Kango (108)	African elephant	22 518
	Black rhinoceros	2 265
	Cape mnt zebra	1 408
	Burchells zebra	1 475
	Red hartebeest	799
	Common duiker	124
	Springbok	1 215
	Klipspringer	96
	Steenbok	82
	Grysbok	82
	Grey rhebok	216
	African buffalo	34 668
	Kudu	8 748
	Eland	8 748
Uniondale (115.2)	African elephant	23 978
	Black rhinoceros	2 412
	Cape mnt zebra	1 499
	Burchells zebra	1 570
	Red hartebeest	851
	Common duiker	132
	Springbok	1 294
	Klipspringer	102
	Steenbok	88
	Grysbok	88
	Grey rhebok	230
	African buffalo	36 915
	Kudu	9 315
	Eland	9 315
Mountain Complexes		
Bokkeveld (110.5)	Cape mnt zebra	1 399
	Red hartebeest	16 428
	Klipspringer	23
	Steenbok	285
	Grysbok	20
	Grey rhebok	234
	Eland	5 994
Gifberg (103.7)	Cape mnt zebra	1 310
	Red hartebeest	15 392
	Klipspringer	22
	Steenbok	267
	Grysbok	18
	Grey rhebok	219
	Eland	5 616
Cederberg (216)	Cape mnt zebra	2 722
	Red hartebeest	31 968
	Klipspringer	45
	Steenbok	555
	Grysbok	38
	Grey rhebok	455
	Eland	11 664
Olifants River (118.8)	Cape mnt zebra	1 499
	Red hartebeest	17 612
	Klipspringer	25
	Steenbok	306
	Grysbok	21
	Grey rhebok	251
	Eland	6 426
Swartruggens (153)	Cape mnt zebra	1 928
	Red hartebeest	22 644
	Klipspringer	32
	Steenbok	393
	Grysbok	27
	Grey rhebok	322
	Eland	8 262
Piketberg (144)	Cape mnt zebra	1 814

Appendix 1 cont.

BHU	Herbivore spp.	Ha/animal
	Red hartebeest	21 312
	Klipspringer	30
	Steenbok	370
	Grysbok	26
	Grey rhebok	303
	Eland	7 776
Groot Winter-hoek (216)	Cape mnt zebra	2 722
	Red hartebeest	31 968
	Klipspringer	45
	Steenbok	555
	Grysbok	38
	Grey rhebok	455
	Eland	11 664
Matroosberg (238)	Cape mnt zebra	2 999
	Red hartebeest	35 224
	Klipspringer	49
	Steenbok	612
	Grysbok	42
	Grey rhebok	501
	Eland	12 852
Hawequas (204)	Cape mnt zebra	2 570
	Red hartebeest	30 192
	Klipspringer	41
	Grysbok	35
	Grey rhebok	429
	Eland	11 016
Franschoek (204)	Cape mnt zebra	2 570
	Red hartebeest	30 192
	Klipspringer	41
	Grysbok	35
	Grey rhebok	429
	Eland	11 016
Cape Peninsula (160)	Cape mnt zebra	2 016
	Red hartebeest	23 680
	Klipspringer	33
	Steenbok	411
	Grysbok	28
	Grey rhebok	337
	Eland	8 640
Kogelberg (170)	Cape mnt zebra	2 142
	Red hartebeest	25 160
	Klipspringer	34
	Grysbok	29
	Grey rhebok	358
	Eland	9 180
KleinRiver (153)	Cape mnt zebra	1 928
	Red hartebeest	22 644
	Klipspringer	32
	Steenbok	393
	Grysbok	27
	Grey rhebok	322
	Eland	8 262
Caledon Swartberg (153)	Cape mnt zebra	1 928
	Red hartebeest	22 644
	Klipspringer	32
	Steenbok	393
	Grysbok	27
	Grey rhebok	322
	Eland	8 262
Riviersonderend (136)	Cape mnt zebra	1 714
	Red hartebeest	20 128
	Klipspringer	28

BHU	Herbivore spp.	Ha/animal
	Steenbok	350
	Grysbok	24
	Grey rhebok	286
	Eland	7 344
Koo Langeberg (204)	Cape mnt zebra	2 570
	Rec hartebeest	30 192
	Klipspringer	42
	Steenbok	525
	Grysbok	36
	Grey rhebok	429
	Eland	11 016
Waboomsberg (122.4)	Cape mnt zebra	1 537
	Red hartebeest	18 056
	Klipspringer	25
	Steenbok	314
	Grysbok	22
	Grey rhebok	257
	Eland	6 588
Witteberg (81.6)	Cape mnt zebra	1 033
	Red hartebeest	12 136
	Klipspringer	17
	Steenbok	211
	Grysbok	15
	Grey rhebok	173
	Eland	4 428
Bredasdorp (40)	Cape mnt zebra	504
	Red hartebeest	5 920
	Klipspringer	8
	Steenbok	103
	Grysbok	7
	Grey rhebok	84
	Eland	2 160
Southern Langeberg (172.8)	Cape mnt zebra	2 180
	Red hartebeest	25 604
	Klipspringer	35
	Grysbok	30
	Grey rhebok	364
	Eland	9 342
Potberg (96)	Cape mnt zebra	1 210
	Red hartebeest	14 208
	Klipspringer	20
	Steenbok	247
	Grysbok	17
	Grey rhebok	202
	Eland	5 184
Klein Swartberg (204)	Cape mnt zebra	2 570
	Red hartebeest	30 192
	Klipspringer	42
	Steenbok	525
	Grysbok	36
	Grey rhebok	429
	Eland	11 016
Rooiberg (105.6)	Cape mnt zebra	1 336
	Red hartebeest	15 688
	Klipspringer	22
	Steenbok	273
	Grysbok	19
	Grey rhebok	223
	Eland	5 724
Groot Swartberg (212.5)	Cape mnt zebra	2 684
	Red hartebeest	31 524
	Klipspringer	44

BHU	Herbivore spp.	Ha/animal
	Steenbok	548
	Grysbok	38
	Grey rhebok	448
	Eland	11 502
Outeniqua (160)	Cape mnt zebra	2 016
	Red hartebeest	23 680
	Klipspringer	33
	Steenbok	411
	Grysbok	28
	Grey rhebok	337
	Eland	8 640
Kamanassie (105.6)	Cape mnt zebra	1 336
	Red hartebeest	15 688
	Klipspringer	22
	Steenbok	273
	Grysbok	19
	Grey rhebok	223
	Eland	5 724
Tsitsikamma (172.8)	Cape mnt zebra	2 180
	Red hartebeest	25 604
	Klipspringer	35
	Grysbok	30
	Grey rhebok	364
	Eland	9 342
Kouga (134.4)	Cape mnt zebra	1 688
	Red hartebeest	29 748
	Klipspringer	28
	Steenbok	345
	Grysbok	24
	Grey rhebok	554
	Eland	7 236
	Mountain reedbuck	721
Baviaanskloof (63)	Cape mnt zebra	794
	Red hartebeest	13 986
	Klipspringer	13
	Steenbok	162
	Grysbok	11
	Grey rhebok	261
	Eland	3 402
	Mountain reedbuck	339
Cockscomb (28)	Cape mnt zebra	353
	Red hartebeest	6 216
	Klipspringer	6
	Steenbok	72
	Grysbok	5
	Grey rhebok	116
	Eland	1 512
	Mountain reedbuck	151
SUCCULENT KAROO BIOME		
Vygieveld		
Western Mountain (75)	Black rhinoceros	707
	Cape mnt Zebra	18 900
	Burchells zebra	19 800
	Red hartebeest	1 665
	Common duiker	39
	Springbok	1 125
	Klipspringer	30
	Steenbok	26
	Gemsbok	2 520
	Eland	8 100
	Grey rhebok	1 680
Klawer (58.5)	Black rhinoceros	417

Appendix 1 cont.

BHU	Herbivore spp.	Ha/animal
	Cape mnt zebra	14 868
	Burchells zebra	15 576
	Red hartebeest	873
	Common duiker	23
	Springbok	885
	Steenbok	15
	Gemsbok	1 322
	Eland	6 372
Knersvlakte (70.5)	Black rhinoceros	502
	Cape mnt zebra	17 892
	Burchells zebra	18 744
	Red hartebeest	1 051
	Common duiker	27
	Springbok	1 065
	Steenbok	18
	Gemsbok	1 590
	Eland	7 668
Tanqua (106.5)	Black rhinoceros	776
	Cape mnt zebra	26 964
	Burchells zebra	28 248
	Red hartebeest	1 584
	Common duiker	42
	Springbok	1 605
	Klipspringer	428
	Steenbok	28
	Gemsbok	2 397
	Eland	11 556
Laingsberg (61.5)	Black rhinoceros	450
	Cape mnt zebra	15 624
	Burchells zebra	16 368
	Red hartebeest	918
	Common duiker	25
	Springbok	930
	Klipspringer	248
	Steenbok	16
	Gemsbok	1 389
	Eland	6 696
Moordenaars (55.5)	Black rhinoceros	406
	Cape mnt zebra	14 112
	Burchells zebra	14 784
	Red hartebeest	829
	Common duiker	22
	Springbok	840
	Klipspringer	224
	Steenbok	15
	Gemsbok	1 254
	Eland	6 048
Touws (81)	Black rhinoceros	587
	Cape mnt zebra	20412
	Burchells zebra	21 384
	Red hartebeest	1 199
	Common duiker	32
	Springbok	1 215
	Klipspringer	324
	Steenbok	21
	Gemsbok	1 814
	Eland	8 748
Strandveld		
Namaqualand (75)	Black rhinoceros	544
	Burchells zebra	9 900
	Red hartebeest	1 110
	Common duiker	30
	Springbok	1 125
	Steenbok	20
	Grysbok	257
	Gemsbok	1 680
	Eland	8 100
Lamberts Bay (45)	Black rhinoceros	326
	Burchells zebra	5 940
	Red hartebeest	333
	Common duiker	18
	Springbok	675
	Steenbok	12
	Grysbok	154
	Eland	4 860
Broken Veld		
Garies (58.5)	Black rhinoceros	662
	Burchells zebra	779
	Red hartebeest	452
	Common duiker	36
	Springbok	708
	Klipspringer	28
	Steenbok	24
	Grysbok	295
	Grey rhebok	1 770
	Gemsbok	684
	Eland	5 098
Loeriesfontein (45)	Black rhinoceros	505
	Burchells zebra	594
	Red hartebeest	344
	Common duiker	28
	Springbok	540
	Klipspringer	21
	Steenbok	18
	Grysbok	225
	Grey rhebok	1 350
	Gemsbok	521
	Eland	3 888
Witrantjies (42)	Black rhinoceros	471
	Cape mnt zebra	1 058
	Burchells zebra	1 109
	Red hartebeest	164
	Common duiker	26
	Springbok	504
	Klipspringer	20
	Steenbok	17
	Grysbok	210
	Grey rhebok	840
	Eland	3 629
Robertson (70)	Black rhinoceros	786
	Cape mnt zebra	1 764
	Burchells zebra	1 848
	Red hartebeest	273
	Common duiker	43
	Springbok	840
	Klipspringer	33
	Steenbok	29
	Grysbok	350
	Grey rhebok	1 400
	Eland	6 048
Little Karoo (75.6)	African elephant	25 354
	Black rhinoceros	865
	Cape mnt zebra	1 981
	Burchells zebra	2 076
	Red hartebeest	296
	Common duiker	47
	Springbok	1 368
	Klipspringer	37
	Steenbok	31
	Grysbok	456
	Grey rhebok	1 520
	African buffalo	48 792
	Kudu	4 104
	Eland	9 850
Oudtshoorn (70)	African elephant	23 352
	Black rhinoceros	797
	Cape mnt zebra	1 825
	Burchells zebra	1 912
	Red hartebeest	273
	Common duiker	43
	Springbok	1 260
	Klipspringer	34
	Steenbok	29
	Grysbok	420
	Grey rhebok	1 400
	African buffalo	44 940
	Kudu	3 780
	Eland	9 072
Prince Albert (51.8)	African elephant	17 347
	Black rhinoceros	592
	Cape mnt zebra	1 310
	Burchells zebra	1 373
	Red hartebeest	203
	Common duiker	32
	Springbok	936
	Klipspringer	25
	Steenbok	22
	Grysbok	312
	Grey rhebok	1 040
	Kudu	2 808
	Eland	6 739
NAMA KAROO BIOME		
Broken Veld		
Gamka (44.2)	Black rhinoceros	494
	Burchells zebra	581
	Red hartebeest	171
	Common duiker	27
	Springbok	17
	Klipspringer	257
	Steenbok	18
	Gemsbok	4 928
	Kudu	162
	Eland	2 376
Steytlerville (27.3)	Black rhinoceros	404
	Burchells zebra	356
	Warthog	1 350
	Red hartebeest	105
	Common duiker	22
	Springbok	11
	Klipspringer	210
	Steenbok	15
	Kudu	132
	Eland	1 458
THICKET BIOME		
Mesic Succulent Thicket		
Gouritz (28)	African elephant	403

Appendix 1 cont.

BHU	Herbivore spp.	Ha/animal
	Black rhinoceros	562
	Bushpig	32
	Blue duiker	10
	Common duiker	31
	Klipspringer	274
	Grysbok	20
	African buffalo	599
	Kudu	184
	Bushbuck	44
	Eland	2 268
Gamtoos (21)	African elephant	302
	Black rhinoceros	416
	Bushpig	24
	Warthog	105
	Blue duiker	8
	Common duiker	23
	Grysbok	15
	African buffalo	449
	Kudu	136
	Bushbuck	33
	Eland	1 701
Sundays (19.6)	African elephant	288
	Black rhinoceros	396
	Bushpig	23
	Warthog	100
	Blue duiker	7
	Common duiker	22
	Grysbok	14
	African buffalo	428
	Kudu	130
	Bushbuck	31
	Eland	1 620
Aloes (8.4)	African elephant	115
	Black rhinoceros	158
	Bushpig	9
	Warthog	40
	Blue duiker	3
	Common duiker	9
	Grysbok	6
	African buffalo	171
	Kucu	52
	Bushbuck	12
	Eland	648
Xeric Succulent Thicket		
Spekboom (64.4)	African elephant	468
	Black rhinoceros	1 286
	Cape mnt zebra	24 192
	Burchells zebra	1 748
	Red hartebeest	474
	Common duiker	70
	Klipspringer	55
	Steenbok	47
	Grysbok	47
	African buffalo	2 834
	Kudu	421
	Bushbuck	1 165
	Eland	3 456
Willowmore (32.2)	African elephant	460
	Black rhinoceros	537
	Cape mnt zebra	12 096
	Burchells zebra	874
	Bushpig	36
	Red hartebeest	237
	Common duiker	29
	Klipspringer	23
	Steenbok	20
	African buffalo	1 417
	Kudu	176
	Bushbuck	499
	Eland	2 592
Addo (22.4)	African elephant	316
	Black rhinoceros	508
	Burchells zebra	5 808
	Bushpig	25
	Warthog	220
	Red hartebeest	326
	Blue duiker	9
	Common duiker	28
	Steenbok	18
	Grysbok	18
	African buffalo	496
	Kudu	166
	Bushbuck	40
	Eland	1 782
FOREST BIOME		
Afromontane Forest		
Knysna (60)	Bushpig	33
	Blue duiker	11
	Common duiker	32
	Bushbuck	47
Swellendam (60)	Bushpig	33
	Blue duiker	11
	Common duiker	32
	Bushbuck	47
Indian Ocean Forest		
Alexandria (60)	African elephant	8 340
	Bushpig	35
	Blue duiker	14
	Common duiker	43
	Grysbok	29
	African buffalo	12 840
	Bushbuck	62

Cape mnt zebra = Cape mountain zebra

Appendix 2: The common names, scientific names, feeding guilds and Large Stock Unit (LSU) equivalents of selected medium- to large-sized mammals in the Cape Floristic Region. LSU equivalents for the herbivores after Grossman (1991); that for African elephant after Meissner (1982); that for blue antelope derived from data in Skinner and Smithers (1990). Taxonomy follows Skinner and Smithers (1990)

Common name	Scientific name	Foraging guild	LSU equiv.
Chacma baboon	*Papio cynocephalus*	Omnivore	
Vervet monkey	*Cercopithecus aethiops*	Omnivore	
Porcupine	*Hystrix africaeaustralis*	Omnivore	
Aardwolf	*Proteles cristatus*	Insectivore	
Brown hyaena	*Hyaena brunnea*	Carnivore	
Spotted hyaena	*Crocuta crocuta*	Carnivore	
Cheetah	*Acinonyx jubatus*	Carnivore	
Leopard	*Panthera pardus*	Carnivore	
Lion	*Panthera leo*	Carnivore	
Caracal	*Felis caracal*	Carnivore	
African wild cat	*Felis lybica*	Carnivore	
Small spotted cat	*Felis nigripes*	Carnivore	
Serval	*Felis serval*	Carnivore	
Bat-eared fox	*Otocyon megalotis*	Carnivore	
Wild dog	*Lycaon pictus*	Carnivore	
Cape fox	*Vulpes chama*	Carnivore	
Black-backed jackal	*Canis mesomelas*	Carnivore	
Honey badger	*Mellivora capensis*	Carnivore	
Aardvark	*Orycteropus afer*	Insectivore	
African elephant	*Loxodonta africana*	Mixed feeder	2.78
Black rhinoceros	*Diceros bicornis*	Browser	1.65
Cape mountain zebra	*Equus zebra zebra*	Bulk grazer	0.63
Burchell's zebra	*Equus burchelli*	Bulk grazer	0.66
Bushpig	*Potamochoerus porcus*	Mixed feeder	0.22
Warthog	*Phacochoerus aethiopicus*	Concentrate grazer	0.25
Red hartebeest	*Alcelaphus buselaphus*	Concentrate grazer	0.37
Bontebok	*Damaliscus dorcas dorcas*	Concentrate grazer	0.21
Blue duiker	*Philantomba monticola*	Browser	0.03
Common duiker	*Sylvicapra grimmia*	Browser	0.09
Springbok	*Antidorcas marsupialis*	Mixed feeder	0.15
Klipspringer	*Oreotragus oreotragus*	Browser	0.07
Oribi	*Ourebia ourebi*	Concentrate grazer	0.07
Steenbok	*Raphicerus campestris*	Browser	0.06
Grysbok	*Raphicerus melanotis*	Browser	0.06
Grey rhebok	*Pelea capreolus*	Concentrate grazer	0.10
Blue antelope	*Hippotragus leucophaeus*	Concentrate grazer	0.49
Gemsbok	*Oryx gazella*	Concentrate grazer	0.56
African buffalo	*Syncerus caffer*	Bulk grazer	1.07
Kudu	*Tragelaphus strepsiceros*	Browser	0.54
Bushbuck	*Tragelaphus scriptus*	Browser	0.13
Eland	*Taurotragus oryx*	Mixed feeder	1.08
Mountain reedbuck	*Redunca fulvorufula*	Concentrate grazer	0.13