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Savannas of southern Africa: attributes and use of some types along the Tropic of Capricorn

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ABSTRACT

Two recent reconnaissance vegetation surveys of savanna in the Kalahari of Botswana and in the western Transvaal (RSA) carried out on a landscape basis are described. Attributes and utilization of four selected stations along a transect of about 1 000 km near the Tropic of Capricorn, with a climate changing eastward from arid to subhumid, are compared. The stations represent microphyllous *Acacia*-savannas and mesophyllous *Burkea–Ochna–Terminalia* savannas on deep red sands, covering extensive parts in both survey areas. Land attributes used are physiography, macro-climate, vegetation (growth), large herbivores and land use practices.

The most striking difference between the four areas are the land use practices.

Some notes on the survey methodology are presented. The authors conclude that for small-scale vegetation-land use surveys the 'holistic' landscape approach can be recommended.

RÉSUMÉ

SAVANES DE L'AFRIQUE DE SUD: CARACTÉRISTIQUES ET EXPLOITATION DE CERTAINS TYPES LE LONG DU TROPIQUE DU CAPRICORNE

Deu prospections récentes de la végétation de savane dans la zone du Kalahari au Botswana et dans le Transvaal occidental, basies sur sa physionomie, sont décrites. Les caractéristiques et l'exploitation de quatre sites choisis le long d'un transect d'environ 1 000 km près du Tropique du Capricorne, avec un climat passant de l'aride en ouest au sub-humide à l'est, sont comparées. Les sites représentent des savanes à Acacia *microphylles et des savanes à* Burkea–Ochna–Terminalia *mésophylles sur sable rouge profond couvrant de vastes superficies dans les deux zones prospectées. Les caractéristique du terrain utilisées sont la physiographie, le macroclimat, la végétation (croissance), les grands herbivores et l'utilisation des sols.*

La différence la plus marquante entre les quatre sites réside dans l'utilisation des sols.

Quelques notes sur la méthodologie de la prospection sont présentées. Les auteurs concluent que pour des prospections à petite échelle de la végétation et de l'utilisation des sols, l'étude 'holistique' du paysage peut être recommandée.

INTRODUCTION

Recently, some reconnaissance vegetation-land (use) surveys have been carried out in savannas of the Sudano-Zambesian Region in southern Africa. Extensive areas were mapped in the Republic of Botswana and the Transvaal Province, Republic of South Africa. The Botswana survey (CARAP, 1980) contains an inventory of the range and game resources of the Kalahari in southern and western Botswana, approximately 240 000 km^2 in size, with final mapping scale at 1: 1 500 000, including more detailed maps at scales of 1: 150 000 and 1: 50 000 of a selected area. The Transvaal study (Van der Meulen, 1979) covers about 25 000 km^2 in the western Transvaal and concentrates on taxonomy and ecology of the plant communities. Final mapping was done at scale 1: 250 000 (Van der Meulen & Westfall, 1979).

Intensive use was made of black and white air photos (scales 1: 20 000–1: 70 000) and LANDSAT-imagery with stratified field sampling more or less according to the Braun-Blanquet method. Because of the small mapping scales, final maps show whole land units which are based not only on their vegetational features, but also on other land attributes like macro-climate, landform, soil and sometimes even the main land use practices.

The survey areas together roughly present a broad strip of land extending about 1000 km from west to east near the Tropic of Capricorn (Fig. 1). Along this transect from the Kalahari Basin of Botswana eastward onto plateau areas of Transvaal, the climate changes from arid to subhumid. Results of the two surveys enable us to compare attributes and utilization of some savanna types along this climatic gradient. The comparison supports our view that small scale vegetation surveys should be carried out on a landscape basis, that is, to include land attributes other than vegetation alone in the survey and the mapping procedure.

ENVIRONMENT

A brief general description is given of the physical environment of the transect area, dealing with main changes in climate from southern Botswana eastward into Transvaal.

Southern Africa is part of the great African plateau, one of the greatest plateaux of the earth's surface, stretching from the Cape Province to the southern limits of the Sahara. Geographically, southern Africa consists of a fairly flat high interior plateau, fringed on either side by strips of coastal

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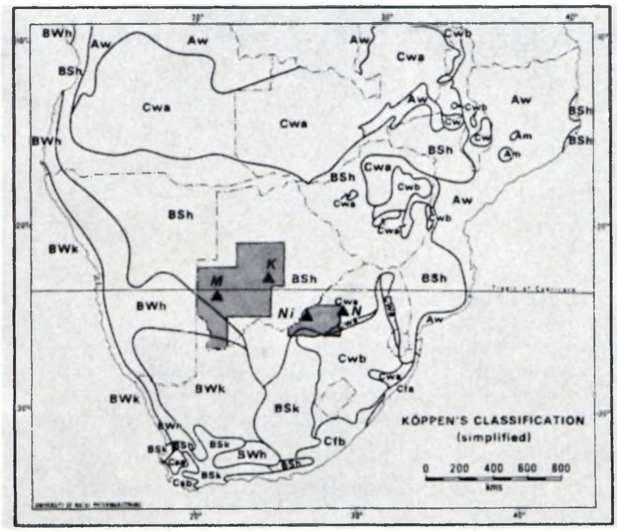

FIG. 1.—Reconnaissance vegetation survey areas (dark) and four selected stations (▲) near the Tropic of Capricorn, plotted on Köppen's classification of climates for southern Africa (Schulze & McGee, 1978). M=Matsheng; K=Kuhtse; Ni=Nietverdiend; N=Nylsvley.

plains along the Pacific Oceans (Wellington, 1955). Our transect area lies on this plateau at about 24° southern latitude. It extends between 21°–28° eastern longitude (Fig. 1). Unlike the coastal strips, the plateau has a strong continental type of climate, designated in the Köppen system as Bsh. This is a dry and hot steppe climate of arid zones with summer rainfall. Mean annual temperature is over 18°C.

Within the Bsh climate type, differences occur along the transect, the climate being warm and dry in southern Botswana, becoming cooler and moister eastward into Transvaal (Schulze & McGee 1978, see also Table 1; Fig. 2). Mean annual precipitation ranges from 200–400 mm in the west to 600–800 mm in the east, whereas the percentage of seasonal variability from mean annual rainfall is much higher in the west (up to about 70%). Throughout the transect area, the rain season is about 5–7 months long. Rain falls in summer. Temperature differences are only pronounced in this season: January average daily maximum temperatures range between 35°/32°C–30°/27°C from west to east and average daily temperatures range between 26°/28°C–22°/20°C. Evaporation varies between 600/800 mm–200/400 mm per year in the same direction (Table 1).

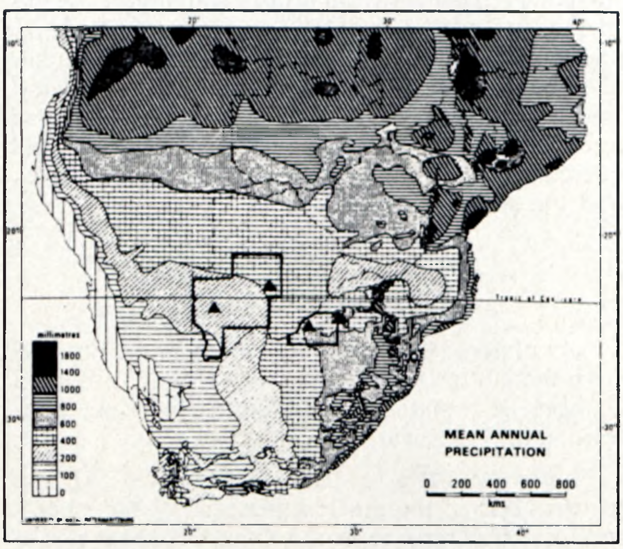

FIG. 2.—Mean annual precipitation for southern Africa. From Schulze & McGee (1978). Survey areas demarcated. Compare with Fig. 1.

General topography consists of gently undulating plains at an elevation of 1 100 m with low depressions and dunes in Botswana. In the western Transvaal, flats with plains at an elevation of about 1 100 m are surrounded by low hills up to 300 m. Soils are reddish arenosols, locally with halomorphic properties. Clays and lithosols are common in the Transvaal hills (Harmse, 1978). The difference in surface drainage is very conspicuous: rivers and wadi's are common in Transvaal. However, surface water in Botswana is rare.

VEGETATION-LAND SURVEYS: A COMPARISON OF RESULTS FROM BOTSWANA AND TRANSVAAL

To discuss the surveys in Botswana and Transvaal in detail is beyond our present scope. We refer to the respective reports. Our purpose is to compare some results from both surveys. In order to compare appropriate land characteristics we concentrate on sandveld tree-savanna types of slightly acid to neutral fersiallitic red sands. Such types cover extensive parts in both survey areas. They are composed either of microphyllous thorn trees (*Acacia* spp.) or of mesophyllous trees (*Burkea africana, Terminalia sericea, Ochna pulchra*). Four stations are selected along the transect, two in Botswana and two in Transvaal. From east to west these are: Matsheng, Kuhtse, Nietverdiend and Nylsvley (Fig. 1, Table 1). For each station data are supplied on the following land features:

(i) climate: type, precipitation, rain season, evaporation, temperature,
(ii) physiography: elevation, relief, soil type, soil pH, surface drainage,
(iii) vegetation: structure, dominant woody plants, dominant grasses, life form composition, phytomass (above ground standing crop), crude protein (CP), phosphorus (P), carrying capacity,
(iv) large herbivores: domestic livestock and wildlife species,
(v) land use types.

Matsheng village area provides an example of the *Acacia*-savannas which occur in the southern parts of the Botswana survey, and Kuhtse gives an example of the mesophyllous savannas in the northern parts. Similarly, Nietverdiend presents the microphyllous *Acacia*-savannas in the western Transvaal survey and Nylsvley* mesophyllous savannas. Both types in Botswana occur on plains and broad interdunal

* This type was chosen because plant production data were available.

TABLE 1.—Land characteristics of savannas at four selected stations along a 1 000 km transect near the Tropic of Capricorn

STATION	MATSHENG	KUHTSE	NIETVERDIEND	NYLSVLEY
COORDINATES (S.lat.:E.long.)	24.00 21.45	23.15 24.30	25.00 26.00	24.40 28.40
Climate				
type (Köppen system)	Bshw	Bshw	Bshw	Bshw
precipitation (mm/yr)	300	400	550–600	600–700
rain season	summer; 4–8 mnths	summer; 4–8 mnths	summer; 5–7 mnths	summer; 5–7 mnths
evaporation (mm/yr)	600–800	400–600	200–400	200–400
air temp (°C)				
average daily max. Jan.	32.5	31	27–30	27–30
average daily min. July	2.5	2.5	0–2.5	0–2.5
Physiography				*
region (Wellington, 1955)	Kalahari Basin Southern Kalahari	Kalahari Basin central Plain	Transvaal Plateau basin floor	Transvaal Plateau cuesta veld
elevation (m above sea level)	1 150	1 000	1 000–1 200	1 200–1 500
relief	(almost) flat	(almost) flat	(almost) flat; locally inselberge	undulating-gentle-moderately steep
soil type	fersiallitic sands	fersiallitic sands	fersiallitic sands	fersiallitic sands
soil pH	4–6	4–6	4–6	4–6
drainage (surface)	none	none	rivers; wadi's	rivers; wadi's
Vegetation				
physiognomy	microphyllous thorn savanna	mesophyllous broad-leaf savanna	microphyllous thorn savanna	mesophyllous broad-leaf savanna
predominant trees/shrubs	*Acacia erioloba* *A. luederitzii* *A. mellifera* *Boscia albitrunca* *Rhus tenuinervis*	*Terminalia sericea* *Ochna pulchra* *Burkea africana* *Lonchocarpus nelsii* *Bauhinia petersiana*	*Acacia erioloba* *A. fleckii- A. tortilis* *A. mellifera* *Boscia albitrunca* *Grewia flava*	*Terminalia sericea* *Ochna pulchra* *Burkea africana* *Combretum* spp. *Grewia flavescens*
predominant grasses	*Stipagrostis uniplumis* *Schmidtia* spp. *Eragrostis lehmanniana*	*Digitaria* spp. *Eragrostis pallens* *Antephora pubescens* *Eragrostis lehmanniana*	*Aristida congesta* *Schmidtia pappophoroides* *Eragrostis lehmanniana*	*Digitaria* spp. *Eragrostis pallens*
life form (cover %)				
macro-phanerophyte (> 8 m)	–	–	locally 1	1, locally 1–5
micro-phanerophyte (5–8 m)	2, locally < 20	2, locally < 20	1–5, locally 5–10	1–5, locally 5–20
nano-phanerophyte (< 5 m) } multi-stemmed phan. (< 5 m) }	2–20, locally 20	20, locally 2–20	1–10, locally 10–20	1–10, locally < 25
woody chamaephyte	1	1	1	1
other chamaephyte	1	1	1	1
hemicryptophyte	30	40	30–35	30–60
therophyte	1	1	1	1
geophyte	1	1	1	1
phytomass (above-ground standing crop.; gr/m2 grasses + forbs)	50–160	70–160	?	90–180
C.P.	deficient	deficient	?	deficient
P.	deficient	deficient	?	deficient
carrying capacity (ha $L.S.U.^{-1}$)	20	20	?	?
Large herbivores				*
domestic (rel.number in %): cattle, goat	cattle (70) goat (30)	– –	cattle (95–100) goat (1–5)	cattle (95–100) –
game (G): hartebeest, wildebeest, gemsbok, springbok, kudu, ostrich, eland-antelope	G	G	–	–
Land use				*
arable agriculture (rel.area in %)	subsistence**	–	subsistence (1–5) commercial (5–10)	subsistence (1–5) commercial (5–10)
grazing	permanent communal summer grazing	–	fenced paddocks	fenced paddocks
hunting/gathering	subsistence	subsistence	–	–
nature conservation	–	'game reserve'	–	private game reserve + nature reserve (1)
urban	–	–	1	1–5

* considered over West Transvaal as a whole
** presence < 1 %

valleys of the Kalahari Basin. The *Acacia* types of the Transvaal survey are described by Van der Meulen (1979) as 'xeric lowland bushveld'. They are common on undulating plains and flats of the Bushveld Igneous Complex Basin. The mesophyllous types are described as 'mesic upland bushveld'. They are usually found on the hills surrounding the Basin, but also in the Basin itself. Floristic community types involved are:- Matsheng: *Acacia erioloba–Acacia luederitzii* Association (Comm. Nrs 7, 8; Fig. 3), Kuhtse: *terminalia sericea–Lonchocarpus nelsii* Association, Nietverdiend: *Acacia*

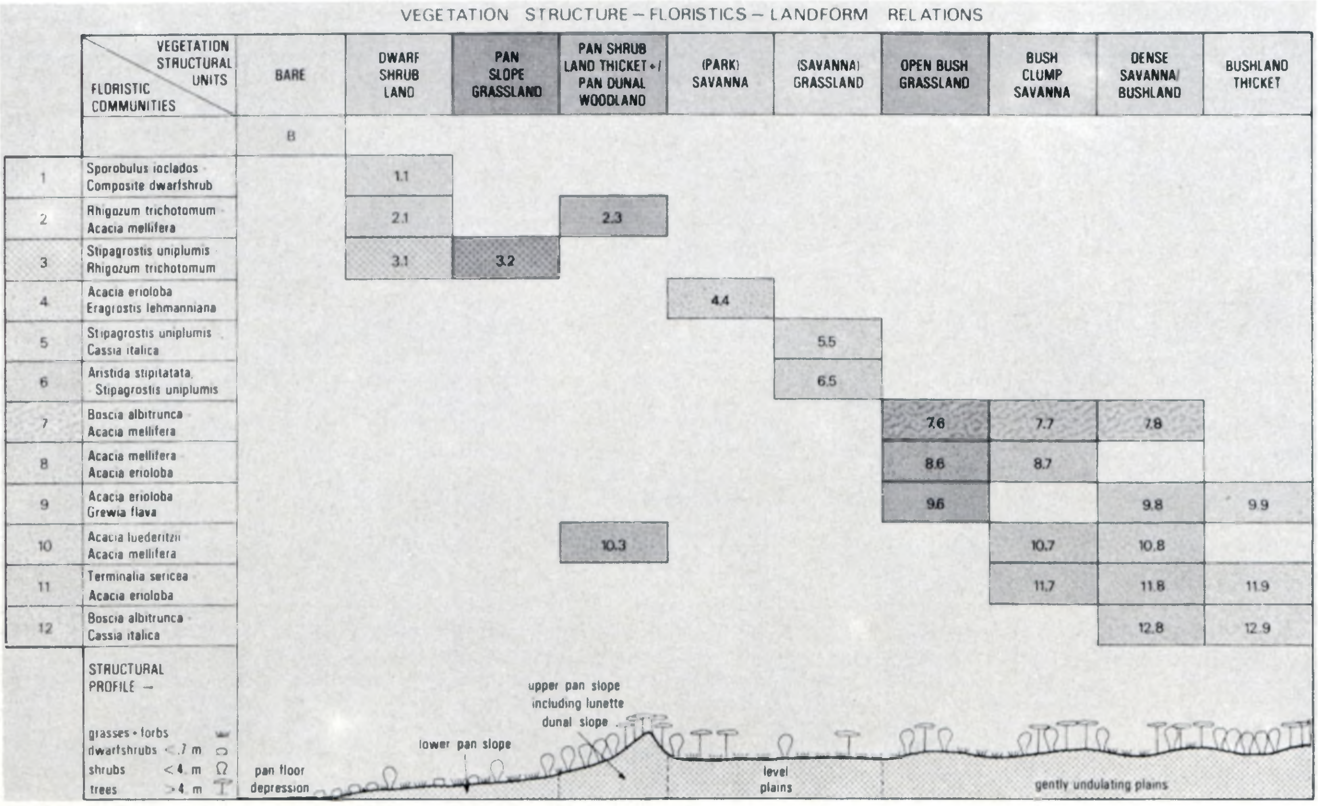

FIG. 3.—Example of presentation of legend units showing vegetation structure-floristics-landform relations in the Matsheng area of Botswana (CARAP, 1980). Note independence of structure and floristic composition of the vegetation.

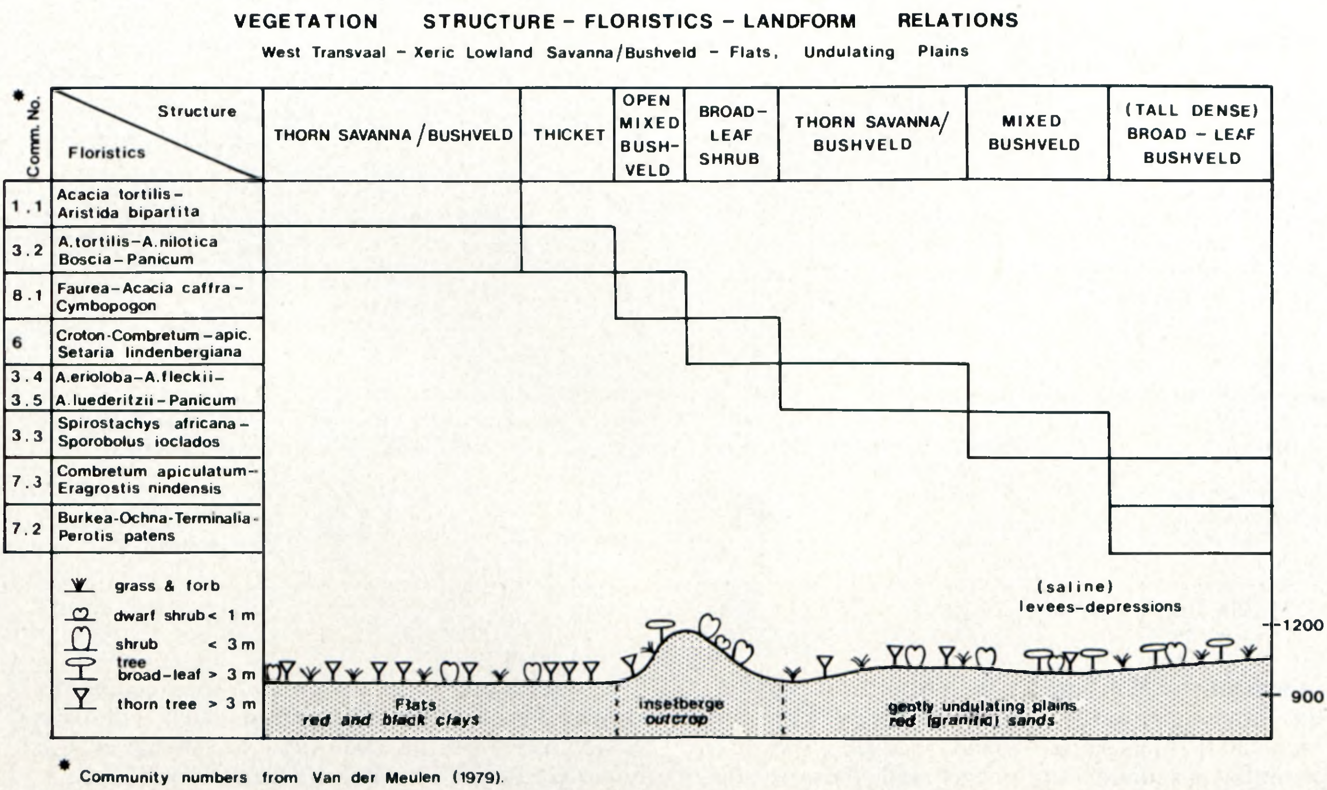

FIG. 4.—Example of vegetation structure-floristics-landform relations in the western Transvaal.

erioloba–Acacia fleckii Association (Comm. Nrs 3.4, 3.5; Fig. 4), Nylsvley: *Eragrostis pallens –Burkea africana* Association (Coetzee *et al.*, 1976).

DISCUSSION AND CONLUSIONS

Some conclusions drawn after a comparison of the data (Table 1) are:

Vegetation

The similarity of the vegetation (structure, floristic composition, life form composition) over such a long distance is remarkable when mesophyllous types and microphyllous types are compared, even though differences in rainfall and temperatures occur. In the *Acacia* types, *Acacia erioloba, A. luederitzii, A. mellifera, Boscia albitrunca* and *Rhus tenuinervis* are dominant woody plants. *Rhus tenuinervis* is absent in western Transvaal. Here, *Acacia fleckii, A. tortilis* and *Grewia flava* are common dominants. It is interesting that in the Transvaal survey *Acacia luederitzii* is usually a dominant where *Acacia erioloba* is scarce.

Dominant grasses in the *Acacia* savannas of southern Botswana include various species of *Schmidtia* and *Stipagrostis*. These are infrequent in the Transvaal survey. Here, *Aristida congesta, Eragrostis lehmanniana* and, locally, *Panicum maximum* are the dominants.

The mesophyllous types too have much in common. *Terminalia, Burkea* and *Ochna* are predominant trees. Species of *Combretum* are co-dominant in Transvaal. At Nylsvley, *Grewia flavescens* is a local dominant. *Lonchocarpus nelsii* and *Bauhinia petersiana* (both absent in the Transvaal survey) are dominant trees in the Botswana area. Common grasses in the ground storey include *Eragrostis pallens* and *Digitaria* spp. In western Transvaal, *Eragrostis pallens* is often replaced as a dominant by species of *Diheteropogon* and *Schizachyrium,* tall coarse tufted sclerophyllous grasses indicating mesic conditions.

In all cases, the ground layer mainly consists of perennial hemicryptophytes. Annuals are scarce.

Although life form spectra show great similarity, the height of the trees is positively correlated with increasing precipitation. In the Kalahari area mesophyllous as well as microphyllous trees do not exceed 5–8 m in height. Tree and shrub layers are composed of micro-, nano- and multi-stemmed phanerophytes. Chamaephytes are scarce. In the western Transvaal trees may grow taller, in favourable localities even up to 10–12 m (macrophanerophytes).

Vegetation growth

Savanna growth, from the point of view of large herbivore food (forage), can be subdivided into (i) herbage: forage from herbs (grasses and forbs) and (ii) browse: forage from woody plants (trees, shrubs). An important measure in rangeland survey and management, is forage growth, defined as the increase in forage weight per unit of land and per unit of area. For a given survey area, herbage growth may be predicted from average rainfall applying the following empirical equation (Houerou & Hoste, 1977):

$$y = a + bx$$

where y = forage growth in kg dry matter. ha^{-1}. yr^{-1}
x = annual rainfall in mm. yr^{-1}
a = constant (near zero in southern Africa for total dry matter, Walter 1939, Rutherford 1978)
b = constant (4/2 in Karoo-Namib Region for total dry matter; Walter 1939, Rutherford 1978).

From the measured forage growth (CARAP 1980) a rainfall varying between 50–150 mm may be deducted with this formula. Indeed, the survey year (1978/79) was a drought year in the Kalahari: the average forage growth calculated on the basis of the average rainfall (300–400 mm) would be 300–400 gr. m^{-2}. yr^{-1}. However, the surveyor should not use the formula except with great caution. Many other factors may limit forage growth, such as soil fertility, erosion, vegetation composition, fire and drainage. The CARAP survey indicated that forage growth at present does not seem to be the limiting factor for livestock/wildlife production over the Kalahari as a whole.

Because browse data are not known to us from all stations, we concentrate on herbage growth data (above ground standing crop). For the Transvaal, survey area data were only available from Nylsvley Nature Reserve in the northern Transvaal (Huntley & Morris, 1978). These appear to be only slightly higher (90–180 gr.m^{-2}.yr^{-1}; survey years 1974/77) than the data obtained from the Botswana survey (70–160 gr.m^{-2}.yr^{-1}; survey years 1977/78). No data are available from *Acacia* savannas in the western Transvaal. However, no important difference was found between herbage growth of *Acacia* types and mesophyllous types in the CARAP survey (Table 1).

Large herbivores and current land use

As regards land use practices, we concentrate on grazing or browsing by game and domestic livestock. The most striking difference along the transect is in the large herbivores and land utilization types. In the Kalahari, domestic livestock may be locally present (Matsheng, for example), but a rich variety of game is usually found. In the western Transvaal, nearly all the game has been replaced by domestic livestock.

Along the transect land utilization types range from nature conservation and traditional hunting/gathering (Kuhtse) over permanently grazed unfenced communal grazing lands and hunting (Matsheng) to commercial fenced cattle ranches subdivided in paddocks and dry farming of (fodder) crops in the western Transvaal.

The communal livestock grazing lands in the Matsheng area are used also by some of the wild herbivores. It is interesting that, not only the small sedentary browsers (duiker, steenbok etc.) use the grazing land, but also the gregarious larger grazers (hartebeest, wildebeest). The land in the Kuhtse area is a game reserve. Land use envisaged here is tourist viewing. Wildlife utilization is not yet developed in the area.

In the western Transvaal, commercial grazing is the most common type of land use. Ranching is extensive with fenced paddocks and rotation systems. Crop cultivation is practised on a small scale. Irrigated crops are found along some of the permanent rivers. Urban development is still relatively low. However, an increase is expected in the near future, because the area lies at the border of the 'Pretoria-Witwatersrand-Vereeniging Complex', one of the most densely populated industrial areas of the Republic of South Africa. Nature conservation is rarely encountered. Edwards (1974) calculated that less than 1% of Acocks's (1975) veld types involved in the survey area is permanently conserved in conservation areas. On the basis of the western Transvaal survey, representative land units could be recommended for conservation. Game is rare in the western Transvaal. At Nylsvley Nature Reserve, a Provincial Reserve, the following indigenous ungulates were found in decreasing order of importance: impala, duiker, kudu, steenbok, warthog, reedbuck (Huntley & Morris, 1978).

The differences in land use types along the transect are explained by the presence of surface water and the accessibility of drinking water and by the colonization in the last centuries by white pastoralists who knew how to drill wells (Transvaal) and black pastoralists without this knowledge (Botswana).

CONCLUDING NOTES ON SURVEY METHODOLOGY

The examples we have given, show that vegetation should be seen as part of the environment in which other land attributes, like climate, physiography animals and land use also play a role.

Considering the future of small scale vegetation-land use surveys in southern Africa, we recommend integrated surveys of the environment (see Zonneveld *et al.*, 1979). Use of air photo interpretation is indispensable for objective stratified field sampling and to delineate final map boundaries. Field samples are classified into floristic vegetation types according to the Braun-Blanquet tabulation method. Such vegetation types serve as a basis for final map units and are characterized by sociological (or diagnostic) species groups, obtained from the phytosociological table.

The legend units should be presented in an illustrative and ecologically meaningful manner showing the relation between land form, vegetation form (structure) and vegetation composition (floristic types). Examples of such presentation are given in Figs. 3 & 4. It is interesting that the relation between floristically similar, but structurally quite different vegetation types, can also readily be seen from the diagrams. This is important, because structure and composition of the vegetation are often independent (cf. Van der Meulen & Westfall, 1980). Good land unit maps should therefore always have reference to both vegetation form and floristic composition. Presentation of the legend units may also be done in a two- or three-dimensional axis system in which the axes represent the main ecological factors operating in the survey area. Fig. 5 gives an example of such a scheme for the vegetation types which were found in the western Transvaal survey.

In our surveys the 'holistic' landscape approach is adopted. With land surveys of an holistic nature, we mean the study of the environment as an integrated entity that one can study as a whole (Zonneveld, 1979). Final land units are based on an integration of classification of each land attribute of that unit. An important contribution to such an integrated landscape approach in the Republic of South Africa

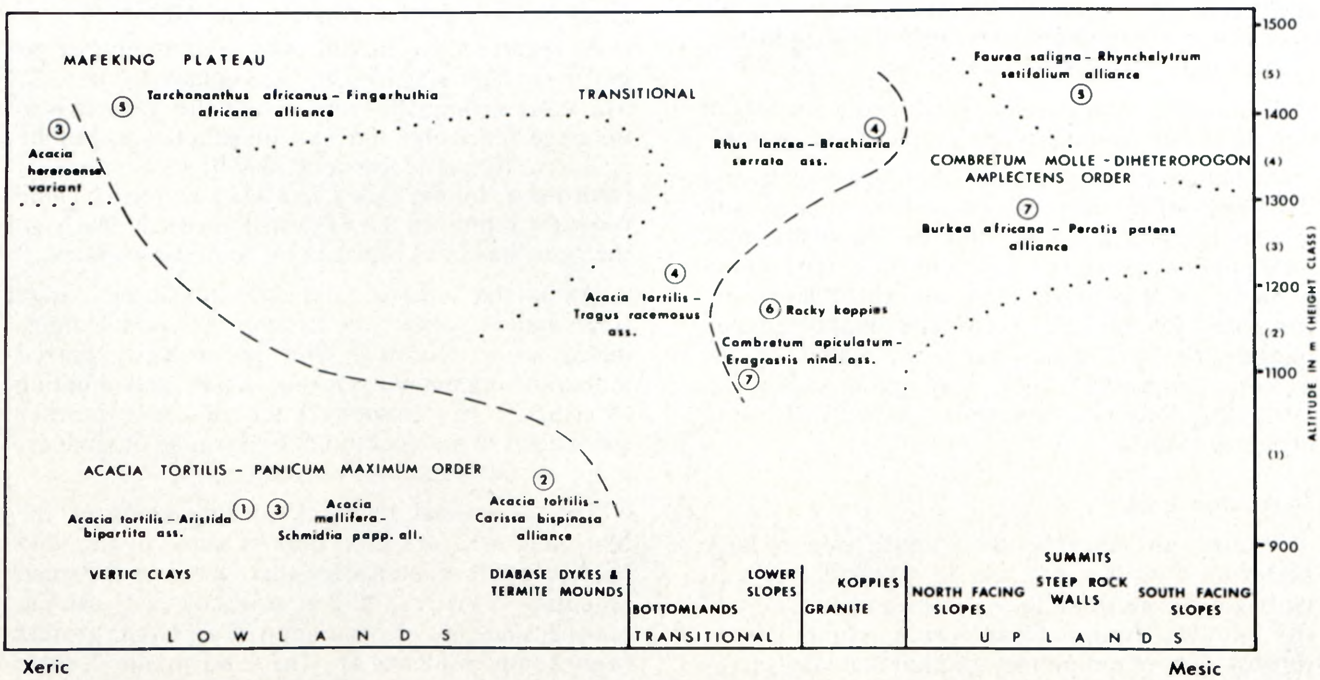

FIG. 5.—Major pattern of floristic vegetation types in the western Transvaal in relation to landform, elevation and moisture (from Van der Meulen, 1979).

is the nationwide 'land-type' survey (final mapping scale 1: 250 000) of the Soil and Irrigation Research Institute in Pretoria (MacVicar *et. al.*, 1974). In this physiographic soil survey unit of land with a characteristic combination of relief-type, soil and macro-climate were mapped as 'land-types'. The vegetation of the western Transvaal was mapped on the basis of such a 'land-type' map (Van der Meulen & Westfall, 1979). Clear correlations were obtained between the various land attributes, demonstrating that holistic land units can be arrived at in this way.

Vegetation and land surveys of an integrated nature require a survey team of people from various disciplines, so that various land data can be collected at the same spot simultaneously. Close co-operation between soil and vegetation survey departments is of scientific and economic importance in the survey of natural resources.

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