SHORT COMMUNICATION

A comparison of some methods used to estimate the grazing capacity of a game ranch in Northern Province, South Africa

SCHMIDT, A.G., G.K. THERON and **W. VAN HOVEN**

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The grazing capacity of a game ranch in Northern Province was estimated in a number of different ways using rainfall and herbaceous composition and phytomass data. The results indicate that the grazing capacity under the present environmental conditions should be approximately 50 % of the recommended agricultural grazer stocking rate. This is in agreement with recent literature, indicating that the methods used should be suitable for determining a first approximation of grazing capacity in the mixed bushveld of Northern Province.

Key words: Grazing capacity, stocking rate, game, bushveld.

A.G. Schmidt, G.K. Theron and W. van Hoven, Centre for Wildlife Management, University of Pretoria, Pretoria, 0002 Republic of South Africa. (Schmidt, Present address*: Port Elizabeth Technikon, Faculty of Forestry, Saasveld campus, Private Bag X6531, George 6530).*

There is no consensus on the definition of grazing or browsing capacity in the literature. The related term carrying capacity was first introduced in 1922 and has since been used in many different ways with many different meanings (Dhondt 1988). In this study the following definition of grazing/browsing capacity by Trollope *et al.* (1990) is used: The productivity of the grazeable/browseable portion of a homogeneous unit of vegetation expressed as the area of land required to maintain a single large stock unit over an extended number of years without deterioration to vegetation or soil. Grazing/browsing capacity is therefore a habitat characteristic and must be distinguished from the term stocking rate, which in this paper refers to the area of land the range manager allots to each large stock unit.

The word "extended" in grazing capacity definitions can imply that grazing capacity remains constant over a number of years (Danckwerts 1982). This is strictly not correct since changes in environmental parameters and grazing pressure cause short-term fluctuations in grazing capacity (Danckwerts 1982).

In this paper the grazing capacity of a game ranch in Northern Province is estimated in a number of different ways. Some of the methods use rainfall data over an extended

period while other methods use vegetation data collected at a specific time. Both short- and long-term estimates have been made with the objective of attaining a first approximation of the grazing capacity.

The study was conducted on Rhino Ranch, a 2 066-ha game ranch situated approximately 40 km east of Ellisras. It is located between 23°30'—23°34'S and 28°00'—28°05'E in the transition zone between Arid Sweet Bushveld and Mixed Bushveld (Acocks 1988). The rock substrate belongs to the Bushveld Complex and consists of coarse-grained granite, anorthosite and gabroid rock. The anorthosite and gabroid rock has weathered to give deep clay soils of the Hutton and Arcadia soil forms and the coarse-grained granite has weathered to form shallow, relatively sandy, soils of the Mispah soil form. Three management units, each associated with one of the above soil forms, have been classified for the area (Schmidt *et al.* 1993). The mean annual rainfall for the Villa Nora rainfall station (station number 06751829; 23°32'S, 28°07'E; 844 m) for the period 1909 to 1990 is 437.8 mm (Weather Bureau, Department of Environment Affairs, Pretoria). The mean annual rainfall during the study period (July 1988 to June 1990) was 372 mm.

The following methods were used to calculate several long and short-term estimates of the grazing capacity on Rhino Ranch from rainfall and vegetation data:

1. The Rainfall method of Coe, Cumming & Phillipson (1976)

Coe *et al.* (1976) tested the hypothesis that it is possible to predict the large herbivore biomass of semi-arid African savannas from annual rainfall data. They found, with linear regression analysis, a significant relationship ($r = 0.94$, $P \leq 0.001$) between annual rainfall (range: 165 to 650 mm) and large herbivore biomass (range: 405 to 4 848 kg/km^2). The regression equation they calculated for wildlife areas receiving less than 700 mm rainfall annually, was:

Large Herbivore Biomass (kg/km^2)
= 8.684 x (mean annual rainfall) - 1205.9

The herbivore biomass data used by Coe *et al.* (1976) included game census estimates from twelve east and southern African wildlife areas. The census data included a wide range of the most common large African grazers and browsers. Herbivore biomass estimates obtained from the above equation would therefore represent first approximations of the combined grazing and browsing capacity of an area.

The long-term grazing capacity was estimated by substituting the mean annual rainfall for Villa Nora for the period 1909 to 1990 (437.8 mm) into the equation. The short-term grazing capacity for the duration of the study period was estimated by substituting the mean annual rainfall for the period July 1988 to June 1990 (372 mm) into the equation.

To make the grazing capacity estimates comparable to the estimates discussed below, the large herbivore biomass in kg/km^2 was divided by 450, the mass in kilograms of a large stock unit (L.S.U.) (Anon 1985). The unit area was also changed from km^2 to ha. The grazing capacity estimate was therefore converted from kg live mass/km^2 to ha/L.S.U..

2. The combined veld condition and rainfall method of Danckwerts (1989)

Danckwerts (1989) provides a grazing capacity model for the False Thornveld (Acocks 1988) of the Eastern Cape, based on veld condition and mean annual rainfall, for areas where *Acacia karroo* does not dominate the woody vegetation or where

woody vegetation is absent. The herbaceous layer of the False Thornveld of the Eastern Cape is an example of typical semi-arid sweet grassveld and therefore it was assumed that the model of Danckwerts (1989) should provide reasonable estimates of the grazing capacity on Rhino Ranch. The model used for Rhino Ranch was thus the following:

$$GC = \{-0.03 + 0.00289 \times (X_1) + [(X_2 - 419.7) \times 0.000633]\}$$

Where:

GC = Grazing capacity in large stock units per hectare
X1 = percentage veld condition score
X2 = mean rainfall in millimeters per year

The above model requires sample site veld condition scores to be expressed as a percentage of a benchmark veld condition score. The highest veld condition score across all management units on Rhino Ranch at the end of the 1989 season was taken as the benchmark's veld condition score. Short- and long-term grazing capacity estimates for Rhino Ranch were calculated by substituting into the model the mean veld condition score for Rhino Ranch and the annual rainfall for Villa Nora for the periods July 1988 to June 1989 (387.5 mm) and July 1909 to June 1990 (437.8 mm) respectively.

3. The herbaceous phytomass method of Moore & Odendaal (1987)

Moore & Odendaal (1987) used the following formula to calculate grazing capacity from herbaceous phytomass data in the eastern Kalahari Thornveld (Acocks 1988) near Vryburg:

$$\text{Grazing capacity (L.S.U. ha}^{-1}\text{ a}^{-1}) = \frac{\text{phytomass (kg/ha)} \times 0.35^{b}}{10^{bb} \times 365^{bbb}}$$

where,

[b] Utilisation factor: Only 35 % of the herbaceous material is grazed while 40 % remains as tufts and stubbles and 25 % is lost to environmental factors

[bb] 10 kg feed per day is required per large stock unit

[bbb] Number of days in a year

This equation was used to calculate the grazing capacity on Rhino Ranch from herbaceous phytomass data collected in April 1990 (Schmidt 1992). Grazing capacity was calculated for the dormant period (May to September), and not for the entire year as in the above equation. It was reasoned that the availability of grazeable material during the dormant period would determine the grazing capacity for the year. The comparative yield method (Haydock & Shaw 1975) was combined with the dry-weight-rank method ('tMannetje & Haydock 1963) to simultaneously estimate the herbaceous phytomass and composition on Rhino Ranch. This approach is recommended by Snyman *et al.* (1990) for the semi-arid savanna of Northern Province and allows grass phytomass to be separately estimated from forb phytomass. Only grass phytomass was considered in the above equation.

The long and short-term estimates of the combined grazing and browsing capacity on Rhino Ranch using the equation of Coe *et al.* (1976) were 0.058 and 0.045 L.S.U/ha (or 120 and 93 L.S.U. for Rhino Ranch) respectively. If 80 % of the combined estimate were considered to represent a grazing capacity estimate and 20 % a browsing capacity estimate, after the stocking rate rule of thumb of Mentis (1983) (40 % L.S.U. bulk grazer to 40 % L.S.U. concentrate grazer to 20 % L.S.U. browser), then the long- and short-term grazing capacity estimates for Rhino Ranch would be 0.046 and 0.036 L.S.U./ha (or 96 and 74 L.S.U. for Rhino Ranch) respectively. These estimates are the most conservative of all the grazing capacity estimates (Table 1). The equation of Coe *et al.* (1976) was,

however, derived from a regression analysis between rainfall data and aerial game counts. According to Bothma *et al.* (1990), most game and particularly browsers, tend to be under-counted rather than over-counted during aerial game counts. Under-counting may therefore partly account for the conservative estimate of grazing capacity. In the large natural wildlife areas surveyed by Coe *et al.* (1976), there may also have been predator-prey relations keeping the large herbivore biomass below the grazing capacity of the area. A further inherent cause of variation in the equation of Coe *et al.* (1976) is the standard fault (2.28) in the slope of the regression equation (8.684).

The long-term grazing capacity estimate from the equation of Danckwerts (1989), 0.090 L.S.U./ha (or 185 L.S.U. for Rhino Ranch), is closest to the long-term agricultural grazer stocking rate recommendation of 0.010 L.S.U./ha (or 207 L.S.U. for Rhino Ranch) (Anon 1993). This estimate is derived from short-term veld condition data and long-term rainfall data. The estimate probably represents an attainable grazing capacity under a more favourable rainfall regime and improved veld condition.

The short-term grazing capacity estimates using the model of Danckwerts (1989) and Moore & Odendaal (1987) are similar at

Table 1

The data and results of four methods used to estimate the long-term and short-term grazing capacity of Rhino Ranch, Northern Province

Method	Data			Grazing Capacity	
	Mean Annual Rainfall (mm)	Percentage Veld Condition Score	Grass Phytomass (kg/ha)	L.S.U. per ha	L.S.U. Rhino Ranch
Coe *et al.* (1976)					
long-term	437.8	-	-	0.046	96
short-term	372.0	-	-	0.036	74
Danckwerts (1989)					
long-term	437.8	37	-	0.090	185
short-term	387.5	37	-	0.057	118
Moore & Odendaal (1987)					
short-term	-	-	222	0.052	107
Grazing capacity maps (Anon 1993)					
long-term	-	-	-	0.100	207

0.057 and 0.052 L.S.U/ha (or 118 and 107 L.S.U. for Rhino Ranch) respectively. These estimates are approximately 50 % of the long-term agricultural grazer stocking rate recommendation of 0.010 L.S.U/ha (or 207 L.S.U. for Rhino Ranch) (Anon 1993). The low grazing capacity estimates are probably mainly due to the below average annual rainfall in the years just prior to the survey period (387.8 mm for the period July 1985 to June 1990). Past mismanagement may also have played a role, but it is unlikely that overstocking at the time of the surveys had a significant affect. The stocking rate on Rhino Ranch in 1989 was estimated from aerial game counts to be approximately 0.048 L.S.U./ha (or 99 L.S.U. for Rhino Ranch). The short-term grazing capacity estimates of Danckwerts (1989) and Moore & Odendaal (1987) are in line with the recommendations of Peel *et al.* (1991) who, under similar conditions to those prevailing in the present survey, suggest that grazer stocking rates in Northern Province should be 50 % of the recommended agricultural grazer stocking rate.

Although it is recognised that it is impossible to accurately determine the grazing capacity of an area, it would appear as if the methods of Coe *et al.* (1976), Danckwerts (1989) and Moore & Odendaal (1987) are suitable for determining a first approximation of grazing capacity in the Northern Province mixed bushveld. It is recommended that systems of adaptive management (Walters & Hilborn 1978) be implemented on game ranches and that initial stocking rate decisions for large herbivores be based on one of the above methods. Annual monitoring of parameters, such as herbaceous composition and phytomass, should then be used to further adjust stocking rates.

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