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STRIPED VEGETATION PATTERNS IN A TRANSVAAL SAVANNA (South Africa)

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RESUME

Des études botaniques et pédologiques ont été entreprises afin de décrire les types de végétation tigrée qui peuvent aisément être observés sur photographies aériennes dans une savane située au Transvaal, en Afrique du Sud. Ce faciès consiste en une alternance de bandes parallèles (d'environ 20 à 50 m de largeur) de végétation arbustive épineuse établie sur sols légèrement saillants (crêtes) et de savane située dans des dépressions, inclinées vers le bas sur un terrain en pente douce.

Il semblerait que les savanes se développent en des sites à conditions saisonnières extrêmes, tandis que les bandes boisées correspondent à des conditions pédologiques optimales du point de vue de l'humidité et de l'aération.

Les auteurs discutent l'orientation des recherches futures susceptibles d'expliquer l'origine de ce faciès.

ABSTRACT

Vegetation and soil studies are undertaken to describe striped vegetation patterns appearing on air photos in a savanna in Transvaal, South Africa. The pattern consists of alternating parallel strips (about 20 - 50 m wide) of thorny wooded scrub on slightly raised soil (crests) and grassland in throughs, running downslope on a gently sloping terrain.

It would appear that the grasslands are on seasonally extreme sites whilst the wooded stripes are related to soil sites with optimal moisture conditions and aeration.

Some further research which might help to explain the origin of the pattern is discussed.

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INTRODUCTION

In a recent phytosociological study of savanna-woodland or Bushveld in Transvaal, South Africa, one of us briefly described vegetation stripes consisting of alternating strips (about 20 - 50 m wide) of grassland and wooded scrub (VAN DER MEULEN, 1979). Difficult to recognize on the ground, the pattern shows clearly on air photos (approximate scale 1 : 36000). The stripes run parallel downslope for several hundred meters (Fig. 1) on a gently sloping terrain and seem to be associated with run-off. Although the pattern can not be mapped on a reconnaissance scale or even the semi-detailed scale which is in South Africa being used at present for land evaluation in savanna regions (VAN DER MEULEN & WESTFALL, 1979), it would be important in the study of local vegetation.

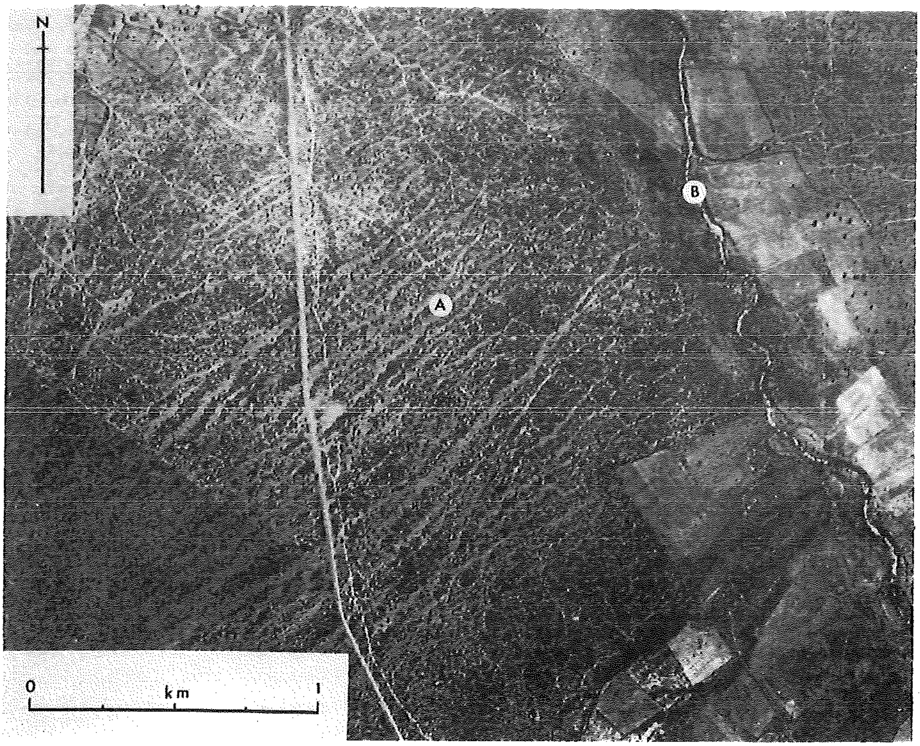

Fig. 1 : Air photo of vegetation stripes taken in 1969. Downslope side is to the top right. A : study area; B : seasonal stream flowing towards the north. Scale is approximate. Photograph : Trigonometrical Survey, Pretoria.

Unlike those patterns occurring elswhere in Africa, vegetation stripes from southern african savannas have received little attention so far. By reporting this pattern we hope to stimulate further research work which might help to explain its origin.

Striped vegetation patterns from other areas.

Striped vegetation patterns have previously been reported from several other arid and semi-arid regions in Africa. They include the well-known stripes and arcs of Somalia and the Sudan (MACFAYDEN, 1950; WORRALL, 1959; BOALER & HODGE, 1962) and the patterns reported by CLAYTON (1966), WHITE (1970) and ZONNEVELD *et al.* (1971, see also ZONNEVELD, 1975) from Nigeria. Vegetation stripes nearest to ours were reported by SIDERIUS (1973) from central east Botswana. Unfortunately, SIDERIUS gives little detail on vegetation and soils.

Usually, the patterns occur on very gently sloping plains (1 : 200 to 1 : 400 slope) and they consist of alternating areas of grass and almost bare soil (WORRALL, 1959; SIDERIUS, 1973) or wooded communities and bare soil (MACFAYDEN, 1950; SIDERIUS, 1973) or wooded communities and grassland (CLAYTON, 1966; BOALER & HODGE, 1962; WHITE, 1970 & ZONNEVELD *et al.*, 1971). It was thought that the pattern resulted from different moisture regimes of the soils under each element of the pattern, the moister soils supporting a lusher vegetation. However, various explanations are given on the origin of such moisture differences. In the pattern reported by BOALER & HODGE (1962) vegetation stripes run along the slope and are thought to be due to parallel longitudinal deposits of differing textures formed by both wind and water action. Vegetation stripes have also been associated with former dunes or desert ripples (CLAYTON, 1966 & ZONNEVELD *et al.*, 1971). In the latter example the dune valleys would have been filled at a later stage with better sorted material transported from elswhere. Difference in soil moisture between these former valleys and the original material of the dunes was probably further developed by sealing of the top soil in the dune material. The process of sealing is caused under low organic matter contents by finer soil particles (silt and clay) filling up the spaces between the bigger sand grains. As a result, percolation of rainwater into the profile is prevented. Soils which are less affected by such sealing are more favourable to tree growth.

The vegetation arcs of WORRALL (1959) and MACFAYDEN (1950) developed in an area where slope and rainfall (100 - 400 mm per year) were supposed to be insufficient for detailed drainage lines to be formed. These patterns have been associated with run-off of water carrying vegetation debris which was deposited in lines or ripples.

THE VEGETATION STRIPES

Location and habitat.

The vegetation pattern reported here occurs in Bushveld of the Transvaal Plateau which is underlain by rocks of the Bushveld Igneous Complex (WELLINGTON, 1955). General elevation of the Complex is about 1000 - 1200 m. The pattern covers an area of about 500 ha and is located near Brits, to the northwest of Pretoria (Fig. 2). The terrain slopes from an elevated outcrop of Bushveld Granite in the west to flats (Springbok Flats) underlain by sandstone rocks of the Karoo System (WELLINGTON, 1955) in the east with an average gradient of less than 1°. Similar vegetation patterns can be found here and there on the Transvaal Plateau, usually on very gently sloping terrain.

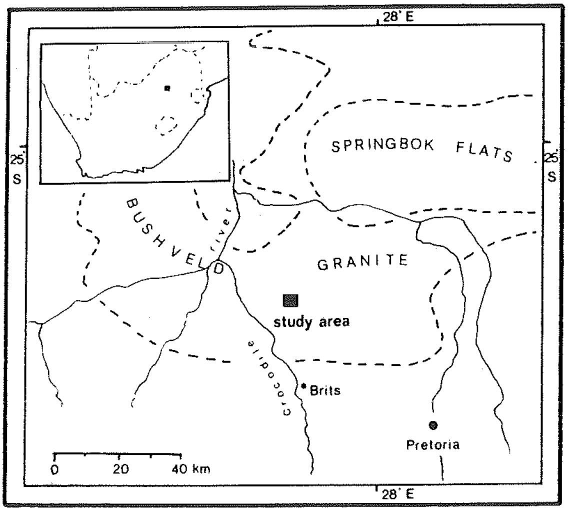

Fig. 2 : Simplified map showing location of study area and main geological formations.

The area has a hot dry steppe climate, designated in the Köppen system as BShw (SCHULZE & McGEE, 1978). Rain falls in summer, from October to March. The average yearly raifall is about 600 mm. Average yearly temperature is about 18.5° C. Ground frost may occur in winter (Weather Bureau, 1954). The soils are fersiallitic sandy clay-loams and sandy loams, often having plinthic properties. In such a case, the soil material is partly or completely cemented by oxides or hydroxides of iron. The soils have been formed over saturated granitic rocks and belong to the Hutton Form (MacVICAR *et al.*, 1977). Better drained profiles are found under the wooded stripes while less well-drained soils occur under the grassland. The wooded stripes are slightly raised above the level of the grassland. Signs of termite activity are often found in the wooded areas.

Vegetation.

VAN DER MEULEN (1979) describes the vegetation as Xeric Lowland Bushveld, belonging to the Microphyllous Thorny Plain Bushveld of WERGER & COETZEE (1978). Typical for xeric lowland bushveld is the predominance of low (up to 5 m) microphyllous thorn trees (*Acacia* spp.), with an understorey of softer textured and smaller tufted palatable grasses like *Panicum maximum*, *Brachiaria nigropedata*, *Cenchrus ciliaris*, *Bothriochloa insculpta* and *Urochloa* spp. Annuals are common and often occur as pioneers on bare soil patches (for example *Tragus racemosus*, *Sporobolus nitens*, *Chloris virgata*).

The pattern is composed of two structural units : a wooded community and a grassland (figures 3 and 5). These elements have formed parallel strips each of about 20 - 50 m width, the wooded strips sometimes being wider (Fig. 1). The strips may join further down slope. On the whole, both communities are severely disturbed by cattle grazing and cutting of firewood by man. At present burning also occurs.

We have sampled the vegetation by means of Braun-Blanquet sampling quadrats laid out subjectively in the grassland and in the wooded community (Tab. I). The two structural units are also floristically distinct.

Wooded community.

This community is a poorly developed stand belonging to VAN DER MEULEN'S (1979) *Acacia luederitzii-Boscia albitrunca* Woodland Association. It is dominated by *Acacia luederitzii* var. *retinens* and reaches up to 3 m in height with occasional emergents up to 5 m (Fig. 3). Growth

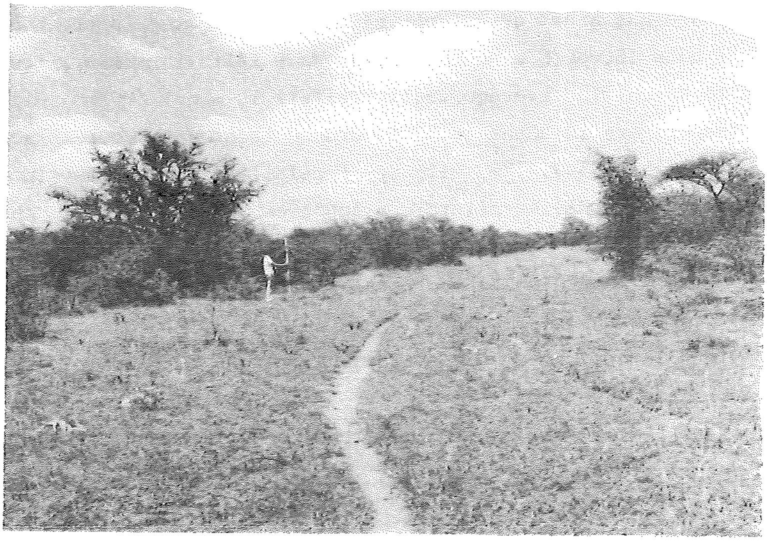

Fig. 3 : Open grassland lane fringed by wooded community. Tall tree on left is *Ziziphus mucronata*. Upslope side is towards background of picture. (November 1978).

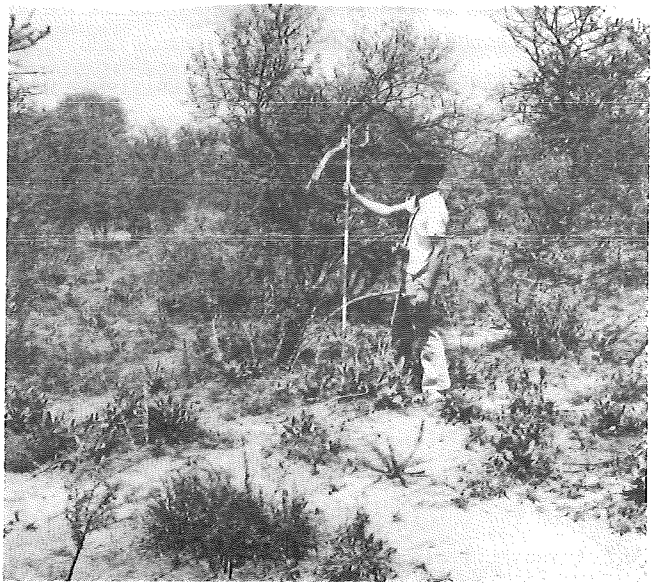

Fig. 4 : Interior of wooded community. Woody plants include *Tarchonanthus camphoratus* (centre), *Acacia luederitzii* (left) and *Acacia karroo* (right). Herbaceous vegetation includes *Aloe transvaalensis*, *Asparagus suaveolens* and *Brachiaria nigropedata*. (November 1978).

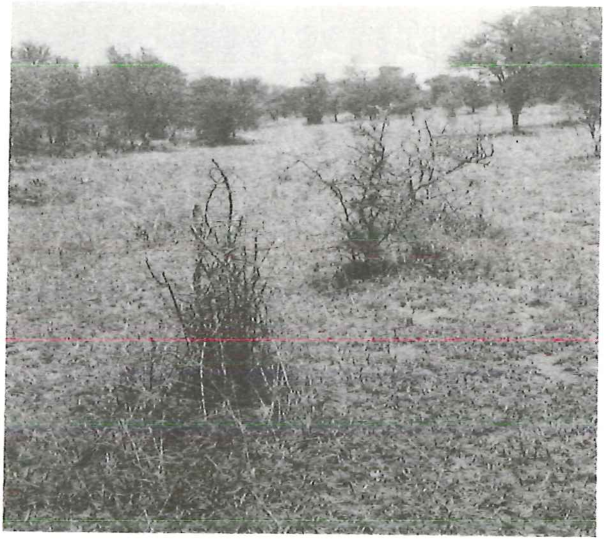

Fig. 5 : Solitary *Dichrostachys cinerea* in grassland lane. The apparently-dead plant in the foreground was sprouting from the base. Previous season's growth had been killed by a fire. (November 1978).

forms include low trees and shrubs (*Grewia flava*, *Euclea undulata*, *Boscia albitrunca*, *Acacia* spp.) dwarf shrubs and sub-woody herbs (*Asparagus suaveolens*, *Abutilon austro-africanum*, *Lycium cinereum*, *Antizoma angustifolia*) and succulents (*Aloe transvaalensis*, *Portulaca pilosa*, *Delospermum herbeum*). Grasses and herbs are sparse and patchy, the taller plants often being gregarious under bush clumps (Fig. 4).

Grassland.

The grassland is dominated by *Brachiaria nigropedata*, *Aristida congesta* and *Eragrostis* spp. However, these species are also common in the wooded community, faithful species include the geophytes *Bulbine* cf. *B. angustifolia* and *Ledebouria revoluta* and the herbs *Sida chrysantha*, *Evolvulus alsinoides* and *Euphorbia inaequilatera*. Scattered woody plants (mainly *Acacia karroo* and *Dichrostachys cinerea*) occur in the grassland. They are usually low and may show damage from fire (Fig. 5).

		522	523	498	516	519	479	518	512	517	520
	Relevé number	522	523	498	516	519	479	518	512	517	520
	Number of species	44	40	48	35	44	42	42	23	23	35
	<u>Differential species for wooded community</u>										
t	*Acacia luederitzii*	1	2	1	2	+					
sc	*Aloe transvaalensis*	+	1	1	1	+					
s	*Grewia flava*	1	1	+	+	+					
g	*Sporobolus nitens*	+	1	1	+	+					
h	*Asparagus suaveolens*	+	+	+	1	+					
g	*Panicum maximum*	+	1	+	+	+					
h	*Abutilon austro-africanum*	+	+	+	+	+					
t	*Ziziphus mucronata*	+	+	+	+	+					
ds	*Lycium cinereum*	+	+	+	+	+					
h	*Ruellia patula*	+	+	+	+	+	+				
s	*Euclea undulata*	+	+	1	+						
h	*Commelina africana*	+	+		+	+					
h	*Antizoma angustifolia*	+	+	+	+						
t	*Boscia albitrunca*	+	+		+	+					
sc	*Portulaca pilosa*	+	+	+		+					+
t	*Acacia tortilis* subsp. *heteracantha*	2	+	2							
ds	*Lantana rugosa*		+	+		+					
t	*Cassine burkeana*	+		+		+					
t	*Peltophorum africanum*		+		+	+					
cl	*Sarcostemma viminale*	+		+	+						
sc	*Delosperma herbeum*	+	+	+							
g	*Cymbopogon plurinodis*	+			+	+					
t	*Rhus pyroides*			+	+	+				+	
	<u>Differential species for grassland</u>										
h	*Sida chrysantha*						+	+	+	+	+
ge	*Bulbine* cf *B. angustifolia*						+	+	+	+	+
h	*Evolvulus alsinoides*		+				+	+	+	+	+
ge	*Ledebouria revoluta*							+	+	+	+
h	*Euphorbia inaequilatera*						+	+	+	+	

h	*Harpagophytum zeyheri*						+		+	+	+
h	*Chascanum hederaceum*		+				+	+	+		+
h	*Tephrosia burchellii*					+	+	+	+		+
h	*Dicerocaryum zanguebarium*						+	+		+	
h	*Geigeria elongata*						+	+			+
h	*Lotononis calycina*						+	+	+		
	Companion species										
t	*Acacia karroo*	+	+	+	+	2	+	+	+	+	+
h	*Felicia fascicularis*	1	+	+	+	+	+	+	+	+	+
g	*Aristida congesta*	+	+	+	1	+	1	+	+		+
g	*Digitaria eriantha*	+	1	+	+	+	+	+			+
h	*Jatropha zeyheri*	+	+			+	+	+	+	+	+
g	*Brachiaria nigropedata*	2	1			+	+	+	+	+	+
g	*Eragrostis lehmanniana*	1	1		+	+		+	1	1	1
g	*Eragrostis superba*			+		+	+	1	1	+	+
h	*Blepharis transvaalensis*	+	+			+	+	+		+	+
sc	*Talinum caffrum*	+	+	+	+	+			+		+
h	*Hibiscus pusillus*		+	+			+	+		+	+
ge	*Ammocharis coranica*	+		+		+	+		+	+	
h	*Crassula transvaalensis*	+	+	+		+	+				+
h	*Cassia italica*	+				+	+		+	+	+
g	*Themeda triandra*	+				+		+	+	1	+
h	*Solanum delagoense*		+	+		+		+		+	+
h	*Cyphocarpha angustifolia*	+		+			+	+	+		+
t	*Dichrostachys cinerea* subsp. *africana*	+			+	+				+	+
h	*Gomphrena celosioides*	+					+	+			+
h	*Justicia flava*		+	1		+	+				
h	*Pollichia campestris*	+			+		+	+			
h	*Cassia mimosoides*	+						+		+	+
g	*Sporobolus festivus* var. *fibrosus*			+			+				+
h	*Cyperus margaritaceus*					+		+			+
t	*Combretum hereroense*			+	+						+
g	*Schmidtia pappophoroides*			+		+			+		
	and the following number of species	6	6	14	8	6	14	15	1	1	4

Tab. I : Floristic classification of the two communities. Growth form symbols used : t = single or multi-stemmed individual more than 2 m, s = multi-stemmed individual less than 2 m, ds = dwarf shrub less than 0,5 m, h = herb, sc = succulent herb, g = grass, cl = climber, ge = geophyte. Nomenclature is according to the present (1.1.1978) usage of the National Herbarium Pretoria.

	Profile n°		Coarse sand 2 - 0.5 mm	Medium sand 0.5 - 0.2 mm	Fine sand 0.2 - 0.02 mm	Sand 2 - 0.02 mm	Silt 0.02 - 0.002 mm	Clay < 0.002 mm
20 cm	woodland	1	15.8	16.9	41.6	74.3	7.4	16.3
		2	20.9	12.8	33.7	67.4	7.4	22.5
		3	18.3	16.4	37.1	71.8	6.3	21.5
	grassland	4	21.1	15.3	29.2	65.7	8.8	21.5
		5	25.1	15.8	29.7	70.6	8.2	16.7
		6	20.8	16.6	32.1	76.6	7.4	15.8
60 cm	woodland	1	19.7	13.8	31.9	65.4	7.7	24.1
		2	19.2	13.1	28.3	60.6	12.7	24.2
		3	17.7	13.4	30.9	62.0	8.7	29.4
	grassland	4	21.0	11.2	26.6	58.8	13.0	23.4
		5	18.7	11.1	25.6	55.4	11.6	29.2
		6	20.3	11.6	30.7	62.6	7.9	29.8
90 cm	woodland	1	18.8	11.9	30.9	61.6	7.1	27.9
		2	14.8	10.5	28.4	53.7	13.6	28.0
		3	15.8	10.6	32.2	58.6	8.7	32.4
	grassland	4	19.4	11.2	29.7	60.3	15.7	20.1
		5	19.9	10.7	27.3	57.9	14.9	25.4
		6	31.9	10.8	24.7	67.4	6.4	23.7

Tab. II : Texture of soils under wooded community (profile n° 1, 2 and 3) and grassland (profile n° 4, 5 and 6) at three depths.

	Profile n°		Na	K	Ca	Mg	S	CEC	pH (H_2O)	Conductivity (mmho)
20 cm	woodland	1	0.1	0.5	3.0	1.3	4.9	8.0	5.7	0.40
		2	0.1	0.3	4.8	2.0	7.2	8.1	6.4	0.55
		3	0.2	0.5	3.6	1.7	6.0	7.2	5.8	0.62
	grassland	4	0.1	0.8	1.3	1.0	3.2	6.4	5.5	1.1
		5	0.1	1.2	1.4	1.1	3.8	5.6	6.0	0.36
		6	0.1	0.3	1.5	1.1	3.0	5.1	5.3	0.53
60 cm	woodland	1	0.2	0.9	6.5	2.3	9.9	9.8	6.9	0.71
		2	0.3	0.4	6.9	2.9	10.5	10.9	6.9	0.71
		3	0.3	0.3	5.3	1.9	7.8	10.0	6.0	0.71
	grassland	4	0.1	0.5	1.7	1.6	3.9	7.7	5.4	0.33
		5	0.1	0.5	2.0	1.6	4.2	8.7	5.3	0.42
		6	0.1	0.4	1.6	1.1	3.2	7.2	5.1	0.32
90 cm	woodland	1	0.3	0.5	8.4	2.4	11.6	11.3	6.7	2.1
		2	0.3	0.3	8.9	3.0	12.5	12.2	7.0	1.7
		3	0.2	0.3	7.7	2.1	10.3	11.2	6.7	0.71
	grassland	4	0.1	0.4	1.5	1.4	3.4	6.8	5.4	0.31
		5	0.1	0.4	1.6	1.4	3.5	7.8	5.0	0.36
		6	0.1	0.2	1.1	0.8	2.2	5.7	5.3	0.20

Tab. III : Exhangeable cations (meq/100 g oven dry soil), acidity and conductivity (soluble salts) of soils under wooded community and grassland at three depths. S = sum of exchangeable bases. CEC = total cation exchange capacity.

Soil analyses.

An analysis of soils from six profiles was undertaken. Three profiles form each plant community were sampled at 20 cm, 60 cm and 90 cm depth and a number of standard soil laboratory tests was carried out. Results are presented in tables II and III.

DISCUSSION

We do not have enough data to present convincing explanations about the origin of the pattern. However, we may give some ideas for future research.

The texture differences (Tab. II) appear to be so small that they can hardly be of ecological or even sedimentological significance (BOALER & HODGE, 1962 & ZONNEVELD *et al.*, 1971). Although Kalahari sand deposits may have influenced geomorphology in the Transvaal (HARMSE, 1967) we believe that our patterns are not associated with former dune fields, like the patterns of CLAYTON (1966) and ZONNEVELD *et al.*, 1971), but rather with erosion and run-off because the stripes run at right angles to the contour lines. Unlike the explanation of MacFAYDEN (1950) and WORRALL (1959) who worked in much drier areas, we think that in our area slope and rainfall are sufficient for slight gulley erosion. Such processes could form a microrelief of parallel troughs alternating with slightly raised crests. In the case of considerable run-off the profiles in the troughs could even become truncated. However, our data do not suggest this because the top soil under the grasslands differs much from the subsoil under the wooded stripes.

ZONNEVELD *et al.*, (1971) have shown that a primary factor which determines presence or absence of woody plants is the water regime on top of the soil profile. We expect that this is also an important factor in our area. Field observations support the view that the grasslands (in troughs) are on seasonally extreme sites whilst the wooded stripes (on crests) are related to soil sites with optimal moisture conditions and aeration. Water was often seen standing the troughs in local hollows for several days. Auger borings showed signs of plinthization at about 20 - 30 cm in several grassland profiles. Water standing or flowing in the troughs during the rain season may also kill or wash away seeds and seedlings and could cause anaerobic conditions to develop in the soils. To support this view, run-off, penetration and sealing of the top soil of grassland and woodland profiles could be investigated. One could examine how often and for how long water remains in the troughs and compare soil moisture regimes.

Table III shows differences in exchangeable cations, acidity and soluble salts between woodland and grassland soils. Na, Ca and Mg values generally increase with depth of soil in the woodland profiles while grassland soils have low values throughout the entire profile. At a depth of 90 cm concentrations of soluble salts are lower in the grassland profiles. These differences can not be ascribed to a higher degree of leaching in grassland soils if run-off is supposed to be greater in the troughs. A possible explanation is that the woody vegetation being more deeply rooted than the grassland, is cycling minerals derived from deeper unleached soil layers more efficiently than the grassland is.

Once vegetation differences between crests and troughs exist, they could be maintained by the vegetation itself and by factors like burning (Fig. 5) and grazing. Thus the pattern appears fairly stable with soil genesis maintaining divergence between the profiles under the wooded community and the grassland.

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REFERENCES

BOALER, S.B. & HODGE, C.A.H., 1962. Vegetation stripes in Somaliland. *J. Ecol.*, 50, 465-474.

CLAYTON, W.D., 1966. Vegetation ripples near Gummi, Nigeria. *J. Ecol.*, 54, 415-471.

HARMSE, H.J. von M., 1967. Soil genesis in the Highveld Regions, South Africa. Dr Thesis, University of Utrecht, 201 p.

MacFAYDEN, W.A., 1950. Vegetation patterns in the semi-desert plains of British Somaliland. *Geogr. J.*, 116, 199-211.

MacVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H., & HARMSE, H.J. von M., 1977. *Grondklassifikasie : 'n binomiese sisteem vir Suid-Afrika*. Pretoria, Departement van Landbou Tegniese Dienste.

SCHULZE, R.E. & McGEE, O.S., 1978. Climatic indices and classification in relation to the biogeography of southern Africa. In : M.J.A. Werger (ed), *Biogeography and ecology of southern Africa*. Junk, The Hague, 19-52.

SIDERIUS, W., 1973. Soil transitions in central and east Botswana (Africa). Dr Thesis, University of Utrecht. Krips, Meppel, 260 p.

VAN DER MEULEN, F., 1979. Plant sociology of the western Transvaal Bushveld, South Africa. Dr Thesis, University of Nijmegen. *Dissertationes Botanicae* Bd 49. Cramer, Lehre, 214 p.

VAN DER MEULEN, F. & WESTFALL, R.H., 1979. A vegetation map of the western Transvaal Bushveld. *Bothalia* 12, 731-735.

WEATHER BUREAU, 1954. *Climate of South Africa*. 1. *Climate statistics*. Govt. Printer, Pretoria, 160 p.

WELLINGTON, J.H., 1955. *Southern Africa, a geographical study*. University Press, Cambridge, 528 p.

WERGER, M.J.A. & COETZEE, B.J., 1978. The Sudano-Zambezian Region. In : M.J.A. Werger (ed), *Biogeography and ecology of southern Africa*. Junk, The Hague, 301-462.

WHITE, L.P., 1970. Brousse tigrée patterns in southern Niger. *J. Ecol.* 58, 549-553.

WORRALL, G.A., 1959. The Butana grass patterns. *J. Soil Sci.* 10, 34-53.

ZONNEVELD, I.S., 1975. Der Zusammenhang zwischen dem horizontalgefüge der Vegetation und dem edaphischen Zustand in einem Savannengebiet nord-Nigerias. In : H. Dierschke (ed.), Vegetation und Substrat. *Ber. Int. Symp. Int. Verein. Vegetationskunde, Rinteln 1969*. Cramer, Vaduz, 511-527.

ZONNEVELD, I.S., DE LEEUW, P.N. & SOMBROEK, W.G., 1971. An ecological interpretation of aerial photographs in a savanna region in northern Nigeria. *ITC Publications* Series B, n° 63. ITC, Enschede, 41 p.