Landscape preference of the white rhinoceros in the central and northern Kruger National Park

D.J. PIENAAR, J. DU P. BOTHMA and G.K. THERON

Pienaar, D. J., J. du P. Bothma and G. K. Theron. 1993. Landscape preference of the white rhinoceros in the central and northern Kruger National Park. *Koedoe* 36(1): 79–85. Pretoria. ISSN 0075-6458.

The long-term landscape preferences of the white rhinoceros for 32 different landscapes in the central and northern Kruger National Park are investigated. A preference index and a chi-square test are used to ascertain if white rhinoceroses prefer or avoid a particular landscape as habitat. Landscapes 13 (Karoo Sediment Plains with *Acacia welwitschii* Tree Savanna) and 11 (Slightly Undulating Granitoid Plains with *Colophospermum mopane* Bush Savanna), are the most preferred landscapes. Landscapes 23 (Basaltic Plains with *Colophospermum mopane* Shrub Savanna), 25 (Moderately Undulating Gabbroic Plains with *Colophospermum mopane* Shrub Savanna), 26 (Irregular Calsitic Plains with *Colophospermum mopane* Shrub Savanna), 28 (Alluvial Plains with *Acacia albida* Tree Savanna), 32 (Recent Sandy Plains with *Baphia massaiensis* Bush Savanna) and 33 (Slightly Undulating Andesitic Plains with *Combretum collinum* Shrub Savanna) appear to be avoided. Characterestics of the preferred landscapes are: moderate to dense grass cover with good quality grasses; open to moderate low-shrub (<2 m) stratum; a moderate tree stratum; an undulating topography with uplands, bottomlands and watercourses; sandy soils with few stones and rocks on the soil surface; permanent water sources.

Key words: *Ceratotherium simum simum*, white rhinoceros, landscape preference, habitat preference, tree savanna, shrub savanna.

D.J. Pienaar, Centre for Wildlife Research, University of Pretoria, Pretoria, 0002. Current address: Kruger National Park, Private Bag X402, Skukuza, 1350; *J. du P. Bothma and G. K. Theron, Centre for Wildlife Research, 0002 University of Pretoria, Pretoria.*

Introduction

Most of the white rhinoceroses reintroduced to the Kruger National Park were released south of the Sabie River in the southern Kruger National Park (Pienaar *et al.* 1992). Six white rhinoceroses (4 males and 2 females) were successfully relocated along the Tsende River in the northern Kruger National Park in January 1964 (Pienaar 1970). By 1991 there were 72 white rhinoceroses in the area between the Olifants and the Limpopo Rivers and sightings have now been made through virtually the whole northern area.

In early 1964 it was observed that some white rhinoceroses were crossing the Sabie River, colonising the central Kruger National Park (Pienaar 1970). By 1991 there were 197 white rhinoceroses between the Sabie and Olifants Rivers. As there are no physical barriers to impede their movements, the animals could move to areas of their choice. This study investigates their dispersal into the 32 different landscapes available to them in the central and northern Kruger National Park (Fig. 1).

The boundaries of the central and northern part of the Kruger National Park are the Sabie River in the south, the Limpopo and Levuvhu rivers in the north, private game reserves and homelands in the west, while the Lebombo Mountain form the boundary with Mozambique in the east. The study area is fenced on the east and west. The geomorphology of the western part consists of deeply weathered underlying granite and gneiss, resulting in an undulating landscape with distinct uplands and bottomlands. Gabbro intrusions occur in the western part and the granites and basalts are separated by a strip of sandstone and

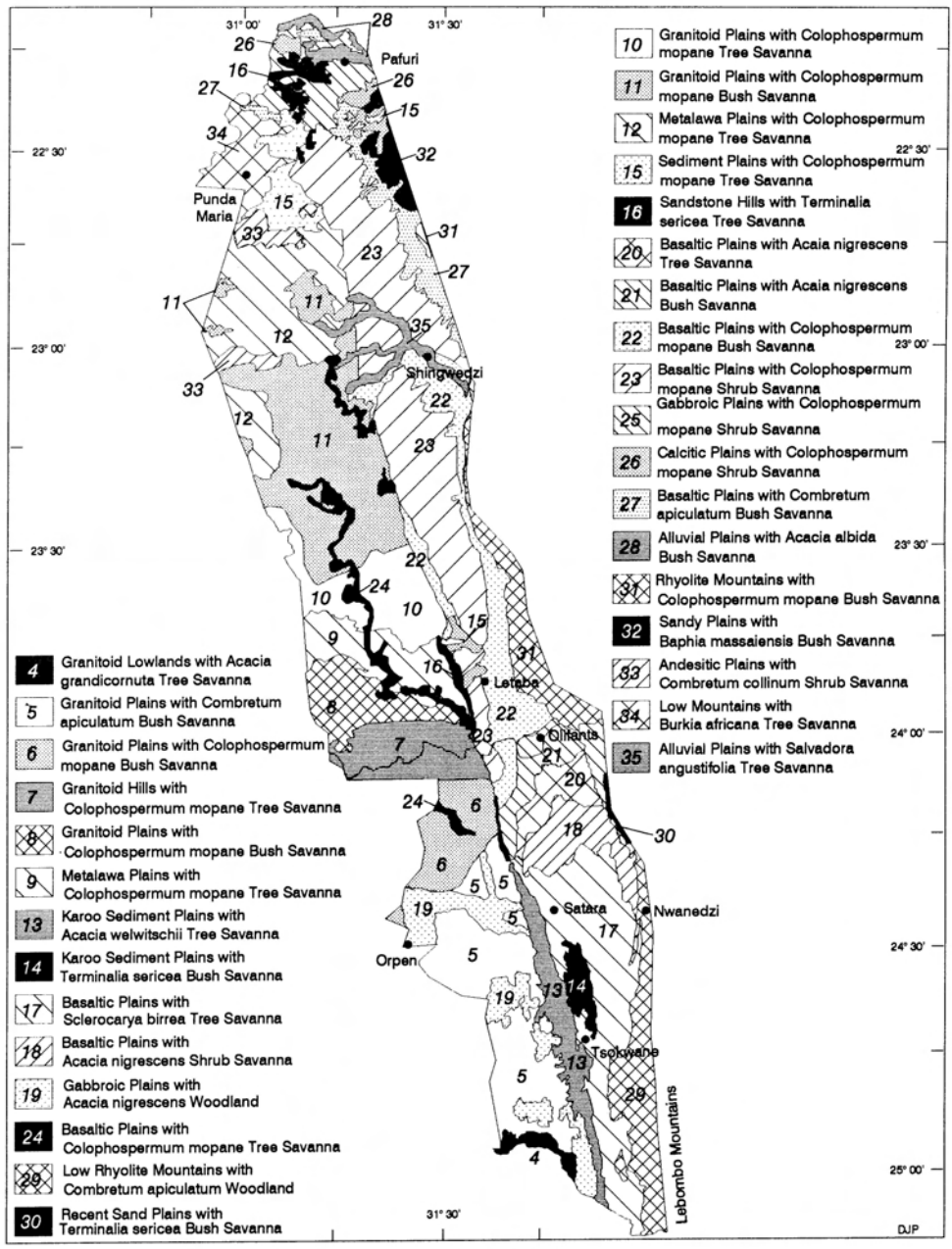

Fig. 1. Landscapes in the central and northern Kruger National Park based on Gertenbach (1987).

shale. The eastern part is underlain by basalts and consists of reasonably flat plains with clay soil. The altitude ranges from 180 m above sea level in the southeast to 580 m in the northwest (Venter 1990). Rainfall occurs mainly during the hot summer months (Gertenbach 1980), and ranges from 430 mm to 600 mm per annum.

This study investigates the white rhinoceros dispersal into, and their choice of, the 32 different landscapes available to them in the central and northern Kruger National Park (Fig. 1) over a period of 13 years. The aim of this study is to investigate the free choice of habitat and the natural dispersal of white rhinoceroses in the Kruger National Park. By ascertaining which landscapes the white rhinoceros selects and avoids and then evaluating the physical characteristics of those landscapes, forecasts can be made regarding the suitability of other areas as white rhinoceros habitat. This is important when relocating white rhinoceroses in order for the animals to be released in the most suitable habitat.

Methods

Details of the methods used to establish white rhinoceros landscape preference in the Kruger National Park have been described by Pienaar *et al.* (1992) but will be briefly outlined again below.

A preference index is used to get a perception of the ratio of habitat use to habitat availability. A chi-square test is then performed to test for the goodness-of-fit of utilised habitat to available habitat types. The null hypotheses tested by the chi-square test is:

H_{01}: usage occurs in proportion to availability, considering all habitats simultaneously, with the option of testing

H_{02}: usage occurs in proportion to availability, considering each habitat separately.

When the chi-square test shows a significant difference in usage versus availability, a Bonferroni z-statistic is used to construct confidence intervals based on the proportion of time an animal uses each habitat type, in order to determine which habitat types are used more or less than expected.

The landscapes where no white rhinoceros were counted for 13 years were not tested with the Bonferroni z-statistic, as the animals obviously avoided these landscapes. The landscape preference was determined for the summed aerial count data from 1979 to 1991.

Results

The preference index of white rhinoceros landscape use in the central and northern Kruger National Park indicates landscapes 14, 13, 18, 6, 5, 11, 29, 20, 17, 10, 16, and 19 as being preferred and landscapes 12, 30, 4, 21, 24, 7, 22, 35, 27, 31, 23, 8, 15, 34, 9, 25, 26, 28, 32, and 33 as being avoided (Fig. 1; Table 1). Table 2 shows the frequency, mean density, proportional landscape use and preference index for data summarised for the central and northern Kruger National Park over the period 1979 to 1991.

The chi-square test for the overall data set from 1979 to 1991 rejected the H_{01} (χ^2= 3 634,906; $P < 0{,}001$; $df = 26$). Landscapes 25, 26, 28, 32 and 33 where no white rhinoceros has been observed for 13 years (Table 2), were not included in this test as they are obviously avoided.

To determine which landscapes are preferred or avoided, confidence intervals were constructed around the proportion of white rhinoceroses counted in each landscape from 1979 ot 1991. When the availability proportion of each landscape was checked against the corresponding confidence interval, H_{02} was rejected for landscapes 13, 11, and 23 (Table 3). The conclusion is that landscapes 13 and 11 are preferred, landscape 23 is avoided and that the other landscapes appear (given the current sample size) to be used by the white rhinoceros roughly in proportion to their relative occurrence in the central Kruger National Park ($\alpha = 0{,}1$; $P < 0{,}01$; $k = 27$).

Discussion

The above results show that Landscape 13 is clearly the most preferred landscape of the white rhinoceros in the central Kruger National Park on a long-term basis. It is also the principal landscape where white rhinoceros distribution is concerned. The soils are sodic and have poor internal drainage with the re-

Table 1
Landscapes described by Gertenbach (1983 & 1987) for the central and northern Kruger National Park, and their respective sizes (km^2)

Landscape number	Landscape name	Size	Proportion of study area
17	Basaltic Plains with *Sclerocarya birrea* Tree Savanna	1 072	0,068
5	Moderately Undulating Granitoid Plains with *Combretum apiculatum* Woodland	1 036	0,066
19	Moderately Undulating Gabbroic Plains with *Acacia nigrescens* Woodland	625	0,041
29	Low Rhyolite Mountains with *Combretum apiculatum* Woodland	623	0,040
6	Slightly Irregular Granitoid Plains with *Colophospermum mopane* Tree Savanna	387	0,025
18	Slightly Undulating Basaltic Plains with *Acacia nigrescens* Shrub Savanna	364	0,023
13	Karoo Sediment Plains with *Acacia welwitschii* Tree Savanna	339	0,021
20	Regular Basaltic Plains with *Acacia nigrescens* Bush Savanna	210	0,013
21	Irregular Basaltic Plains with *Acacia nigrescens* Bush Savanna	248	0,016
7	Irregular Granitoid Hills with *Colophospermum mopane* Tree Savanna	516	0,033
14	Karoo Sediment Plains with *Terminalia sericea* Bush Savanna	120	0,008
4	Granitoid Lowlands with *Acacia grandicornuta* Tree Savanna	118	0,008
31	Low Rhyolite Mountains with *Colophospermum mopane* Bush Savanna	549	0,035
22	Irregular Basaltic Plains with *Colophospermum mopane* Bush Savanna	844	0,054
16	Very Irregular Clarens Sandstone Hills with *Terminalia sericea* Tree Savanna	207	0,013
24	Slightly Undulating Basaltic Plains with *Colophospermum mopane* Shrub Savanna	266	0,017
23	Basaltic Plains with *Colophospermum mopane* Shrub Savanna	2 063	0,132
30	Recent Sand Plains with *Terminalia sericea* Bush Savanna	18	0,001
11	Slightly Undulating Granitoid Plains with *Colophospermum mopane* Bush Savanna	1 479	0,094
10	Very Irregular Granitoid Plains with *Colophospermum mopane* Tree Savanna	620	0,040
12	Metalawa Plains with *Colophospermum mopane* Tree Savanna	1 077	0,069
35	Alluvial Plains with *Salvadora angustifolia* Tree Savanna	174	0,011
27	Slightly Undulating Basaltic Plains with *Combretum apiculatum* Bush Savanna	347	0,022
8	Moderately Undulating Granitoid Plains with *Colophospermum mopane* Bush Savanna	419	0,027
15	Karoo Sediment Plains with *Colophospermum mopane* Tree Savanna	316	0,020
34	Low Soutpansberg Group Mountains with *Burkea africana* Tree Savanna	341	0,022
9	Slightly Undulating Metalawa Plains with *Colophospermum mopane* Tree Savanna	421	0,027
25	Moderately Undulating Gabbroic Plains with *Colophospermum mopane* Shrub Savanna	359	0,023
26	Irregular Calcitic Plains with *Colophospermum mopane* Shrub Savanna	78	0,005
28	Alluvial Plains with *Acacia albida* Tree Savanna	91	0,006
32	Recent Sandy Plains with *Baphia massaiensis* Bush Savanna	153	0,010
33	Slightly Undulating Andesitic Plains with *Combretum collinum* Shrub Savanna	162	0,010
TOTAL		15 669	1,000

Table 2

Landscape utilisation data for the white rhinoceros in the central and northern Kruger National Park, depicting mean density of white rhinoceroses per landscape (animals km^{-2}), frequency of white rhinoceroses (number counted in each landscape) and preference indices of white rhinoceroses for the 18 landscapes for the period 1979 to 1991

Land-scape	Frequency	Density	Proportion of count ($\hat{P}_i$)	Preference index
14	131	0,0840	0,0565	0,8644
13	303	0,0688	0,1306	0,8343
18	169	0,0357	0,0729	0,6811
6	167	0,0332	0,0720	0,6569
5	281	0,0209	0,1211	0,4541
11	370	0,0192	0,1595	0,4081
29	154	0,0190	0,0664	0,4010
20	51	0,0187	0,0220	0,3903
17	211	0,0151	0,0909	0,2478
10	103	0,0128	0,0444	0,1087
16	33	0,0123	0,0142	0,0712
19	101	0,0119	0,0435	0,0442
12	121	0,0086	0,0522	-0,2412
30	2	0,0086	0,0009	-0,2496
4	13	0,0085	0,0056	-0,2560
21	15	0,0047	0,0065	-0,5915
24	15	0,0043	0,0065	-0,6191
7	15	0,0022	0,0065	-0,8037
22	23	0,0021	0,0099	-0,8160
35	4	0,0018	0,0017	-0,8447
27	7	0,0016	0,0030	-0,8636
31	6	0,0008	0,0026	-0,9262
23	18	0,0007	0,0078	-0,9411
8	3	0,0006	0,0013	-0,9516
15	2	0,0005	0,0009	-0,9573
34	1	0,0002	0,0004	-0,9802
9	1	0,0002	0,0004	-0,9840
25	0	0	0	−1
26	0	0	0	−1
28	0	0	0	−1
32	0	0	0	−1
33	0	0	0	−1
Total	2 320	Mean = 0,0124	1	-

sult that small pans commonly occur. Dominant grasses include *Sporobolus nitens, Dactyloctenium aegypteum, Chloris virgata, Panicum coloratum* and *P. maximum*. The structure of the woody component comprises a moderate tree savanna with tall shrubs and sparse low shrubs. As a result of the palatable short grazing, the open low shrub layer and the large number of small pans, this landscape is favourable to white rhinoceroses.

Landscape 11, is the most preferred landscape of the white rhinoceros in the northern Kruger National Park. Landscape 11 has an undulating topography with distinct bottomlands where accumulation of clay and minerals takes place. Pans used by white rhinoceroses for wallowing also occur frequently. The tree, high shrub and low shrub stratum have a crown cover percentage of 4, 10 and 8 respectively. The herbaceous layer is moderate to dense and usually less than 1 m in height. Dominant grasses are *Digitaria eriantha, Panicum maximum, Heteropogon contortus, Pogonarthria squarrosa, Schmidtia pappophoroides, Brachiaria nigropedata* and *Aristida meridionalis*.

Landscapes 23, 25, 26, 28, 32, 33, (Fig. 1, Table 2) in the central and northern Kruger National Park are all avoided by the white rhinoceros.

Landscape 23 is the largest landscape in the Kruger National Park and consists of flat to concave plains with clay soils underlain by basalt. The woody vegetation is dominated by multi-stemmed *Colophospermum mopane* shrubs, 1 m to 2 m high. The herbaceous layer is dense and is dominated by *Bothriochloa radicans, Themeda triandra, Schmidtia pappophoroides, Cenchrus ciliaris, Panicum coloratum* and *Setaria woodii*. Although Landscape 23 is avoided in the long term, a recent shift of white rhinoceroses from Landscape 11 to Landscape 23, thought to be temporary and drought related, has been observed. Large areas of Landscape 11 were burnt in 1991 and with the present drought (the worst in 60 years), there has been almost no grass regrowth to date. However, on the plains of Landscape 23 the grass cover is still relatively good, and this is where the white rhinoceroses are presently feeding (pers obs., August 1992).

Table 3
White rhinoceros landscape preference or avoidance in the central and northern Kruger National Park between 1979 and 1991 (α=0,1; P <0,01; k=27; $Z\alpha/2k$=2,90236)

Landscape number	Chi-square contribution	Proportion of landscape	Confidence interval	Preference or avoidance
14	721,629	0,0081	$-0,0021 \leq P_{14} \leq 0,1150$	Neutral
13	1273,299	0,0229	$0,0744 \leq P_{13} \leq 0,1868$	Prefer
18	245,833	0,0246	$0,0148 \leq P_{18} \leq 0,1309$	Neutral
6	210,016	0,0261	$0,01394 \leq P_{6} \leq 0,1300$	Neutral
5	106,155	0,0699	$0,0646 \leq P_{5} \leq 0,1776$	Neutral
11	104,142	0,0998	$0,1042 \leq P_{11} \leq 0,2147$	Prefer
29	41,346	0,0420	$0,0082 \leq P_{29} \leq 0,1246$	Neutral
20	12,745	0,0142	$-0,0376 \leq P_{20} \leq 0,0816$	Neutral
17	17,218	0,0723	$0,0335 \leq P_{17} \leq 0,1484$	Neutral
10	1,367	0,0418	$-0,0145 \leq P_{10} \leq 0,1033$	Neutral
16	0,180	0,0140	$-0,0456 \leq P_{16} \leq 0,0741$	Neutral
19	0,206	0,0440	$-0,0154 \leq P_{19} \leq 0,1025$	Neutral
12	9,278	0,0726	$-0,0065 \leq P_{12} \leq 0,1108$	Neutral
30	0,166	0,0012	$-0,0594 \leq P_{30} \leq 0,0611$	Neutral
4	1,144	0,0080	$-0,0545 \leq P_{4} \leq 0,0657$	Neutral
21	12,847	0,0167	$-0,0536 \leq P_{21} \leq 0,0665$	Neutral
24	15,098	0,0179	$-0,0536 \leq P_{24} \leq 0,0665$	Neutral
7	49,346	0,0348	$-0,0536 \leq P_{7} \leq 0,0665$	Neutral
22	83,198	0,0569	$-0,0500 \leq P_{22} \leq 0,0699$	Neutral
35	18,384	0,0117	$-0,0585 \leq P_{35} \leq 0,0619$	Neutral
27	38,332	0,0234	$-0,0572 \leq P_{27} \leq 0,0632$	Neutral
31	69,730	0,0370	$-0,0576 \leq P_{31} \leq 0,0628$	Neutral
23	270,515	0,1391	$-0,0523 \leq P_{23} \leq 0,0678$	Avoid
8	56,183	0,0283	$-0,0589 \leq P_{8} \leq 0,0615$	Neutral
15	42,873	0,0213	$-0,0594 \leq P_{15} \leq 0,0611$	Neutral
34	48,509	0,0230	$-0,0598 \leq P_{34} \leq 0,0607$	Neutral
9	60,351	0,0284	$-0,0598 \leq P_{9} \leq 0,0607$	Neutral
Total	3 634,906	1	–	–

The landscapes in Table 3 which are classed as neutral in terms of white rhinoceros use, fall on a gradient between the two extremes with some being more preferred than others. From the preference index (Table 2) it can be seen that Landscapes 14, 18, 6 and 5 also have acceptable white rhinoceros habitat. It can thus be accepted that the rate of increase in white rhinoceros density in these landscapes will be higher than in the landscapes shown to be avoided in Table 2. If the white rhinoceros density in one of these landscapes increases, it may be considered as a preferred landscape.

Conclusions

White rhinoceroses exhibit a definite preference and avoidance for certain landscapes in the central Kruger National Park. Landscape 13 (Karoo Sediment plains with *Acacia welwitschii* tree-savanna) is by far the most preferred landscape while landscapes 23 (Basaltic Plains with *Colophospermum mopane* Shrub Savanna), 25 (Moderately Undulating Gabbroic Plains with *Colophospermum mopane* Shrub Savanna), 26 (Irregular Calcitic Plains with *Colophospermum mopane* Shrub Savanna), 28 (Alluvial Plains with *Acacia*

albida Tree Savanna), 32 (Recent Sandy Plains with *Baphia massaiensis* Bush Savanna) and 33 (Slightly Undulating Andesitic Plains with *Combretum collinum* Shrub Savanna) appear to be avoided. If white rhinoceroses are to be moved out of the southern Kruger National Park they should be released in landscapes 13, 14, 5, 6 and 18 of the central and northern districts.

The landscapes of the Kruger National Park selected by white rhinoceroses have most of the following characteristics:

- a moderate to dense grass cover with good quality grasses;
- an open to moderate low-shrub (<2 m) stratum;
- a moderate tree stratum;
- an undulating topography with uplands, bottomlands and watercourses;
- sandy soils with few stones and rocks on the soil surface;
- access to permanent water sources;
- the occurrence of small pans for mud baths.

The white rhinoceros population in the Kruger National Park tends to avoid landscapes characterised by:

- a sparse grass cover with poor quality grasses;
- a dense low-shrub stratum;
- plains with sparse tree and high-shrub strata;
- very mountainous or broken terrain;
- soils with abundant stones and rocks on the surface;
- a shortage of permanent water.

Both the methods used here to ascertain habitat preference yield similar results. Although the preference index is not a statistical test, it ranks the landscapes according to animal density and provides a direct indication of each landscape's relative importance as habitat for the white rhinoceros. It is thus viewed as an acceptable method to ascertain preference when used in combination with a statistical test as done in this study.

Acknowledgements

We are grateful to the National Parks Board for allowing us to carry out this study and for logistical assistance. We thank the Rhino & Elephant Foundation, the Shikar-Safari Club International, the University of Pretoria and the FRD for financial support. We thank our colleagues in the Kruger National Park for their support, in particular Mr P.C. Viljoen, Mrs M. Rochat, Mr D. Barrat, Dr H. Biggs, Dr A.J. Hall-Martin, Dr W.P.D. Gertenbach and Dr C. Knox. The data in this paper form part of an M.Sc. study conducted on the white rhinoceros by the senior author.

References

GERTENBACH, W.P.D. 1980. Rainfall patterns in the Kruger National Park. *Koedoe* 23: 35-43.

GERTENBACH, W.P.D. 1983. Landscapes of the Kruger National Park. *Koedoe* 26: 9-121.

GERTENBACH, W.P.D. 1987. *'n Ekologiese studie van die suidelikste mopanieveld in die Nasionale Krugerwildtuin.* Ph.D. thesis, University of Pretoria, Pretoria.

KIRBY, F.V. 1896. *In haunts of wild game. A hunter-naturalist's wanderings from Kahlamba to Libombo.* London: William Blackwood.

PIENAAR, U. DE V. 1970. The recolonisation history of the square-lipped (white) rhinoceros *Ceratotherium simum simum* (Burchell) in the Kruger National Park (October 1961 – November 1969). *Koedoe* 13: 157-169.

PIENAAR, D.J., J. DU P. BOTHMA AND G.K. THERON. 1992. Landscape preference of the white rhinoceros in the southern Kruger National Park. *Koedoe* 35(1): 1-7.

VENTER, F. J. 1990. *A classification of land for management planning in the Kruger National Park.* Ph.D. thesis, University of South Africa, Pretoria.