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The plant ecology of the farm Groothoek, Thabazimbi District. I. Ordination

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ABSTRACT

The vegetation of the farm Groothoek, Thabazimbi District, situated in the Sour Bushveld (Acocks, 1975) of the Waterberg, Transvaal, is classified according to the Braun-Blanquet method and the communities are ordinated by means of detrended correspondence analysis (DCA). Five major vegetation types with 22 communities are described in terms of habitat factors, relevant to the ordination.

RÉSUMÉ

L'ÉCOLOGIE VÉGÉTALE DE LA FERME GROOTHOEK DANS LE DISTRICT DE THABAZIMBI.
1. PROGRAMMATION

Le végétation de la ferme Groothoek dans le District de Thabazimbi, situé dans le Sour Bushveld (Acocks, 1975) de Waterberg au Transvaal, est classée suivant la méthode Braun-Blanquet et les formations végétales sont programmées au moyen de l'analyse DCA (detrended correspondence analysis). Cinq types majeurs de végétation avec 22 formations végétales sont décrits selòn leur habitat, en fonction de la programmation.

INTRODUCTION

The plant ecology of the farm Groothoek in the Thabazimbi District was studied in order to supply data on the Sour Bushveld (Acocks, 1975), for the Department of Agriculture and Fisheries resource inventory. This veld type is found mainly in the Waterberg of the Transvaal and little is known about the vegetation. The study included classification of the vegetation and correlation of the vegetation with the environment to facilitate later study of the entire Waterberg region.

Van der Maarel (1980) recommends the use of ordination as an aid to classification and to help explain environmental influences. The detrended correspondence analysis (DCA) method of ordination (Hill & Gauch, 1980) is used for this study as it overcomes the problem of the 'arch effect' produced by the principal component analysis (PCA) and reciprocal averaging (RA) methods of ordination (Greig-Smith, 1980; Hill & Gauch, 1980 and Van der Maarel, 1980).

STUDY AREA

The study area consists of the farm Groothoek 278 KQ situated between 24° 28′ and 24° 31′ south latitude and 27° 32′ and 27° 39′ east longitude. The farm covers approximately 4 000 ha over an altitudinal range of 1 200 m to 2 100 m. The summit of Kransberg forms the northern boundary with the greatest farm area consisting of two plateaux at approximately 1 500 m and 1 200 m altitude to the south. Bakker's Pass lies to the west allowing vehicular access to the upper plateau.

The Kransberg Massif consists of sandstone from the Kransberg Series of the Waterberg System. Outcrops of sandstone, shale and conglomerate from the Nylstroom Series of the Waterberg System, are found on the upper plateau while sandstone outcrops are found on the lower plateau. A diabase dyke, of post-Waterberg age, is exposed in Bakker's Pass. The soils arising from these parent materials are mainly of the Mispah Form Mispah Series.

The study area is representative of Acocks's (1975) Sour Bushveld in a relatively undisturbed condition with sufficient variation in vegetation and environment for observations to be relevant to other areas in the Waterberg where this veld type occurs.

CLIMATE

The Waterberg is classified as Cwa according to Köppen's classification (Schulze, 1947), although this is not supported by direct evidence as no full climatological station has ever been maintained in the area. Rainfall statistics indicate the area as falling under the category Cw, warm temperate with summer rainfall, and the high probability that the January mean exceeds 22°C indicates the Cwa classification (Schulze, 1947). Rainfall records for the ten-year period July 1963 to June 1973 on the upper plateau suggest a mean annual rainfall of 680 mm. The consensus of local opinion, however, is that this period was unusually dry.

METHODS

The Braun-Blanquet method of sampling and synthesis followed in the study is described by Westhoff & Van der Maarel (1973), Mueller-Dombois & Ellenberg (1974) and Werger (1974).

The vegetation was stratified according to physiognomic-physiographic units determined by interpretation of 1: 33 000 aerial photographs of the study area. Sampling sites were selected by means of random co-ordinates within each physiognomic-physiographic unit. This procedure is accommodated within the flexible Braun-Blanquet method

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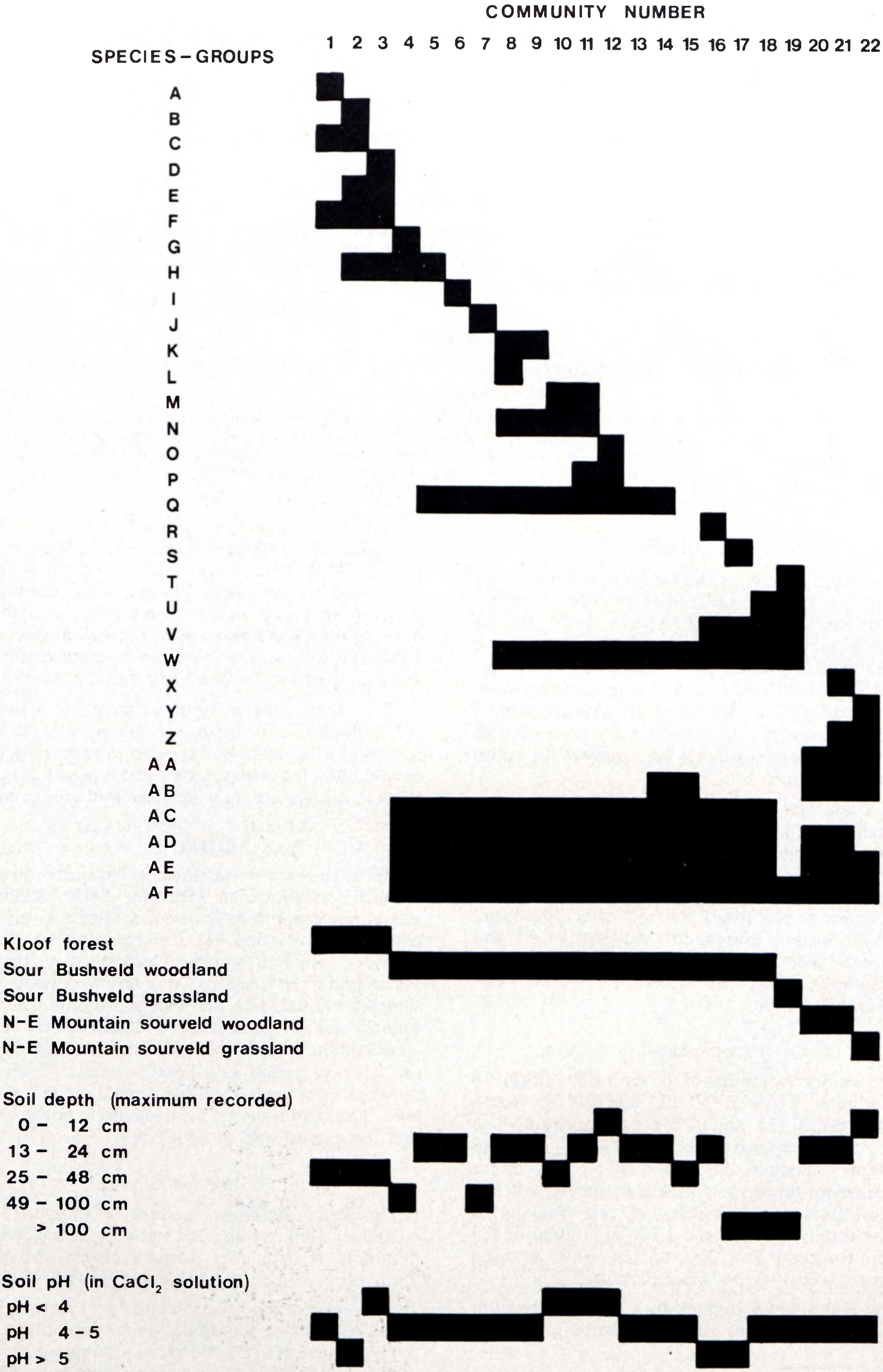

FIG. 1.—A simplified classification of the vegetation of the farm Groothoek, Thabazimbi District showing the main environmental factors according to the ordination.

(Coetzee, 1975). 170 quadrats, 10 × 20 m, were sited in homogeneous stands representing the different physiognomic-physiographic units. The 10 m × 20 m quadrat size used is considered adequate for bushveld vegetation (Coetzee *et al.*, 1976; Van der Meulen, 1979).

Data recorded at each sampling site include the species present in each quadrat with estimated canopy cover-abundance according to the Domin-Krajina scale (Mueller-Dombois & Ellenberg, 1974), altitude, geological formation, aspect, slope, soil depth, soil form and series, geomorphology, vegetation formation class and estimated percentage rock cover.

The vegetation is classified according to the Braun-Blanquet method using the PHYTOTAB program package (Westfall, Dednam, Van Rooyen & Theron, 1982). The main environmental factors influencing the communities were ordinated on floristic data by detrended correspondence analysis (DCA) (Hill & Gauch, 1980) using the DECORANA program (Hill, 1979).

RESULTS AND DISCUSSION

Classification of the vegetation, according to the Braun-Blanquet method, revealed five major vegetation types with 22 plant communities. A simplified classification of communities together with habitat factors found to be relevant in the ordination, is shown in Fig. 1.

The five major vegetation types (Fig. 1) are as follows:

(i) Kloof forest in moist, sheltered habitats (Communities 1–3).

(ii) Woodland, representative of Acocks's (1975) Sour Bushveld, on moderately deep to deep soils in moderately exposed habitats (Communities 4–18).

(iii) Grassland, representative of Acocks's (1975) Sour Bushveld on moderately deep soils in exposed, dry habitats (Community 19).

(iv) Woodland, representative of Acocks's (1975) North-Eastern Mountain Sourveld on moderately shallow soils in moderately exposed habitats (Communities 20–21).

(v) Grassland, representative of Acocks's (1975) North-Eastern Mountain Sourveld on shallow, rocky soils in exposed habitats (Community 22).

The North-Eastern Mountain Sourveld communities (Acocks, 1975) are outliers of this veld type and are found above 1 500 m altitude on the Kransberg Massif.

The results of the DCA ordination are shown in Figs 2 & 3. Communities are placed in cells, either alone, or with similar communities according to the x, y and z axes of the ordination. Fig. 2 shows the ordination of axes x and y (first and second axes) and Fig. 3 shows the ordination of axes x and z (first and third axes). The gradient of length for the x-axis is 9,25 sd, for the y-axis 4,23 sd and for the z-axis 2,69 sd where the value sd is defined so that the root-mean-square, standard deviation is 1 (Hill, 1979).

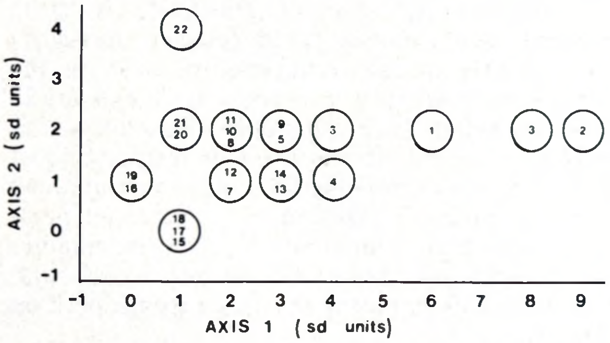

FIG. 2.—A detrended correspondence analysis (DCA) ordination of communities. Scatter diagram with communities grouped into cells along the first and second axes (z and y axes) of the ordination.

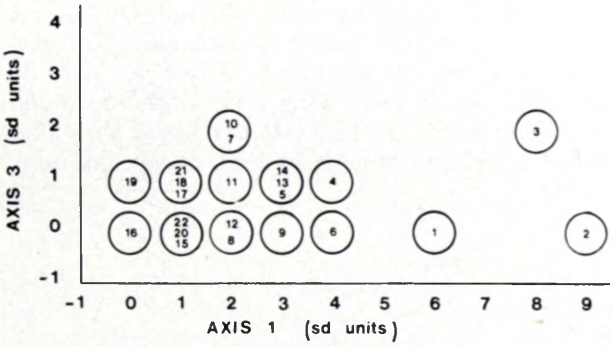

FIG. 3.—A detrended correspondence analysis (DCA) ordination of communities. Scatter diagram with communities grouped into cells along the first and third axes (x and z axes) of the ordination.

Separation of cells along axis 1 (x-axis) shows a gradient from grassland and open woodland (Communities 16 and 19) on the left to closed woodland and forest (Community 2) on the right (Fig. 4). Although no data concerning the moisture status of the communities were recorded, this gradient probably corresponds with a temperature/moisture gradient (Theron, 1973). This would range from the exposed areas of the plateau and summit grasslands and woodlands with wide temperature and moisture fluctuations, on the left of the scatter diagrams to closed woodlands and forests of the sheltered slopes and kloofs with narrow temperature and moisture fluctuations, on the right.

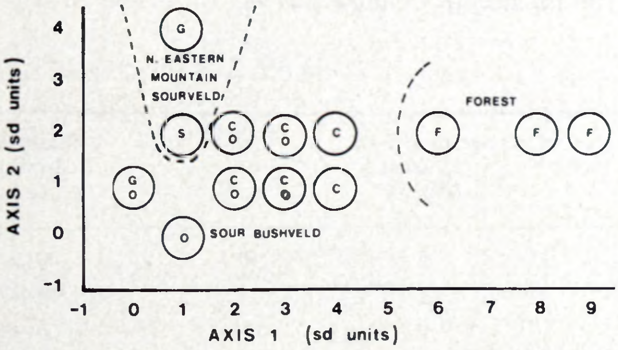

FIG. 4.—The position of five major vegetation types along the first and second axes of ordination. The first axis represents a temperature/moisture gradient from grassland to forest. G = grassland, S = sparse woodland, O = woodland, C = closed woodland and F = forest.

Community 22 (summit grassland) is more exposed than Community 19 (plateau grassland) but, because of the occurrence of mist on the summit, more moisture is received by Community 22 than Community 19. Furthermore, Community 19 is possibly subjected to inversion of temperature at night, because of slopes to the north and south, and therefore probably experiences a greater temperature range, than Community 22. The communities are consequently separated on the x-axis with Community 19 occupying the most extreme position (Fig. 2).

Separation of cells along axis 2 (y-axis) shows a general correlation with maximum recorded soil depth per cell (Fig. 5). This ranges from shallow soil (Community 22) at the top of the scatter diagram to deep soil (Communities 15, 17 and 18) at the bottom. The occurrence of Communities 16 (open woodland) and 19 (grassland) in one cell may be attributed to the underlying rock formation found with Community 19 which is impermeable shale that causes a high water-table to form during the rainy season.

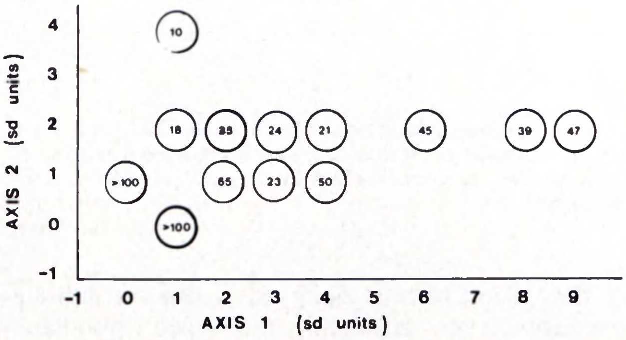

FIG. 5.—The maximum recorded soil depth, in centimetres in the community cells (Fig. 2). The second axis represents a soil depth gradient from deep soil to shallow soil.

The soil is generally deep, but where it is shallow water remains on the surface for long periods after rain. This seasonally high water-table could have the same limiting effect on root penetration as shallow soil by inhibiting growth of deep roots. The position of Community 19 on the y-axis indicates that the effective, maximum soil depth for root penetration, is under 100 cm and not over 100 cm as recorded. The position of Communities 12, 13, 14 and 16 at 1 sd unit on the y-axis and Community 15 at 0 sd units on the y-axis (Figs 2 & 5) suggests that the possible, maximum soil depth for these communities was not sampled, although the separation of cells in the centre of the scatter diagram (Figs 2 & 3) are not necessarily significant (Hill, 1979). The maximum recorded soil depths per cell on the y-axis (Fig. 5) for each sd unit, are similar to the soil depth classes which were determined on the basis of the floristic classification (Fig. 1), a comparison of which appears in Table 1.

Separation of cells along axis 3 (z-axis) shows a general correlation with mean soil pH per cell, determined in a $CaCl_2$ solution (Fig. 6). This ranges from low pH values at the top of the scatter diagram to high pH values at the bottom (Fig. 6). According to Peech (1965) soil pH, determined in a $CaCl_2$ solution, is a better indication of base saturation and is less influenced by biological and meteorological conditions, than soil pH, determined in a water solution. Soil pH determined in a water solution showed a poorer correlation with the cells along axis 3 than soil pH determined in a $CaCl_2$ solution, which supports Peech's (1965) observation.

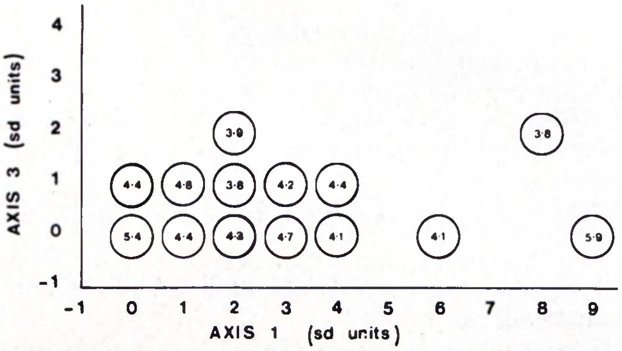

FIG. 6.—The average soil pH, determined in a $CaCl_2$ solution in the community cells (Fig. 3). The third axis represents a pH gradient from high soil pH values to low soil pH values.

Communities 3, 7, 10 and 11 have a low soil pH of under 4 (Fig. 6) indicating a high base saturation (Daubenmire, 1974). This can be partly attributed to the presence of aluminium in the soil (Daubenmire, 1977), which exceeded 1,5 me % for Communities 3, 10 and 11 and represents the highest values recorded for aluminium in the study area.

All recorded habitat data were compared with the first, second and third axes of the ordination. Apart

TABLE 1. — Soil depth classes based on ordination and floristic classification

Position of y-axis (sd units) (Fig. 5)	Maximum soil depth range (Fig. 5)	Soil depth classes based on floristic classification
4	0–10 cm	0–12 cm
2	18–47 cm	13–48 cm
1	50–65 cm (excluding Communities 13, 14 and 19)	49–100 cm
0	>100 cm	>100 cm

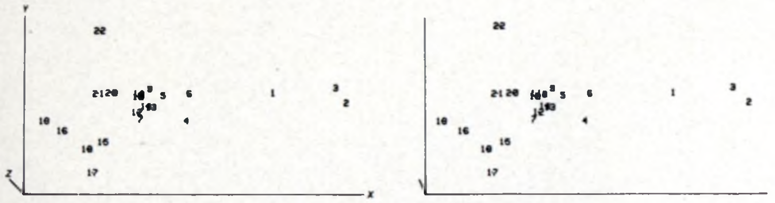

FIG. 7.—A stereogram of the three axes of ordination (x, y and z axes) according to Fewster & Orlóci (1979) for viewing with a pocket stereoscope.

from maximum recorded soil depth the inferred temperature/moisture correlation and soil pH in a $CaCl_2$ solution, either none or only partial correlation could be found. As only the first, second and third axes were considered for the main environmental gradients, other, lesser factors could show correlation with the fourth axis. However, the gradient of length for the third axis shows little separation of the cells, being only 2,69 sd (Fig. 6), whereas separation of cells on axes 2 and 1 are 4,23 sd and 9,25 sd respectively. The significance of the third axis is, therefore, considerably less than that of axes 1 and 2 while axis 4, at 2,23 sd, is of even less significance for the main environmental gradients (Hill, 1979). The first three axes of the ordination are combined in a stereogram, according to the method of Fewster & Orlóci (1978) for three-dimensional viewing (Fig. 7) with the aid of a pocket stereoscope.

The five major vegetation types revealed in the classification (Fig. 1) are also present in the ordination (Fig. 4). Forest communities are separated to the right of the scatter diagram, with Sour Bushveld grassland to the left. The Sour Bushveld woodland vegetation is represented by the cells in the centre of the scatter diagram ranging from open woodland to the left, to closed woodland to the right. The North-Eastern Mountain Sourveld grassland on shallow rocky soil is separated on axis 2, above, with North-Eastern Mountain Sourveld woodland directly below. The Sour Bushveld open woodland vegetation on deep soil is represented by the cells at the bottom of axis 2.

CONCLUSIONS

The ordination of communities confirms the five major vegetation types found in the vegetation classification according to the Braun-Blanquet method. The main environmental gradients influencing these vegetation types are soil pH, soil depth and apparently a temperature/moisture gradient. The possibility of estimating moisture available to vegetation, although difficult to establish in surveys where sampling sites are only visited once, should nevertheless, receive more attention. Finally, the ordination shows discontinuities in the vegetation, hence the need for a classification.

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