Bothalia 14, 2: 299–301 (1983)

A homogeneity index based on species diversity in Sour Bushveld

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ABSTRACT

The co-efficient of variation (CV) for the linear regressions of species-area curves, on a linear species number/log area scale, for the samples in a community, appears to indicate the homogeneity of the community. A CV of less than 15% appears to indicate homogeneous vegetation while a CV greater than 15% seems to be indicative of vegetation heterogeneity, as correlated with extremes in recorded environmental factors in Sour Bushveld.

INTRODUCTION

The plant ecology of the farm Groothoek, Thabazimbi District, was studied in order to supply data on the Sour Bushveld (Acocks, 1975) on natural resource inventory for the Department of Agriculture's Natural Resources Classification. The study included classification of the vegetation according to the Zürich-Montpellier approach (Werger, 1974) as well as alpha and beta diversities according to Whittaker *et al.* (1979). Alpha diversity refers to the number of species in a community (Whittaker, 1972), whereas the rate of increase in species number with increasing area is also characteristic of a community and is indicative of dispersion (Whittaker *et al.,* 1979).

Both species number and rate of increase can be illustrated by means of a linear regression of the species-area curve on a linear species-number/log area scale (Whittaker *et al.*, 1979).

Many attempts have been made to quantify vegetation homogeneity (Raabe, 1952; Curtis, 1959; Dahl, 1960 and Moravec, 1971), however, there has been no satisfactory objective method (Mueller-Dombois & Ellenberg, 1974). In this study, the relative homogeneity of the plant communities is assessed after the classification of the vegetation.

STUDY AREA

The study area is the farm Groothoek 278KQ situated in the south-western Waterberg area of the Transvaal between southern latitudes 24° 28' and 24° 31' and eastern longitudes 27° 32' and 27° 39'. The original farm Groothoek, which has subsequently been subdivided into a number of small farms covers approximately 4 000 ha.

The study area varies in altitude from 1 050 to 2 080 m. The soils are mainly of the Mispah Form, Mispah Series. Also locally present are: Shortlands Form, Bokuil Series; Hutton Form, Middelburg Series; Westleigh Form, Sibasa Series and Kroonstad Form, Slangkop Series. The soils are derived from sandstone conglomerate and shale of the Waterberg Group as well as post-Waterberg diabase. The vegetation is described by Acocks (1975) as Sour Bushveld, with an outlier of North-Eastern Mountain Sourveld above 1 600 m altitude.

METHODS

Analysis

A total of 170 quadrats, each measuring 10 m × 20 m, was distributed on a stratified random sampling basis throughout the study area for classifying the vegetation. Species diversity data (Whittaker *et al.*, 1979) were obtained by recording species presence in nested quadrats within each 10 m × 20 m quadrat. Five 1 m × 1 m, one 2 m × 5 m and one 10 m × 10 m subsamples within each 10 m × 20 m quadrat were used. All permanently recognizable species were recorded in each quadrat.

Habitat data recorded at each sample site included altitude, geological formation, aspect, slope, soil depth, soil form and series, geomorphology, vegetation structure and estimated percentage surface rock cover. Soil samples were collected for later chemical analysis.

Synthesis

The vegetation was classified into communities and sub-communities with the aid of the PHYTOTAB program (Westfall *et al.*, 1982) and the condition of the vegetation with respect to grazing was assessed (Westfall *et al.*, 1983). The species diversity for each quadrat was determined by the linear regression of the species area curve, on a linear species-number/log area scale. Species number is plotted on the ordinate with the log of the area, in square metres, on the abscissa. The log area scale, therefore, reads: 0 (1 m^2); 1 (10 m^2); 2 (100 m^2) and 2,3 (200 m^2). The species number for 1 m^2 was taken as the average of the five 1 m^2 subsamples for each quadrat.

The species number was extrapolated to log 3 (1 000 m^2), because this range can be extrapolated to allow standard comparisons (Whittaker *et al.*, 1979). The co-efficient of variation (CV) was calculated for the variation in species number at log 3 of the quadrats in each community. The communities were then listed according to their CV and comparisons were made with recorded environmental factors.

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RESULTS

The listing of communities according to their quadrat CV is given in Table 1 together with the environmental factors which have a sufficiently wide variation within a community to possibly account for the high CV. The following factors appear to be significant (Table 1):

(i) Veld condition assessment, composition score, which is the lowest for communities 4 and 7. The composition score is derived from a benchmark within the community and the sample quadrats (Westfall *et al.*, 1983), the low score indicating a large floristic difference between benchmark and sample quadrats, because of different levels of overgrazing.

(ii) The sum of the standard deviations for the veld condition classes of the quadrats in each community is indicative of the uniform utilization of a community. Where the sum of the standard deviations is large, as in communities 7 and 16, overgrazing in parts of the communities can be expected. Waterlogging in parts of Community 16 during the rainy period as well as the camp system employed could account for the differential use, and overgrazing in Community 7 takes place in the vicinity of a kraal.

(iii) The slope ranges from 0° to 38° in Community 17b, which is the widest range in the study area. Drainage lines and interfluves on the upper slope of the mountain on which this community occurs, account for this range in slope.

(iv) The aspect of Community 18, being on the summit of a mountain, has the greatest variation in the study area.

(v) Variations in soil depth where the minimum recorded depth is greater than 69 mm or where the difference in soil-depth range is less than approximately 180 mm do not appear to influence vegetation homogeneity. Communities 9.2, 11.1 and 9.1 have shallow soils in parts and maximum recorded depths of 230 to 250 mm, which could influence vegetation homogeneity.

(vi) Surface rock cover has the greatest variation in Community 9.2 varying from 5–80%.

(vii) Soil electrical resistance has the greatest range in communities 17b, 11.1, 8.2 and 17a. These communities have moderate to steep slopes where nutrients could be leached from the upper areas and accumulate in the lower areas, accounting for the range in soil electrical resistance.

Community 8.1 does not have a single recorded habitat factor which could account for the high CV. However, a combination of habitat factors or possibly a single factor, not recorded, could be responsible. Community 2 is situated on the escarpment in the west of the study area. Although regarded as kloof forest the landform is heterogeneous with cattle able to graze in places. The heterogeneity of the landform, although difficult to quantify as extreme, could account for the high CV in Community 2.

TABLE 1. – Homogeneity of the plant communities on the farm Groothoek, Thabazimbi District, according to the CV for quadrat diversity (extrapolated to 1 000 m^2), and correlated with extremes in recorded environmental conditions

Community number	Homogeneity index expressed as CV (%)		Veld condition assessment, composition score (%) Grassland	Woodland sparse	Woodland open	Woodland closed	Kloof forest	$\Sigma\ \sigma$ for veld condition classes	Difference in slope range (°)	Aspect range (°)	Soil * depth range (mm)	Difference in surface rock cover range (%)	Difference in soil electrical resistance range (ohms)
14	4,46				34								
5	9,66					21							
10	9,76				42						40–80		
12	10,62				42								
11.2	10,98				36								
1	12,70	Homogeneous					31						
6	13,77					26							
15	14,46				36								
13	14,69				45								
3	14,74						27				Minimum greater than 69	Less than 56	Less than 2 900
4	15,65					14			Less than 29				
9.2	16,06					30					50–230	75	
17b	16,09			45					38				3 900
11.1	16,29										40–230		4 600
8.1	17,00				41			Less than 63		Less than 181			
8.2	17,22	Heterogeneous			26								3 200
18	17,60		67							270	40–100		
7	18,87					13		72					
9.1	18,98					30					40–250		
17a	20,32			22									3 700
16	27,90		31					70					
2	29,71						19						
						Over-grazing		Unequal grazing	Exteme habitat conditions recorded in communities				

* The minimum soil depth recorded is 40 mm. A range greater than 179 mm from the minimum depth appears to influence homogeneity, therefore the range of 40–80 mm does not appear to be significant.

It appears, therefore, that a CV of 15% is an acceptable boundary between heterogeneous and homogeneous vegetation in Sour Bushveld, because no environmental heterogeneity (extremes in environmental factors) could be detected for the communities with a CV of less than 15%. The CV gradient represented in Table 1 is difficult to corroborate with the recorded environmental factors, but personal observation confirms the order of the communities regarding homogeneity.

DISCUSSION

The variations in species number (diversity) and the rate of increase in species with increasing area (dispersion) provide a simple method of determining homogeneity in a floristically defined community. The rate of increase in species with increasing area partly determines the species number at log 3 so that both parameters, diversity and dispersion, are taken into account.

In the study area the main environmental factors influencing vegetation homogeneity are grazing, slope, aspect, soil depth, surface rock cover and soil electrical resistance as an expression of soluble salts. Notably lacking in influence is soil form, where three communities in the homogeneous range have two different soil forms each. Communities 5 and 4 are structurally and floristically similar, the difference being that Community 4 is diagnosed by mainly weedy species. This is confirmed by the lower composition score and higher CV for Community 4. The difference is attributed to overgrazing in Community 4.

The homogeneity index, as expressed by the CV for the communities, is of particular importance when interpreting the composition scores. For example, Community 18 has a high composition score, but is relatively heterogeneous. Grazing management should, therefore, take the heterogeneity of the vegetation into account. The open woodlands have markedly higher composition scores and are generally less heterogeneous than the closed woodlands. This could be significant in timeous control of woody encroachment. Community 8.2, for example, although predominantly open, is closed in places.

The homogeneity index can also indicate sampling adequacy. In the floristic classification, Community 17a is represented by two quadrats only and is considered a variation of Community 17b. Community 16 is represented by 12 quadrats of which three are heavily infested with *Stoebe vulgaris*. The potential vegetation is grassland without *S. vulgaris,* however, and the high CV indicates the infestation. Community 2 is represented by eight quadrats. This community could consist of several communities, because of the topographic range, if studied in greater detail than in the present study. It is noteworthy that sampling adequacy in this study is suspect with a CV of greater than 20%. The remaining communities are considered to be adequately sampled.

CONCLUSIONS

The homogeneity index based on species diversity appears to be a simple, yet sensitive method for quantifying homogeneity in floristically defined communities, in Sour Bushveld. The homogeneity index can be of value in assessing veld condition and determining sampling adequacy. Further data will, however, have to be analysed to determine the adequacy of the suggested 15% criterion between homogeneous and heterogeneous vegetation in vegetation other than Sour Bushveld.

ACKNOWLEDGEMENTS

The authors thank Dr J.C. Scheepers for comments and suggestions.

UITTREKSEL

Die koëffisiënt van variasie (KV) van die linière regressies van spesies-area-kromme, volgens 'n linière spesies getal/log area skaal vir monsters binne 'n plant-gemeenskap blyk om die homogeniteit van die gemeenskap aan te dui. 'n KV van minder as 15% blyk om homogene plantegroei aan te dui terwyl 'n KV van hoër as 15% blyk om heterogene plantegroei aan te dui. Die KV-waardes van die gemeenskappe is met die uiterstes in aangetekende omgewingsfaktore vir elke gemeenskap gekorreleer.

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