CHAPTER 9
ECOLOGICAL CAPACITY

INTRODUCTION

The term carrying capacity has been used in many different ways with different meanings in the past (Dhondt 1988). Little consensus exists in the literature on the definition of carrying capacity (Schmidt, Theron and Van Hoven 1995). Trollope *et al.* (1990) define carrying capacity as the potential of an area to support livestock through grazing and/or browsing and/or fodder production over an extended number of years without deterioration to the overall system. Dhondt (1988) suggests dropping the term altogether and rather using the term ecological capacity. Dhondt (1988) points out that if this term were to be used, then it must be defined as the animal density that can be sustained over a long period of time without damaging the ecosystem.

Since carrying capacity was the accepted term in the past, this term will be used only in the following description - thereafter, and in subsequent chapters, the term ecological capacity, as defined by Dhondt (1988), will be used. In terms of herbivores, the terms grazing capacity and browsing capacity will be used. Combined, the grazing capacity and browsing capacity are the ecological capacity of an area to support herbivores. Carrying capacity estimates have been in the past expressed in terms of biomass (Bigalke 1972; Coe, Cummings and Phillipson 1976) or in relation to the energy requirements of a well-studied animal through the common denominator of metabolic mass (Meissner 1982). Such animals were usually livestock. Various methods have been presented for the calculation of carrying capacity (Bigalke 1972; Coe *et al.* 1976; Mentis and Duke 1976; Mentis 1977; Danckwerts 1982a, 1982b; Meissner 1982; Moore and Odendaal 1987; Danckwerts 1989; Peel, Cummings and Phillipson undated). Carrying capacity was expressed in terms of large stock units (LSU). A large stock unit is defined as a steer of 450 kg gaining mass at a rate of 500 g on grass with a mean digestibility of 55 % and to maintain this 75 mJ of metabolic energy per day is required.

Various methods that were originally developed for the determination of the livestock carrying capacity of an area have been used for the estimation of the ecological capacity of wild ungulates (Coe *et al.* 1976; Mentis and Duke 1976; Mentis 1977; Danckwerts 1982a, 1982b; Meissner 1982; Moore and Odendaal 1987; Danckwerts 1989). Since these methods were developed mostly for grazing livestock they only gave an indication of the grazing capacity. Therefore the agricultural carrying capacity is of limited use in wildlife situations. Since rotational

grazing is difficult to implement on game ranches, the overall game ranch ecological capacity will be lower than the agricultural carrying capacity (Sievers 1991). Different habitat and feeding preferences also exist between wild ungulates and domestic stock (Sievers 1991).

According to Peel *et al.* (undated) the methods given above take into account only the grass component of the veld. These techniques were also developed for commercial livestock and are not suitable for game. Peel *et al.* (undated) indicated that the woody component of the vegetation has been omitted from these techniques. Since these two forage sources are utilised separately by grazers and browsers with some overlap between the two, Peel *et al.* (undated) suggest describing the two separately. The ecological capacity of an area should therefore be calculated as the sum of the grazing capacity and the browsing capacity. Grazing capacity describes the grazable portion of the veld and is the number of animal units per unit area of land which will achieve maximum animal production per unit input, without resulting in soil erosion or vegetation composition changes that would reduce the potential of the vegetation to produce animal products (Danckwerts 1982, In: Peel *et al.* undated). Since the woody component reacts differently to utilisation, the browsing capacity is defined as the number of browser units that may achieve stable animal production (Peel *et al.* undated). The method proposed by Peel *et al.* (undated) also takes into account the different feeding strategies among wild ungulates, namely grazers (bulk feeders and selective grazers), browsers and mixed feeders (grazers and browsers). Because of these differences in feeding patterns Peel *et al.* (undated) regarded the large stock unit method as inefficient for calculating ecological capacity. Peel *et al.* (undated) suggested calculating the ecological capacity of an area by adding the browsing and grazing capacity to derive stocking rates expressed as grazer units and browser units. A grazer unit is defined as an animal of 450 kg that grazes exclusively. A browse unit is defined as an animal of 140 kg that browses exclusively. A basal metabolic rate of $W^{0.75}$ is used.

Knowledge of the ecological capacity of the veld is essential for the development of sound management systems and the planning of reserves (Meissner 1982). Ecological capacity is affected by factors such as rainfall, veld condition, availability of palatable and nutritious plant material, water availability and distribution of water-points, competition, energy and nutritional requirements and behaviour of the animals (Meissner 1982). All of these factors must be taken into account when calculating the ecological capacity of an area. The present study will attempt to take these factors into account as far as is possible since little information in this regard exists for wild African ungulates (Meissner 1982).

The aim of this part of the study is therefore to:

- Determine the palatability and digestibility of the herbaceous and woody species.
- Determine a first approximation of the ecological capacity of Sango Ranch.

METHODS

Grazing capacity

Grazing capacity was determined using the computer program GRAZE (Bredenkamp pers. comm)[13]. Mean annual rainfall, veld condition scores, size in ha, the percentage canopy cover of trees and shrubs, grass canopy cover and information on accessibility and fire for each of the six management units of Sango Ranch were entered into the program to give the grazing capacity in ha per large stock unit.

Browsing capacity

Browsing capacity was determined from the available browse as calculated in Chapter 8 using the BECVOL method (Smit 1996). Following Von Holdt (1999) 5 % and 10 % of total available browse is used to calculate the browsing capacity. The number of browse units are derived from the assumed consumption rate for a browse unit (1 533 kg per year) (Owen-Smith 1985). Browser units are converted to large stock units by dividing dry material by 4 928 which is the dry mass feeding requirements for 1 large stock unit per year (Botha 1999). This enables the calculation of ecological capacity in a single unit.

RESULTS AND DISCUSSION

Grazing capacity

The grazing capacity estimates in ha per large stock unit and the total large stock units for average rainfall and below average rainfall periods using GRAZE (Bredenkamp pers. comm.)[13] are presented in Table 50. Wild ungulates cannot be stocked at the same rate as domestic cattle, because differences exist in their feeding behaviour and the movement of game animals cannot be controlled (Mentis 1977). Therefore wild ungulates should be stocked at a lower rate than cattle (Mentis and Duke 1976). The grazing capacity for game is usually calculated at 70 % of that for cattle (Cauldwell 1998). The *Acacia tortilis* Closed Woodland Management Unit has the highest grazing capacity of the management units of

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Table 50. Veld condition scores, benchmark comparisons and grazing capacities of the management units of Sango Ranch, Save Valley Conservancy, Zimbabwe using GRAZE (Bredenkamp pers. comm)[13].

MANAGEMENT UNIT	AREA IN HA	VELD CONDITION SCORE	GRAZING CAPACITY (HA PER LSU)				TOTAL LSU FOR GAME AVERAGE RAINFALL YEARS	TOTAL LSU FOR GAME BELOW AVERAGE RAINFALL YEARS
			Average rainfall		Below average			
			Cattle	Game	Cattle	Game		
1	7 096.7	51.0	4.7	7.9	9.0	15.0	902.7	471.9
2	21 769.8	52.3	4.3	5.9	8.2	11.2	3 686.7	1 943.0
3	10 731.6	55.4	4.0	5.8	7.4	10.8	1851.0	993.3
4	13 07.2	61.7	3.7	5.2	6.8	9.5	249.7	138.2
5	19 75.7	52.5	4.5	5.8	8.5	11.0	342.2	179.2
6	224.8	42.5	5.6	9.5	11.1	19.4	23.6	11.6
Total	43 105.8	-	-	-	-	-	7 056.0	3 737.2
Average	-	52.6	3.35	5.01	6.38	9.61	1 175.98	622.9

Sango Ranch (Table 50). The *Echinochloa colona* Wetland Management unit, with the poorest veld condition score also has the lowest grazing capacity (Chapter 6, Table 50),. The grazing capacity estimates obtained are similar to those obtained from other areas in southern Africa and are considered realistic for the Lowveld savanna areas of southern Africa (Van Rooyen pers. comm.)[11]. If 90 % of the ecological capacity estimate were considered to be in the form of grazing and 10 % browsing (Botha 1999), then the grazing and browsing estimates for Sango Ranch would be 6 350.4 LSU and 635.0 LSU, respectively for average rainfall years. During below average rainfall years the grazing and browsing capacities will be 3 363.5 LSU and 373.7 LSU, respectively.

Browsing capacity

The browsing capacity in browser units per ha which are present at two height levels on Sango Ranch are depicted in Table 51 and were calculated from Table 42. The available browse figures were taken from Table 42. The total available browse below 2 m is 10 309 675.9 kg, 5 % of this equates to 515 483.8 kg and 10 % to 1 030 967.6 kg. The total available browse from a height of 2 and 5 m above the ground is 21 795 644.5 kg, 5 % of this is 1 089 782.3 kg and 10 % of this is 2 179 564.5 kg. These figures are divided by the assumed consumption rate of 1 533 kg per year for a browse unit. Using 5 % of total available browse, the available browse below 2 m should be able to sustain 336.3 browse units or 104.6 large stock units. The available browse between 2 and 5 m should be able sustain 710.9 browse units or 221.1 large stock units. The total browsing capacity is then 0.0243 browse units per ha or 0.008 large stock units per ha or 1047.2 browse units or 325.7 large stock units. Using 10 % of total available browse, the available browse below 2 m should sustain 672.5 browse units or 209.2 large stock units, and the available browse between 2 and 5 m should be able to sustain 1 421.7 browse units or 442.2 large stock units. The total browsing capacity is then 0.0486 browse units per ha or 0.02 large stock units per ha or 2 094.2 browse units or 651.4 large stock units. The figures given in Table 51 are also calculated per management unit.

The *Colophospermum mopane* Woodland Management Unit has the highest browsing capacity (0.0360 browse units per ha), while the lowest browsing capacity is found in the *Acacia tortilis* Closed Woodland Management Unit (0.0122 browse units per ha). The low browsing capacity in the *Acacia tortilis* Closed Woodland Management Unit is due to the high canopy of the woody vegetation, which is mostly unavailable to browsers.

Table 51. Browsing capacities in browsing units per ha in two height levels of the management units of Sango Ranch, Save Valley Conservancy, Zimbabwe.

MANAGEMENT UNIT	Area (ha)	NUMBER OF BROWSE UNITS				BROWSING CAPACITY			
		5 %		10 %		5 %		10 %	
		0-2 m	>2-5 m	0-2 m	>2-5 m	0-2 m	>2-5 m	0-2 m	>2-5 m
1	7 096.7	37.5 (11.7 LSU)	69.7 (21.7 LSU)	75.0 (23.3 LSU)	139.3 (43.4 LSU)	0.0053	0.0098	0.0105	0.0196
2	21 769.8	207.3 (64.5 LSU)	512.0 (159.3 LSU)	414.7 (130.0 LSU)	1 023.9 (318.6 LSU)	0.0095	0.0235	0.0190	0.0470
3	10 731.6	77.3 (24.1 LSU)	70.4 (21.9 LSU)	154.7 (48.1 LSU)	140.7 (43.8 LSU)	0.0072	0.0066	0.0144	0.0131
4	1 307.2	8.1 (22.8 LSU)	7.9 (2.5 LSU)	16.3 (5.1 LSU)	15.8 (5.0 LSU)	0.0062	0.0060	0.0125	0.0121
5	1 975.7	5.5 (1.7 LSU)	48.5 (15.1 LSU)	11.0 (3.4 LSU)	96.9 (30.2 LSU)	0.0028	0.0246	0.0056	0.0490
6	224.8	0.5 (0.1 LSU)	2.6 (0.8 LSU)	0.9 (0.3 LSU)	5.1 (1.6 LSU)	0.0022	0.0116	0.0040	0.0227
Total	43 105.8	336.3 (104.6 LSU)	710.9 (221.1 LSU)	672.5 (209.2 LSU)	1 421.8 (442.2 LSU)	0.0078	0.0165	0.0156	0.0330

1. The *Acacia tortilis* Open Woodland Management Unit
2. The *Colophospermum mopane* Woodland Management Unit.
3. The *Combretum apiculatum* Woodland Management Unit
4. The *Acacia tortilis* Closed Woodland Management Unit
5. The *Diospyros mespiliformes* Riverine Management Unit
6. The *Echinochloa colona* Wetland Management Unit

The GRAZE method (Bredenkamp pers.comm.)[13] gave a browsing capacity of 635.0 large stock units or 0.01 large stock units per ha for average rainfall years and 373.7 large stock units or 0.008 large stock units per ha for below average rainfall years. Van Rooyen (pers. comm.) recommends a browsing capacity of 0.03 browse units per ha for the dense bushveld savanna areas of South Africa. The results obtained for Sango Ranch are almost identical to the 5 % and 10 % figures obtained by Von Holdt (1999) for an open bushveld savanna in Kenya. The browsing capacity of Sango Ranch is thus taken as 0.0486 browse units per ha or 0.02 large stock units per ha or 2 094.2 browse units or 651.4 large stock units for average rainfall years. For below average rainfall years the browsing capacity is taken as 0.0243 browse units per ha or 0.008 large stock units per ha or 1047.2 browse units or 325.7 large stock units for below average rainfall years. The stocking rates currently present on Sango Ranch are discussed in Chapter 11. The suggested ecological capacity for Sango Ranch is therefore 7 056.0 large stock units for average rainfall years and 3 727.2 large stock units for below average rainfall years, with a browsing capacity of 651.4 large stock units for all years.