A simple index of habitat suitability for Cape mountain zebras

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An index of habitat suitability for Cape mountain zebras was calculated using two parameters: acceptability indices for different grass species, and the aerial cover of the grass species in the habitat. The index was tested by calculating its value for a range of different habitat patches and comparing this with the frequency of use of the patches by zebras. The close relationship between the index and the observed frequency of use verified that the index could be used as a guide to habitat suitability. Two methods were used to determine the frequency of use of the patches: counts of faecal pellet groups and frequency of sightings. Both methods yielded similar results but the pellet group counts were less time-consuming and expensive. It is recommended that the index of habitat suitability be used (i) as a parameter for monitoring of long-term changes in habitat suitability in the Mountain Zebra National Park and (ii) as a guide for selecting appropriate areas to re-introduce mountain zebras.

Key words: acceptability indices, faecal pellet counts, grazing, monitoring, point surveys, re-introduction.

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Introduction

The total number of Cape mountain zebras *Equus zebra zebra* in existence has increased substantially (Novellie *et al.* 1992) but not yet to the point of justifying removal from its current status of 'vulnerable' in the South African Red Data Book of terrestrial mammals (Smithers 1986). The future security of the subspecies depends to a large extent on the successful translocation of individuals from the secure and expanding population in the Mountain Zebra National Park (MZNP) to other parts of its historical range. Choosing appropriate sites for re-introduction requires some means of determining habitat suitability. It is also necessary to monitor the habitat in reserves where zebra have been established in order to prevent habitat degradation through overgrazing. There is thus a need for an index of habitat suitability that can be used either as a parameter to monitor, or to assign priorities to different areas proposed for re-introduction. The objective of this paper is to use the considerable body of information gathered on the feeding preferences and habitat use of Cape mountain zebra (Grobler 1983; Novellie 1990; Winkler 1993) to derive such an index. The index was based on data gathered in the MZNP, but its area of potential application includes most of the grasslands and karroid vegetation of the eastern Cape.

Study area

The MZNP, situated 24 km from the town of Cradock in the eastern Cape Province, falls within the transitional zone between the dwarf shrublands of the central and western Karoo and the 'sweet' grasslands to the east (Van der Walt 1980). The vegetation of the MZNP comprises a mixture of dwarf shrubs (karoo bushes) and grasses. The Acocks (1988) veld types present are: Karroid *Merxmuellera* Mountain Veld, Karroid *Merxmuellera* Mountain Veld replaced by Karoo and False Karroid Broken Veld. Despite its small size (6 536 ha) the MZNP includes a wide variety of plant communities (Van der Walt 1980).

The region is characterised by relatively low and erratic rainfall. The mean annual rainfall in the MZNP recorded over the period 1962-1989) is 395 mm, varying from 698 mm in the wettest year to 200 mm in the driest. Temperatures can sometimes exceed 40°C in the hottest month (January) and are often subzero in the coldest (July).

The large herbivore species present in the MZNP during the study period included: Cape mountain zebra *Equus zebra zebra*, eland *Taurotragus oryx,* red hartebeest *Alcelaphus buselaphus*, black wildebeest *Connochaetes gnou*, blesbok *Damaliscus dorcas phillipsi*, springbok *Antidorcas marsupialis,* mountain reedbuck *Redunca fulvorufula*, grey rhebok *Pelea capreolus*, kudu *Tragelaphus strepsiceros*, klipspringer *Oreotragus oreotragus*, steenbok *Raphicerus campestris,* grey duiker *Sylvicapra grimmia* and ostrich *Struthio camelus*.

Methods

Derivation of the habitat suitability index

The habitat suitability index was derived from two parameters: the percentage aerial cover of the different grass species in the habitat and an index of acceptability of each grass species to zebras. Only grass species were considered as Winkler (1993) found that plants other than grass made up a negligible proportion of the zebras' diet. The acceptability index was that of Winkler (1993), who used the feeding quadrat method (Grobler 1981, 1983) to analyse food selection. This entailed observing foraging animals and precisely noting the positions of a number of sites at which they fed. After the animals had moved on, the observer went to the predetermined sites and placed a 1 m^2 quadrat at each. All the plant species within the quadrat were listed and categorised as either grazed or avoided by the zebras. A total of 757 such quadrats were examined over a one year period (Winkler 1993). The acceptability index for each grass species was defined as the number of quadrats in which the species was eaten divided by the number of quadrats in which the species was present. The index thus varies between zero and one.

Winkler (1993) calculated an acceptability index for each of four seasons: late growing, early dormant, late dormant and early growing, and found evidence of seasonal differences in acceptability for several grass species. For the purpose of the present study, however, a year-round indication of habitat suitability is required, and the seasonal differences are not relevant. The acceptability indices used here were therefore calculated from Winkler's (1993) results as the average of the four seasons listed above.

The habitat suitability index (HSI) was calculated as follows:

$$HSI = \sum_{i=1}^{k} a_i c_i$$

where :

a_i = the acceptability index of species i
c_i = the percentage aerial cover of species i
k = the number of grass species in the habitat.

Testing the habitat suitability index

The HSI was tested by determining the frequencies of use by zebras of a range of different habitat patches in the MZNP, and examining these frequencies in relation to the values of the HSI calculated for each habitat patch. A high positive correlation between the HSI and the intensity of use of the patches by zebras would help to substantiate the index.

The set of habitat patches used for this test was that established in the MZNP by Novellie (1990) as part of a different study. These sites (10 in total) were originally selected in order to represent areas that carried high large herbivore densities. The vegetation composition at the sites was not taken into consideration in selecting them (see Novellie 1990). These habitat patches were useful for testing the habitat suitability index in that they varied in intensity of use by mountain zebras from heavy to light. The patches occurred in three of the vegetation communities described by Van der Walt (1980): patches 1–5 were in rocky plateau grassland, patch 8 was in degraded plateau grassland, and patches 6, 7, 9 and 10 were in lower slope degraded dwarf shrubland on shale (see Table 1).

At each of these 10 habitat patches, a plot measuring 100 m x 100 m (1 ha) was permanently marked by means of iron fencing standards. Within each one-hectare plot, six to eight subplots, each measuring 25 m x 7 m, were located at random. In each subplot a 200 point survey for canopy spread cover was conducted as described by Novellie & Strydom (1987). The points were arranged in eight rows of 25 each, with one-metre spacing between rows. A canopy spread strike was recorded if a point fell within an imaginary line drawn around the perimeter of the canopy of a plant (see Roux 1963). The number of plots involved was too high to complete all in one year. The point surveys within four of the one-hectare plots were conducted in 1987 and the remaining six were completed in 1988. These surveys were all conducted in late summer and early autumn (December to May).

Table 1
Canopy spread cover of grass species in ten one-hectare plots in the Mountain Zebra National Park

	Plots									
	1	2	3	4	5	6	7	8	9	10
Themeda triandra	20,9	25,0	7,0	3,4	15,1	0,1	1,0	0	0,1	0,1
Sporobolus fimbriatus	0	0	0	0,5	0	0,3	0,1	0,3	0	0,2
Cymbopogon plurinodis	5,8	0,1	14,1	2,1	4,6	0,2	0,1	0	0,2	0
Panicum stapfianum	0	0	0	0	0	0,3	0	0,1	0	0
Heteropogon contortus	0,2	1,3	0	0	0,1	0,5	0	0	0,2	0
Eragrostis lehmanniana	0	0	0	0	0	0	0	1,0	0	0
Merxmuellera disticha	21,7	4,8	0,1	0,2	0,1	4,9	6,2	0	1,8	10,0
Aristida canescens	0	1,6	0	0	0	0	0	0	0	0
Digitaria eriantha	4,2	12,3	3,8	2,6	3,7	2,7	3,5	0	5,5	4,1
Cynodon incompletus	0,1	0	0,9	4,6	0,8	16,6	9,2	30,4	6,9	5,2
Eragrostis curvula	10,7	4,6	9,3	33,9	14,3	5,6	4,1	5,8	5,0	2,0
Eustachys paspaloides	0,7	0	0	0,1	0,8	0	0,1	0	0,2	0,1
Tragus koelerioides	2,7	1,2	13,9	3,0	4,3	10,9	8,6	0,1	13,4	7,4
Eragrostis obtusa	0	0	0,2	0,2	0,1	0,8	0,3	1,1	0,1	0,2
Aristida congesta	0	0	0,5	0	0,3	0,3	0	0,5	0	0,4
Aristida diffusa	0,3	1,3	0	0	0	1,3	7,9	0,1	3,1	0,5
Microchloa caffra	0,4	0,3	1,1	0,6	0,1	0,7	0	0,8	0,8	0,3

The degree of use of the patches by zebras was determined using two different methods: (i) the frequency of sightings of zebras within the one-hectare plots and (ii) the density of zebra pellet groups within the one-hectare plots.

The first of these methods is described by Novellie (1990). Each plot was visited from five to 10 times each month between 1 January 1988 and 31 January 1989, and note was made of whether one or more zebras were present within the plot boundaries. The degree of use of the plots was expressed as the percentage of visits in which zebras were observed to be present.

The density of pellet groups in each plot was recorded on the same day as surveys for canopy spread cover. Between six and 12 subplots, each measuring 25 m x 8 m (200 m^2), were located at random within each one-hectare plot. The numbers of zebra pellet groups within each subplot was counted. A pellet group was defined as one or more pellets situated less than one metre from one another. Pellets separated by more than one metre were counted as being from different groups. The mean pellet group density of all subplots within each one-hectare plot was then used as an indication of the intensity of use by zebras.

One potential difficulty with using counts of faecal pellet groups is that the animals may have specific

Table 2
Indices of acceptability of some grass species to Cape mountain zebra in the Mountain Zebra National Park (from Winkler 1993)

Species	Index
Themeda triandra	0,97
Sporobolus fimbriatus	0,85
Cymbopogon plurinodis	0,81
Panicum stapfianum	0,77
Heteropogon contortus	0,69
Eragrostis lehmanniana	0,68
Merxmuellera disticha	0,52
Aristida canescens	0,50
Digitaria eriantha	0,46
Cynodon incompletus	0,41
Eragrostis curvula	0,38
Eustachys paspaloides	0,32
Tragus koelerioides	0,29
Eragrostis obtusa	0,27
Aristida congesta	0,25
Aristida diffusa	0,24
Aristida adscensionis	0,17
Microchloa caffra	0

'latrine' areas where dung accumulates, and may avoid feeding in such areas. This tendency has, for example, been observed in ponies (Edwards & Hollis 1982; Putman *et al.* 1987). The areas of highest dung density may therefore not coincide with foraging areas. It was therefore necessary to determine the extent to which the plots were used for foraging as distinct from other activities. To do this, note was made of the activity of the zebras sighted within the one-hectare plots. The predominant activity of the animals was recorded as either 'foraging' or 'other' (moving or resting).

Relationships between the HSI and the intensity of use of the different plots were examined by means of linear regression. Regression models were calculated relating the HSI to (i) mean pellet group density, (ii) total sighting frequency of zebras (irrespective of activity) and (iii) sighting frequency including only foraging zebras.

Results

The canopy spread cover of the different grass species in the one-hectare plots are shown in Table 1 and the acceptability indices in Table 2. As noted by Winkler (1993) the large-tufted, leafy perennial species such as *Themeda triandra*, *Cymbopogon plurinodis*, *Sporobolus fimbriatus* and *Panicum stapfianum* had the highest acceptability indices, and hence the plots dominated by such species had the highest HSI's (Table 3). Low-growing creeping grasses such as *Tragus koelerioides* and stemmy annuals (e.g. *Aristida congesta*) were not favoured, which is reflected in the low HSI for plots where such species were abundant. Tufted grasses with hard wiry leaves, such as *Eragrostis curvula* or *Merxmuellera disticha* were intermediate in terms of acceptability (Table 2).

The sighting frequencies of zebras are compared with the density of pellet groups in the plots in Table 3. Differences between the two measures of intensity of use probably resulted partly from the fact that they cover different periods. The pellet group counts were of pellets that accumulated before the plant surveys were done, whereas the sighting frequencies were collected over an extended period after the plant surveys. Nevertheless, the measures of frequency of use are significantly correlated. The Pearson product-moment correlation coefficient between the total sighting frequency and the pellet counts is 0,70 ($df = 8$, $P < 0{,}05$) and that between the sightings of foraging animals and the pellet counts is 0,69 ($df = 8$, $P < 0{,}05$). This indicates that preferences between the plots shown by zebras were reasonably consistent over the study period. The overall agreement between the sightings of foraging zebras and the pellet group counts indicates that no major distortion was caused by a possible differentiation between foraging and 'latrine' areas.

The regression models relating the two measures of intensity of use of the plots to the HSI all yielded highly significant F ratios (Table 4). The regression relating pellet group density to the HSI yielded the best prediction, explaining 77,9% of the variance in Y (R^2 = 77,9%). The regression relating the HSI to the total sighting frequency of zebras (i.e. irrespective of activity) explained relatively less of the variance (61,8%) than that including

Table 3
The habitat suitability index for ten plots compared with the frequency of use of the plots by Cape mountain zebras in the Mountain Zebra National Park. Frequency of use is measured by sighting frequencies and faecal pellet group counts

	Plots									
	1	2	3	4	5	6	7	8	9	10
Habitat suitability index (HSI)	44	37	28	22	27	17	16	16	13	13
Total sighting frequency	6,8	7,9	2,4	5,5	8,3	2,0	2,7	1,6	1,7	0,8
Sighting frequency, including sightings of foraging animals only	3,9	3,2	1,6	1,6	2,5	2,0	1,8	0	0,8	0
Mean number of pellet groups in 200 m^2 plots	18	21	16	15	8	4	1	3	1	3
Number of visits to each plot to determine sighting frequencies	103	126	126	127	120	101	112	124	118	122

sightings of feeding animals only (75,9% – Table 4).

Discussion

The regression analyses indicate that the HSI is capable of predicting the intensity of use of different habitats by mountain zebras with reasonable accuracy. The measure thus seems suitable as a rough guide to habitat suitability. A certain amount of error may be expected because the index ignores several factors that are of undoubted importance. For example, Winkler (1993) showed that characteristics such as the height, leafiness and greenness of the grass have a significant influence on food selection in mountain zebras. It is well known that grass height is a key factor influencing habitat use by grazers and that zebra tend to prefer relatively taller swards (Bell 1971; Grobler 1983; McNaughton 1985). However, in the MZNP the height structure of the sward is strongly influenced by grass species composition because of the characteristic height differences between species (Novellie 1990). Similarly, the leaf-to-stem ratio of the sward is closely linked to grass species composition because of inherent differences between species in leafiness (Winkler 1993). As already noted, the grass species favoured by zebras tend to be tall and relatively leafy, and hence it is difficult to separate the relative importance of sward structure and species composition as factors influencing food selection. Thus for the purpose of a rapidly applicable index it seems reasonable to ignore the height structure of the sward. Greenness, while of considerable importance in determining habitat use, varies too much over the short term to be of relevance to a measure of habitat suitability that is intended for long-term applications.

It could also be argued that by using acceptability indices that were averaged over the

Table 4

Linear regression analyses relating the frequency of use of ten habitat patches by Cape mountain zebras in the Mountain Zebra National Park to the habitat suitability indices for each patch. (The data analyzed are shown in Table 3)

	Slope	Intercept	F ratio	R^2
I. Y = total sighting frequency; X = habitat suitability index	0,212	–0,959	12,9*	61,8%
II. Y = sighting frequency — including sighting of foraging animals only; X = habitat suitability index	0,104	–0,684	25,23*	75,9%
III. Y = mean density of faecal pellet groups; X = habitat suitability index	0,642	–5,964	28,17*	77,9%

* indicates that the F ratio is significant at $P < 0{,}01$

seasonal cycle potentially important seasonal differences have been overlooked. For example, certain species may have a very low year-round acceptability index but their presence in the habitat may be critical in helping the animals to survive a period of food shortage. An example of this has been described for kudu (Owen-Smith & Cooper 1989) where evergreen woody plants are little favoured in general, but are of critical importance as 'stepping stones' in the late dry season. Winkler's (1993) analysis of seasonal differences in acceptability reveal no really important 'seasonallly critical' species. With few exceptions, the acceptability indices of the most favoured species tended to remain high irrespective of season.

A further possible criticism of the index is that other habitat characteristics, such as cover and density of woody plants, slope, aspect or altitude are not taken into consideration. The ten plots used to assess the index were all in treeless areas which were flat to slightly sloping. However, these characteristics evidently have only a minor influence on habitat use. In the MZNP the zebras utilise almost all available habitat types irrespective of topography or woody plant cover (Winkler 1993). The sole exception is the riverine habitat which is utilised at night but not during the day – probably because of the presence of humans during the day. There is clear evidence that the animals tend to avoid areas with low cover of palatable grasses, which justifies assessing habitat suitability on the basis of the abundance of favoured food plants.

As noted, the use of pellet group counts as a means of assessing habitat use is potentially subject to difficulties because of a tendency on the part of some animal species to avoid feeding in sites with high dung densities. However, no evidence of this was observed in mountain zebra, and the density of pellet groups appeared to reflect habitat suitability. As a means of comparing the use of different habitat patches by zebras the pellet counts were more rapid and cheaper than the sighting frequencies. Because of the relatively low frequency of sighting of zebras in the one-hectare plots frequent visits (> 100 visits, see Table 3) to the plots were necessary to obtain a reliable sample size.

The index was both derived and tested in the same habitat types in the Mountain Zebra National Park. Before it can be accepted for general use it is desirable to test it in other conservation areas where mountain zebra occur. One disadvantage of the index is that it is based on acceptability indices, and if applied in a different area the acceptability of some of the grass species to zebras may not be known. A possible solution is to assign an index to the unknown grass on the basis of comparison of structural characteristics with species for which acceptability indices are available. Since the major factors that influence acceptance are tuft size, leafiness and hardness or wiriness of the leaves (Winkler 1993) the comparison should be made on the basis of these characteristics. Further research is required in order to derive a reliable index that can be used to assess new habitats. The index presented in this paper should nevertheless be useful for monitoring the habitat in the Mountain Zebra National Park.

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