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The vegetation of the northeastern Orange Free State, South Africa: physical environment and plant communities of the Ea land type

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Keywords: Braun-Blanquet method, classification, geology, Grassland Biome, land types, soils

ABSTRACT

The research was carried out in the Ea land type of the northeastern Orange Free State, with the objective of reclassifying and refining Acocks's veld types. TWINSPAN classification results were further refined by Braun-Blanquet procedures. The 100 relevés distributed over the Ea land type resulted in the recognition of four major vegetation types which may be divided into nine plant communities. The communities were hierarchically classified, described and ecologically interpreted. DECORANA ordination was used to determine vegetation/environmental gradients and relationships.

UITTREKSEL

Navorsing is gedoen op die Ea-landtipe in die noordoostelike Oranje-Vrystaat met die doel om Acocks se veldtipes te herklassifiseer en te verfyn. Die resultate van die TWINSPAN-klassifikasie is met behulp van Braun-Blanquetprosedures verder verwerk. Die 100 relevés wat oor die hele Ea-landtipe versprei is, het vier hoofplantegroeitipes opgelewer wat in nege plantgemeenskappe onderverdeel kan word. Die gemeenskappe is hiërargies geklassifiseer, beskryf en ekologies geïnterpreteer. Plantegroei- en omgewingsgradiënte is met behulp van DECORANA-ordening bepaal.

CONTENTS

INTRODUCTION

The Grassland Biome of South Africa covers approximately 27% of the country. As a result of intensive agricultural practices and urbanization, together with industrialization, the deterioration of the grassland led to concern amongst decision-makers, resulting in the launch of the Grassland Biome Project (Mentis & Huntley 1982). This project aims at developing a better knowledge and understanding of the grasslands of South Africa to permit efficient land-use planning, utilization, conservation and management. To reach these goals, it is necessary to reclassify Acocks's (1988) Veld Types. This reclassification means a more detailed identification, description and mapping of the present grassland types (Scheepers 1986). The northeastern Orange Free State was identified as an area for which little or no phytosociological data exist. This study will also contribute to the syntaxonomic synthesis presently being undertaken by the Botany Department of the University of Pretoria (Bredenkamp *et al.* 1989; Kooij 1990; Fuls *et al.* 1992a, b; Bezuidenhout 1988).

STUDY AREA

The total study area is situated in the northeastern corner of the Orange Free State, i.e. between 29° 00′ and 29° 47′ E longitude and 27° 00′ and 28° 00′ S latitude, bordering Transvaal and Natal (Figure 1). It covers approximately 5 600 km² and comprises five land types, namely land types A, B, C, E and F (Land Type Survey Staff 1984), which can be further subdivided (Figure 2).

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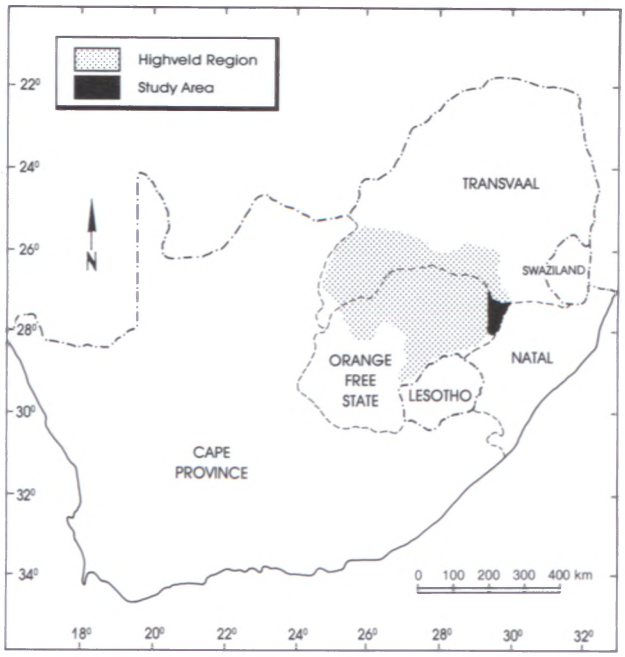


FIGURE 1.—Map of South Africa indicating the total study area situated in the Highveld Region.

One third of the area (184 000 ha) is covered by the Ea land type which is dealt with in this report. The other land types are to be discussed in detail in later papers. A land type is an area which is uniform with respect to terrain form, soil pattern and climate. Towns situated in the area are Vrede and Memel (Land Type Survey Staff 1984). According to Acocks (1988), the study area represents six veld types: Patchy Highveld to *Cymbopogon–Themeda*

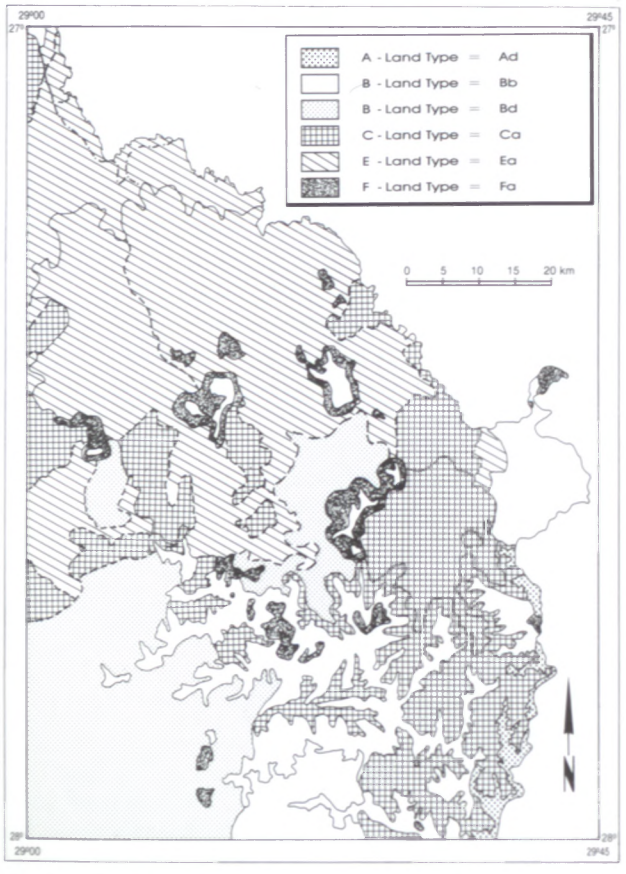


FIGURE 2.—Map indicating the distribution of the different land types (Land Type Survey Staff 1984).

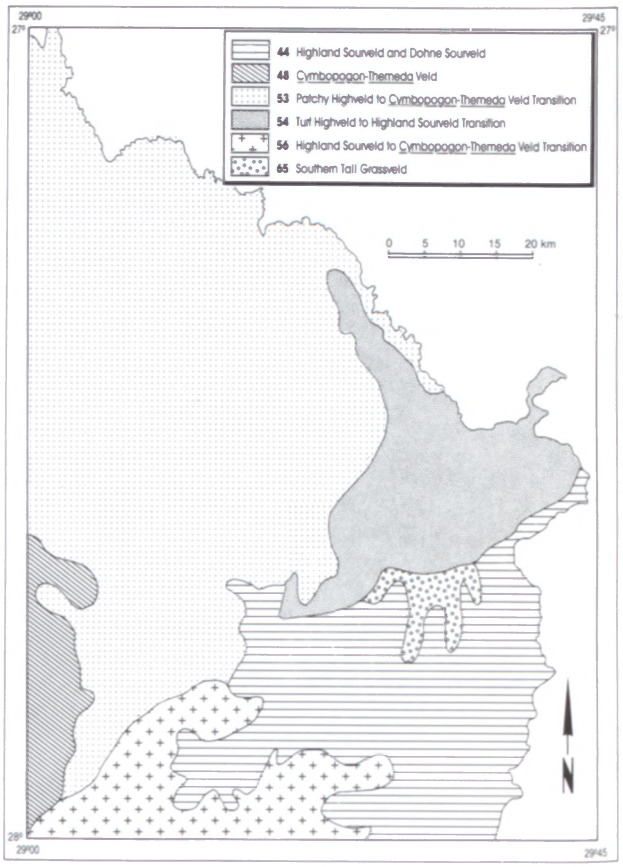


FIGURE 3.—The distribution of the different veld types within the total study area according to Acocks (1988).

Veld Transition (No. 53), covering approximately 50% of the total study area, is restricted to the northern and central parts. The Highland Sourveld (No. 44) stretches along the Natal border in the east. Smaller patches of *Cymbopogon–Themeda* Veld (No. 48) and Highland Sourveld to *Cymbopogon–Themeda* Veld Transition (No. 56) occur in the southwestern and southern parts. The Turf Highveld to Highland Sourveld Transition (No. 54) stretches over the central eastern part, while one olated patch of Southern Tall Grassveld (No. 65) occurs to the south of Memel (Figure 3).

GEOLOGY

KAROO SEQUENCE

The Karoo Sequence occupies the total study area (Figure 4). Two important groups which can be distinguished here, are the Ecca and Beaufort Groups. The Clarens, Elliot and Molteno Formations are also part of this sequence, but they are limited in extent.

Ecca Group

This group is restricted to the north and northeastern parts of the study area, bordering Transvaal (Figure 4). The Ecca Group can be subdivided into a Lower Ecca sandstone and shale, a Middle Ecca shale, and an Upper Ecca sandstone and shale [South African Committee for Stratigraphy (SACS) 1980]. Ecca shales are in general dark grey and carbonaceous. Ecca sandstone was deposited in an aquatic environment.

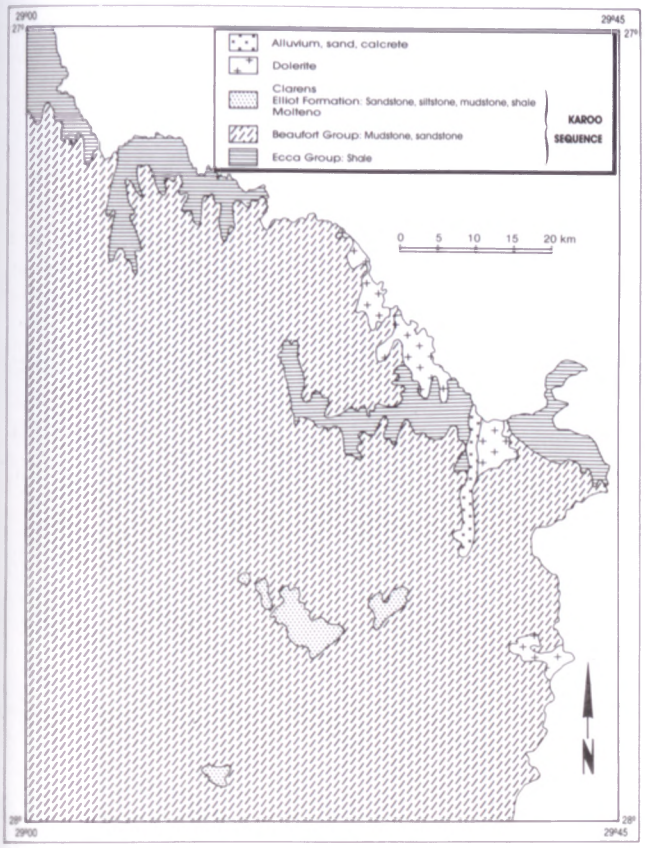


FIGURE 4.—The geology of the total study area (adapted from Dept. of Mineral and Energy Affairs 1984).

Beaufort Group

The Beaufort Group covers more than 80% of the study area. It can be subdivided into three subdivisions, namely the Lower, Middle, and Upper Beaufort Beds. The argillaceous rocks are massive or blocky weathered. The mudstones are greenish grey, blue-grey or red. Cross-bedded sandstones are common.

Clarens Formation

The Clarens Formation, previously known as Cave Sandstone, is a massive, fine-grained rock type, which reaches a thickness of up to hundreds of metres. Under weathering conditions, this formation features fantastic shapes in the form of pillars and caves. Exposed surfaces are white or cream-coloured, whereas its base is pink or deep red. A few isolated hills in the central and southern part of the study area have the characteristic shapes of this formation as described above. The main components are subangular to rounded grains of quartz and subordinate feldspar. The accumulation of sandstone is probably of aeolian origin, being re-arranged later by flowing water (Du Toit 1954).

Elliot Formation

Purple and red mudstones and shales, together with red sandstones and thick beds of yellow and white feldspathic sandstones are characteristic of this formation (Du Toit 1954). It is well distinguished by its prevailing colouration as can be seen on the slopes of the few koppies in the study area.

Molteno Formation

This formation is distinguished by the typical grey and blue colouration of the shales, and the coarse grain and 'sparkling' appearance of the dominating sandstones. Between Harrismith and Memel the Molteno Formation occurs only as a single thin grit, covered by the Elliot Formation and underlain by the Beaufort Group (Du Toit 1954).

Alluvium, sand, calcrete

Alluvium and sand are more recent by-products of erosion, most probably originating from the Beaufort Group (pers. obs.). A narrow strip of these deposits, together with calcrete, occurs in the Seekoeivlei area, which is drained by the Klip River (Department of Mineral and Energy Affairs 1984).

Dolerite

The dolerites intruded the sediments of the Karoo Sequence during the last stages of the Drakensberg volcanicity. These intrusions are either horizontal, evenly inclined or undulating sheets (SACS 1980). The dolerite dykes are restricted to the eastern part of the study area.

PHYSIOGRAPHY

The study area is part of the inland plateau region or highveld (Figure 1) and consists of plains with moderate relief to closed hills and mountains with moderate and high relief (Kruger 1983; Mentis & Huntley 1982). The altitude is between 1 500 and 2 000 m with some peaks reaching heights of up to 2 200 m. There is a clear gradient in the physiography of the area from south to north. Three broad divisions can be distinguished.

The southern and eastern parts are characterized by isolated hills and mountains with moderate and high relief. The middle part is depicted by lowlands, hills and mountains with a moderate to high relief. This part can further be described as strongly undulating irregular land, gradually changing over into plains with moderate relief. These plains are slightly irregular, undulating, with occasional hills scattered over the area. This region is most suitable for cultivation purposes, whereas the rest of the area is more suited to cattle farming.

The Drakensberg forms a clear watershed, separating the tributaries of the Vaal River, west of the escarpment, from the tributaries of the Tugela River, east of the escarpment. The study area is situated in the catchment area of the Vaal River. The Klip River is the main drainage line into which several smaller rivers and spruits flow (Figure 5). The northern part of the study area is mainly drained by the Spruitsonderdrift and Kommandospruit, which are both perennial streams. There is a gradual flattening towards the north, resulting in less deeply incised low to moderate undulating plains in the north. These are in strong contrast to the deeply incised mountainous southern part.

SOILS

According to Land Type Survey Staff (1984), the soils are undifferentiated and can have one or more of either vertic, melanic and red structured diagnostic horizons. The names and descriptions of the different soil forms are

TABLE 1.—The mean monthly temperatures and extreme temperatures (°C) for two weather stations closest to the study area

	Frankfort						Standerton					
	1985–1990						1985–1990					
	Max.	Min.	Max.	Date	Min.	Date	Max.	Min.	Max.	Date	Min.	Date
Jan.	28.3	14.8	36.4	18-01-73	4.0	30-01-61	27.3	14.4	37.2	05-01-29	2.5	05-01-60
Feb.	27.0	13.9	36.1	27-02-83	4.4	28-02-65	26.5	14.0	35.0	15-02-84	3.3	20-02-24
Mar.	26.5	11.3	35.0	03-03-84	0.6	10-03-74	26.0	12.4	34.0	03-03-84	0.6	15-03-30
Apr.	23.5	7.5	31.5	05-04-83	−4.0	27-04-55	24.2	8.8	31.7	01-04-33	−5.3	30-04-17
May	21.6	1.0	29.0	02-05-79	−7.5	19-05-84	21.3	2.7	30.0	03-05-33	−10.6	31-05-18
Jun.	18.1	−2.9	24.6	09-06-83	−11.0	20-06-57	17.6	−1.1	25.0	01-06-32	−12.8	11-06-07
Jul.	18.6	−3.7	23.8	29-07-60	−12.0	23-07-54	18.5	−2.1	26.1	31-07-40	−12.8	18-07-13
Aug.	21.8	0.4	27.9	19-08-77	−10.0	14-08-55	21.7	1.7	29.9	30-08-22	−11.7	16-08-13
Sep.	23.3	5.2	33.7	29-09-83	−8.3	09-09-74	23.6	5.9	34.4	30-09-23	−7.8	16-09-30
Oct.	24.8	9.3	34.2	30-10-65	−1.9	21-10-65	24.6	9.5	35.2	21-10-61	−3.8	01-10-13
Nov.	26.1	12.1	35.6	07-11-68	1.4	15-11-76	25.6	11.5	34.4	06-11-68	−1.1	25-11-12
Dec.	27.3	13.5	36.0	31-12-84	1.1	06-12-84	26.5	13.5	37.4	31-12-82	2.2	08-12-70
Av.	23.9	6.9					23.6	7.6				

used according to the Soil Classification Working Group (1991). The Glenrosa and Mispah Forms are restricted to terrain units 1 and 2 and very often occur together to form a complex. These soils are shallow (< 200 mm) and have a low clay content (15–20%) and are mostly not arable. Terrain units 3 and 4 are characterized predominantly by pedocutanic, lithocutanic and yellow-brown apedal B horizons. Soils are relatively deep (> 350 mm) and have a higher clay content (> 35%). Although the Ea land type is generally more suitable for crop production than the rest of the study area, large areas are non-arable because of the high clay content of the soils. Terrain unit 5 is characterized by either rock and alluvium or the vertic Rensburg and Arcadia soil forms. The last two forms have a high clay content (> 55%) and are deep (> 500 mm).

CLIMATE

Rainfall

The study area is situated in the summer rainfall zone with an average annual rainfall of 750 mm. Precipitation takes place mostly in the form of thunderstorms, between November and March. Midsummer droughts occur towards the end of December until middle of January (Department of Agriculture and Water Supply 1986). Rainfall data for weather stations at Frankfort and Standerton are given in Figure 6 (Weather Bureau 1986).

Temperature

Mean annual maximum and minimum temperatures for the period 1985–1990 and extreme temperatures recorded at Frankfort and Standerton are given in Table 1. The frost period extends from April to October, which means a frost-free period of approximately 150 days a year (Weather Bureau 1986).

METHODS

Relevés were compiled in 100 stratified random sample plots. Stratification was based on terrain units (De Beer 1988; Land Type Survey Staff 1984). Sampling of the different terrain units was done on a subjective basis. Five different topographical positions were distinguished, namely 1 = crests, 2 = scarps, 3 = midslopes, 4 = footslopes and 5 = valley bottoms, floodplains or drainage lines (Land Type Survey Staff 1984). Minimum plot sizes of 16 m² are considered to be adequate for grassland surveys (Scheepers 1975). Nevertheless, it was decided to fix the plots at 100 m² because of the large scale on which this survey was conducted, and to ensure that scarce, possible diagnostic species were included. This

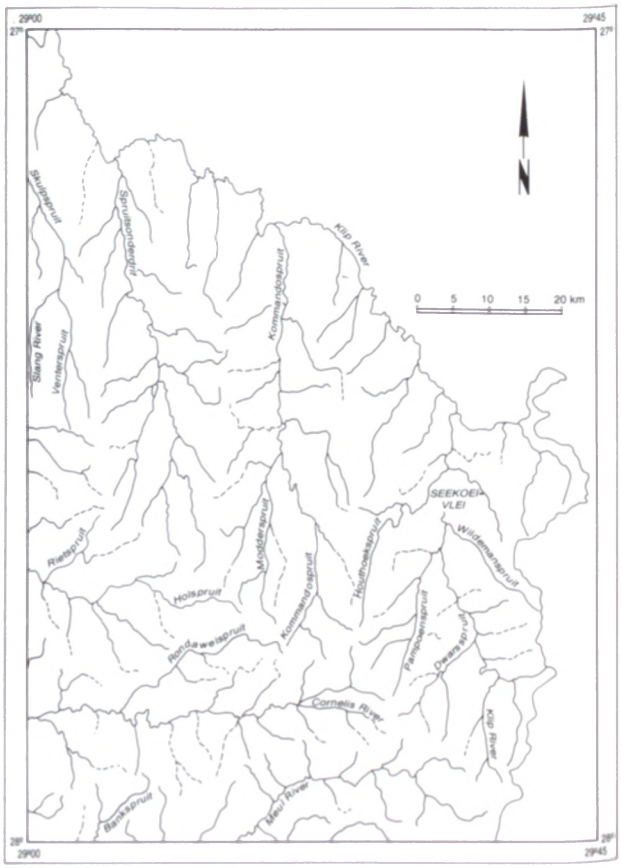


FIGURE 5.—The drainage of the total study area with the Klip River as main drainage line.

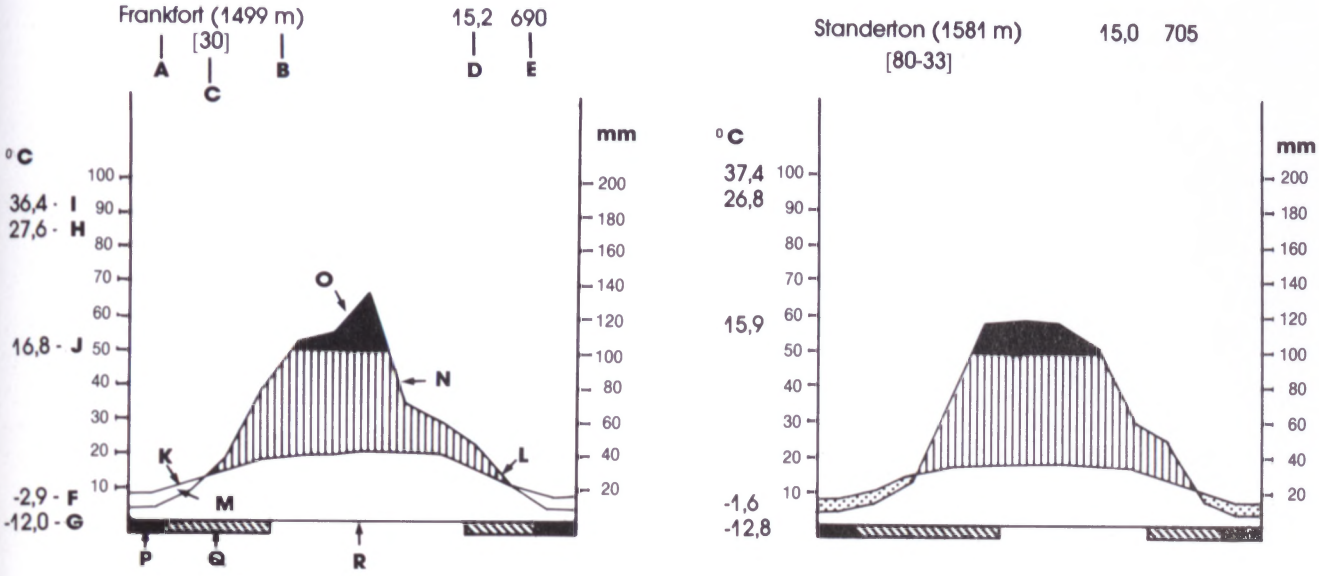


FIGURE 6.—Climatic diagrams for two weather stations. A, station; B, height above sea level; C, duration of observations in years (indicates temperature and precipitation respectively); D, mean annual temperature in °C; E, mean annual precipitation in mm; F, mean daily minimum temperature (coldest month); G, lowest temperature recorded; H, mean daily maximum temperature (hottest month); I, highest temperature recorded; J, mean daily temperature fluctuation; K, mean monthly temperature; L, mean monthly precipitation; M, dry season; N, wet season; O, very wet season (mean monthly precipitation (>100 mm); P, cold season (mean daily minimum below 0°C); Q, month with absolute minimum below 0°C; R, frost-free period (Weather Bureau 1986).

is essential for efficient Braun-Blanquet type data processing and also in accordance with the aim of identifying areas for possible conservation. The floristic composition in each sample was determined by using the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974). In accordance with Werger (1973), scale-unit 2 was divided as follows: A, covering 5–12% of the sample plot area and; B, covering 13–25% of the sample area. Taxon names conform to those of Gibbs Russell *et al.* (1985 & 1987). Structural classification was according to Edwards (1983). The following habitat data were recorded in each sample plot: geology, topography, terrain unit, slope and aspect, rockiness, soil types and erosion.

To derive a first approximation of the vegetation types, two-way indicator species analysis (TWINSPAN) (Hill 1979a) was applied. This was further refined by Braun-Blanquet procedures (Behr & Bredenkamp 1988; Bredenkamp *et al.* 1989). The results obtained are presented in a phytosociological table (Table 2). Detrended correspondence analysis (DECORANA) (Hill 1979b) was applied to the floristic data set to determine vegetation gradients and illustrate vegetation/environmental relationships.

DESCRIPTION OF COMMUNITIES

The Ea land type is characterized mainly by the constant presence, mostly with high cover-abundance values of *Themeda triandra*, and *Eragrostis curvula* and *E. plana* (species group L, Table 2). The number of species recorded in the relevés varies between 15 and 25, with an average of 19 species.

1. *Artemisia afra–Rhus dentata* shrubveld

This shrubveld is situated on moderate to steep scarps (30°–90°) (terrain unit 2) facing rivers and streams (Figure 7). Shallow, rocky soils of the Glenrosa and Mispah Forms are typical of this terrain type (Figure 8). The average rock size is more than 500 mm in diameter, covering more than 20% of the surface. Clear signs of erosion can be observed, which are ascribed mainly to the steepness of the slopes. The utilization of the vegetation by dassies (*Procavia capensis* Pallas 1766) is apparent in some areas.

The vegetation is characterized by species group C (Table 2) and the diagnostic species include the shrubs *Artemisia afra, Rhus dentata* and *Diospyros austro-africana. Bidens pilosa* and *Hibiscus trionum* are weeds and are often associated with disturbed areas. Dominant woody species are the diagnostic shrub species. Conspicuous and dominant grasses include *Themeda triandra, Eragrostis curvula* and *E. plana* of species group L, and *Aristida congesta* and *A. junciformis* of species group I (Table 2). The herbaceous layer of terrain unit 2 is more conspicuous and better developed than those of other terrain units.

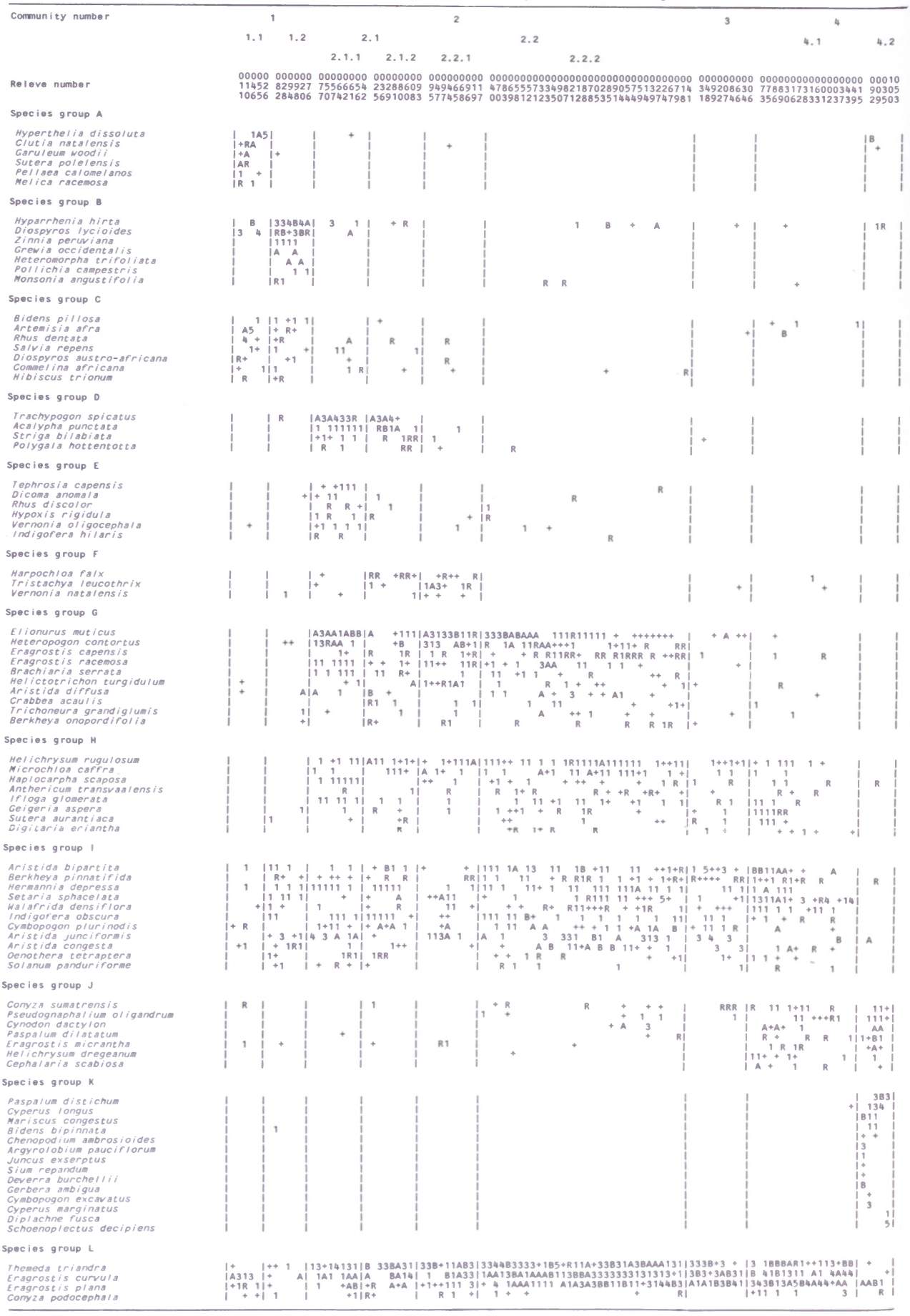
1.1 *Hyperthelia dissoluta–Eragrostis curvula* shrubveld

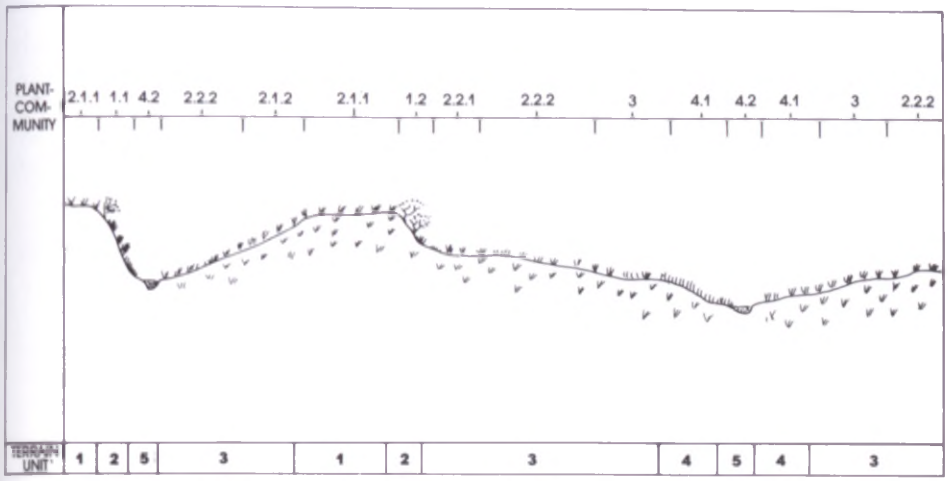
This shrubveld is situated on steeper (40°–90°) slopes and displays patches of bare soil with a relatively high degree of erosion (Figures 7 & 8). Diagnostic species include the dominant grass species *Hyperthelia dissoluta*, the forbs *Clutia natalensis, Garuleum woodii, Sutera polelensis*, the xerophytic fern *Pellaea calomelanos* and the grass *Melica racemosa* (species group A, Table 2). *Themeda triandra, Eragrostis curvula* and *E. plana* are among the most constantly present companion grass species occurring in this community. An average of 15 species was recorded per sample plot.

1.2 *Hyparrhenia hirta–Diospyros lycioides* shrubveld

This shrubveld is characterized by species group B (Table 2) and can be further distinguished from the

TABLE 2.—Phytosociological table of the vegetation of the Ea land type in the northeastern Orange Free State





1.1	*Hyperthelia dissoluta-Eragrostis curvula* shrubveld
1.2	*Hyparrhenia hirta-Diospyros lycioides* shrubveld
2.1.1	*Vernonia oligocephala-Trachypogon spicatus* grassland
2.1.2	*Harpochloa falx-Trachypogon spicatus* grassland
2.2.1	*Tristachya leucothrix-Elionurus muticus* variation
2.2.2	*Heteropogon contortus-Eragrostis plana* variation
3	*Themeda triandra-Eragrostis plana* grassland
4.1	*Eragrostis curvula-Setaria sphacelata* grassland
4.2	*Eragrostis plana-Paspalum distichum* grassland

FIGURE 7.—A schematic representation of the terrain units with the associated plant communities identified in the Ea land type.

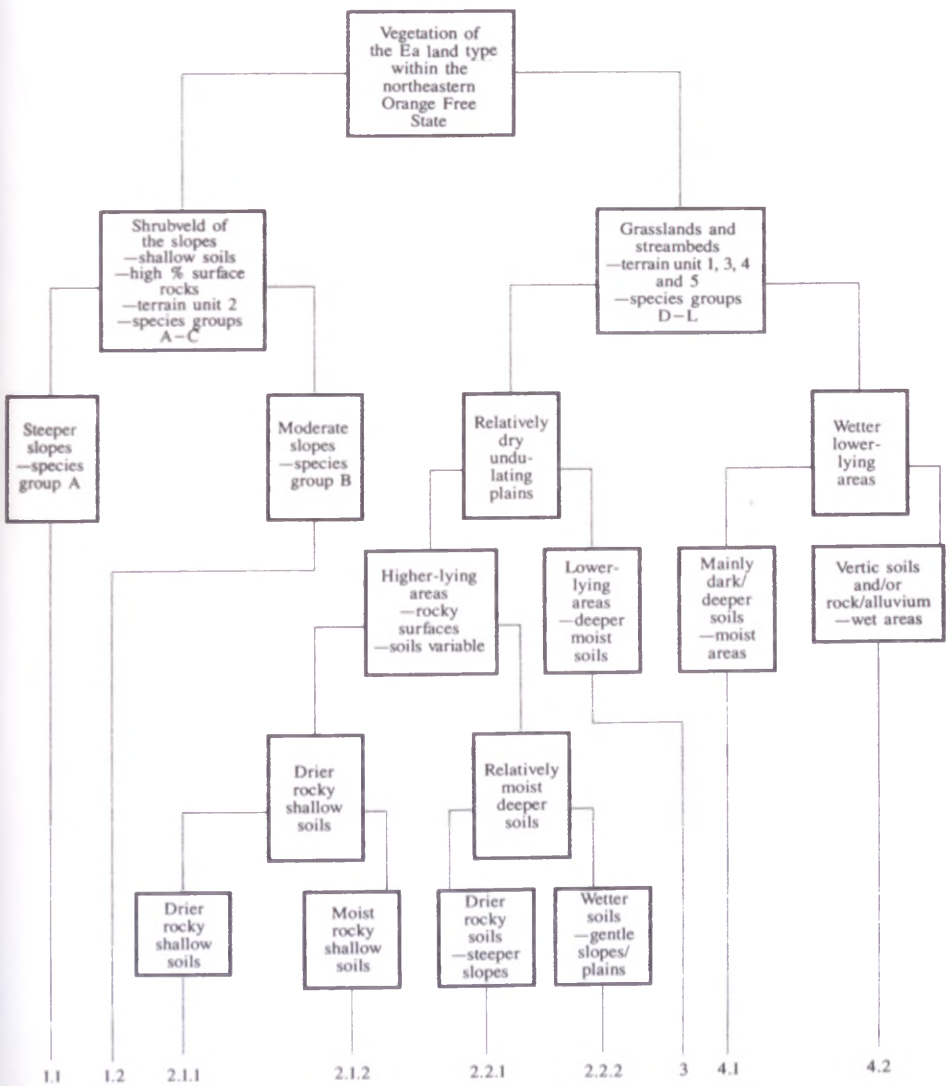


FIGURE 8.—Hierarchical diagram to indicate the prominent habitat characteristics which are associated with the respective plant communities.

Hyperthelia dissoluta–Eragrostis curvula shrubveld by the presence of conspicuous and constantly present grass species of species group I (Table 2). Diagnostic species include the tall and dominant grass species *Hyparrhenia hirta*, the shrubs *Diospyros lycioides*, *Grewia occidentalis* and *Heteromorpha trifoliata* and the weedy *Zinnia peruviana* and *Monsonia angustifolia* (species group B, Table 2). A further characteristic of this community is the presence of seral and pioneer species listed in species group I, for example the grasses *Aristida junciformis*, *A. congesta* and *A. bipartita*. An average of 23 species was recorded per sample plot.

2. *Themeda triandra–Elionurus muticus* grassland

This plant community is to a great extent similar to grasslands described by Bezuidenhout (1988) and Kooij (1990), except for the prominence of *Eragrostis plana* and other species typical of the moister eastern grasslands of the Orange Free State. This community compares well to the *Elionurus muticus–Themeda triandra* alliance described by Fuls *et al.* (1992a). This grassland type covers more than 60% of the Ea land type enclosed by the study area. A great diversity of soil forms occur, including Mispah, Glenrosa, Mayo, Inhoek, Westleigh, Swartland, Clovelly, Oakleaf, Glencoe, Bonheim and Arcadia. Soil depth varies from 100 to more than 700 mm. Deeper soils (>500 mm) display higher clay contents (35–55%). Most of these soils have been ploughed, and cultivated lands replace this grassland community to a great extent (Figure 7).

This grassland is characterized by species group G (Table 2) and the diagnostic grass species are the prominent and conspicuously present *Elionurus muticus*, *Heteropogon contortus*, *Eragrostis capensis*, *E. racemosa*, *Brachiaria serrata*, *Helictotrichon turgidulum*, *Aristida diffusa* and *Trichoneura grandiglumis*. Diagnostic forbs are *Crabbea acaulis* and *Berkheya onopordifolia* (Table 2). Other prominent species are *Themeda triandra*, *Eragrostis plana* and *E. curvula*, while the asteraceous forbs *Helichrysum rugulosum* and *Berkheya pinnatifida* are conspicuously present.

2.1 *Elionurus muticus–Trachypogon spicatus* grassland

This grassland is situated on terrain unit 1 and the higher-lying parts of terrain unit 3, with low to moderate slopes (2°–30°) (Figure 7). Soils are shallow (<300 mm) (Figure 7) and have a relatively low clay content.

Species group D (Table 2) characterizes this grassland and includes the diagnostic co-dominant grass species *Trachypogon spicatus*, as well as the forbs *Acalypha punctata*, *Striga bilabiata* and *Polygala hottentotta* (Table 2). Prominent species include *Elionurus muticus*, *Themeda triandra*, and *Eragrostis curvula*.

Two variations can be distinguished, namely the *Vernonia oligocephala–Trachypogon spicatus* variation and the *Harpochloa falx–Trachypogon spicatus* variation. These two variations are distinguished by the presence of species groups E and F respectively (Table 2). No clear differences in the habitat can be found to explain the occurrences of the two variations, but soil moisture regime seems to be decisive in the delimitation of the two variations.

2.2 *Microchloa caffra–Elionurus muticus* grassland

This grassland covers the largest part of the Ea land type within the study area with respect to the other plant communities. It occurs on a wide range of soil types, for example vertic Arcadia to orthic Glenrosa Forms. This grassland occurs on crests, slopes and plains (Figure 7). The terrain as a whole is gently undulating with slopes of 0°–8°. Overgrazing, especially by sheep, often results in patches of bare soil, which are prominent in this grassland. The reason for patch-overgrazing is the disproportionate utilization of the veld, resulting in patches being over-utilized (Fuls 1992). These patches are gradually retrograding until bare patches of soil develop.

This grassland is the typical form of the *Themeda triandra– Elionurus muticus* grassland and is characterized by the presence of species group G and the absence of species group D (Table 2). Dominant grass species include *Elionurus muticus*, *Heteropogon contortus*, *Eragrostis curvula*, *Themeda triandra* and *Eragrostis plana*. The forb *Helichrysum rugulosum* is constantly present but less conspicuous. An average of 20 species was recorded per sample plot. Two variations can be distinguished, the *Tristachya leucothrix–Elionurus muticus* and *Heteropogon contortus–Eragrostis plana* variations. The former is characterized by the presence of species group F, and is further distinguished from the other variation by a higher percentage surface rock and lower soil moisture regime (Figure 8). The *Heteropogon contortus–Eragrostis plana* variation is clearly distinguished by higher cover-abundance values for *Eragrostis curvula* and *E. plana* (Table 2), indicating a higher soil moisture content with respect to the former variation.

3. *Themeda triandra–Eragrostis plana* dry/wet grassland

This grassland represents a transitional zone between relatively dry and wet grasslands, separating the relatively drier communities on the higher-lying terrain units from the relatively moister communities on the lower-lying terrain units (Figure 7). The soils are deep (>500 mm) and moist (Figure 8). Overgrazing in this grassland can be observed to a lesser extent in the form of bare soil patches, but rather as dense patches of *Eragrostis plana*, invading the disturbed areas.

The transitional grassland is differentiated by the presence of species groups H and I, and the absence of species group G (Table 2). No diagnostic species could be identified for this grassland. The dominant species include *Eragrostis plana*, *Themeda triandra*, *Eragrostis curvula* and *Aristida bipartita*. The herbaceous layer is not well developed and open and includes species such as the forbs *Helichrysum rugulosum* and *Berkheya pinnatifida*, indicating a degree of degradation. An average of 15 species per sample plot was recorded, indicating a decrease in species diversity with an increase in soil moisture.

4. *Eragrostis plana–Eragrostis curvula* wet grassland

This grassland represents the vegetation falling within moist to wet areas, including footslopes and drainage lines (Figure 7). The areas adjacent to drainage lines, display gentle slopes (0°–5°) and subsequently show few signs

of erosion. Rivers and streams in contrast, often used by cattle and sheep as drinking places, frequently show serious signs of erosion. Seasonal and perennial water pans occur widely scattered over the area, often attracting a variety of birds. These pans are also accessible to cattle and sheep. Since most of the rivers and streams flow throughout the year, they may be used by stock at any time.

This grassland is characterized by species group J (Table 2), and the diagnostic grass species are *Paspalum dilatatum*, *Cynodon dactylon*, *Eragrostis micrantha*, and the forbs *Conyza sumatrensis*, *Pseudognaphalium oligandrum*, *Helichrysum dregeanum* and *Cephalaria scabiosa* (Table 2). Two communities can be distinguished.

4.1 *Eragrostis curvula–Setaria sphacelata* moist grassland

This grassland represents the vegetation found in moist areas adjacent to drainage lines, and is transitional to grassland (Figure 7). This is indicated by the presence of species groups H and I, which are differential species for this community. Soils are deep (>500 mm) and without any surface rocks. These areas are not suitable for cultivation due to the high clay content (>55%) of the soils. Cover-abundance values for the diagnostic and dominant species are relatively high, indicating a dense vegetation cover.

Conspicuous and constant species are the grasses *Eragrostis curvula*, *Aristida bipartita*, *Setaria sphacelata*, *Themeda triandra* and *Eragrostis plana*, as well as the forbs *Berkheya pinnatifida* and *Hermannia depressa* (Table 2). An average of 17 species was recorded per sample plot.

4.2 *Eragrostis plana–Paspalum distichum* wet grassland

This grassland represents the vegetation found along rivers, streams and pans (Figure 7). Riverbeds and streambeds are degraded to a large extent, often displaying bare rock surfaces and alluvium (Figure 8). Soils found here are of the Rensburg Form, being deeper than 500 mm. Few widely spaced pans do occur in the area; they are restricted to depressions. Trampling effects by cattle and sheep are noticeable especially on the margins of these pans, where the animals normally drink. The vegetation in these marginal zones is clearly disturbed.

A decrease in species diversity can be observed, if the species-richness of this community is compared with that of other vegetation types. This grassland is characterized by species group K (Table 2), and the diagnostic species include the grasses *Paspalum distichum*, *Cymbopogon excavatus* and *Diplachne fusca*, the herbs *Cyperus longus*, *Mariscus congestus*, *Bidens bipinnata*, *Chenopodium ambrosioides*, *Argyrolobium pauciflorum*, *Juncus exsertus*, *Sium repandum*, *Deverra burchellii*, *Gerbera ambigua*, *Cyperus marginatus* and *Schoenoplectus decipiens* (Table 2). Other conspicuous species are the grasses *Eragrostis plana*, *Cynodon dactylon*, *Paspalum dilatatum* and *Eragrostis micrantha*, and the herbs *Pseudognaphalium oligandrum* and *Conyza sumatrensis*.

The herbaceous layer is prominent, but not dominant to the grass layer. The presence of species group K and the simultaneous absence of species groups H and I distinguishes this community from the *Eragrostis curvula–Setaria sphacelata* grassland. An average of only 13 species was recorded per sample plot.

ORDINATION

Figure 9 represents the distribution of all 100 relevés along the first and second axes of a DECORANA ordination. No discontinuities are observed and by inspection it is clear that the vegetation communities are distributed along a moisture/trophic gradient. This gradient is extracted by the first axis of the DCA ordination. McDonald (1987) found in his study on the vegetation of the Swartboschkloof that soil moisture played a secondary role next to the major role being played by soil geology. In his study on the vegetation of the mire Northern Kisselbergmosen, SE Norway, Okland (1990) found that depth to the water table had a major influence on the distribution pattern of the vegetation. The communities found under extreme conditions, namely the dryland and wetland communities, occur on the periphery of the diagram. The dryland community is represented by the *Artemisia afra–Rhus dentata* shrubveld, occurring on dry, sandy, dystrophic soils to the top left of the diagram.

The wetland community, *Eragrostis plana–Eragrostis curvula* grassland, occurs on wet, clayey, eutrophic soils to the right of the diagram. The *Themeda triandra–Elionurus muticus* and *Themeda triandra–Eragrostis plana* grasslands are situated in an intermediate position. No separation occurs in Figure 9, concerning the last two grassland types. A gradient along the second axis can also be observed. Communities at the top of the axis occur on scarps and slopes, whereas the bottom part represent communities occurring on undulating terrain.

Figure 10 represents an ordination of only the *Themeda triandra–Elionurus muticus* grassland. The relevés of variations 2.2.1 and 2.2.2 are more or less situated to the right of the relevés of community 2.1. The fact that no clear discontinuity can be observed emphasizes the indistinct, gradual change from dryland to wetland communities associated with the gradually undulating terrain. Relevés to the right of the diagram are situated on wetter lower-lying bottomland areas with deep, clayey vertic soils. The left part of the diagram represents drier higher-lying areas with shallow, sandy orthic soils. No gradient can be observed along the second axis.

CONCLUSION

The application of Braun-Blanquet procedures to refine the results of the TWINSPAN classification was successful. Four major vegetation types were identified, which are further subdivided into nine plant communities. These units do exist in practice and can be incorporated in veld management programmes.

It is of the utmost importance that the farmer considers each unit on its own and that management programmes take into account the characteristics of each unit (see Eckhardt *et al.* submitted). Communities, which are considered as having conservation value, are those occurring on steep slopes (40°–90°) adjoining wet grassland communities. The *Hyperthelia dissoluta–Eragrostis curvula* shrubveld and *Eragrostis plana–Paspalum*

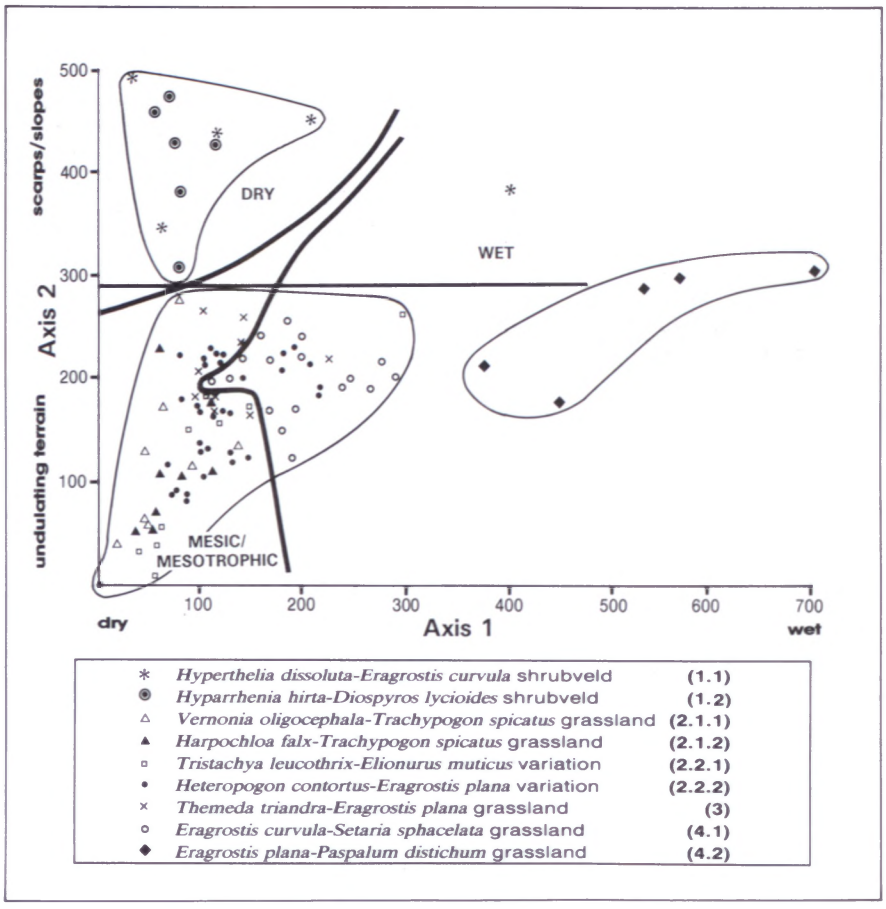


FIGURE 9.—A scatter diagram of the ordination of the vegetation on the Ea land type.

distichum grassland together form a complex in some areas, which is worthwhile conserving. Some of these areas are partly or totally inaccessible to cattle and sheep and therefore still remain in a relatively undisturbed state.

The results obtained by ordination (DECORANA) indicate the response of vegetation types to different environmental conditions. Moisture and trophic regimes have a strong influence on the distribution of vegetation types. A correlation between these two habitat factors and the vegetation can be observed. The application of the Braun-Blanquet method for the B, C and F land types should result in the identification of many more vegetation units, since these land types appear to be heterogeneous with respect to their topography.

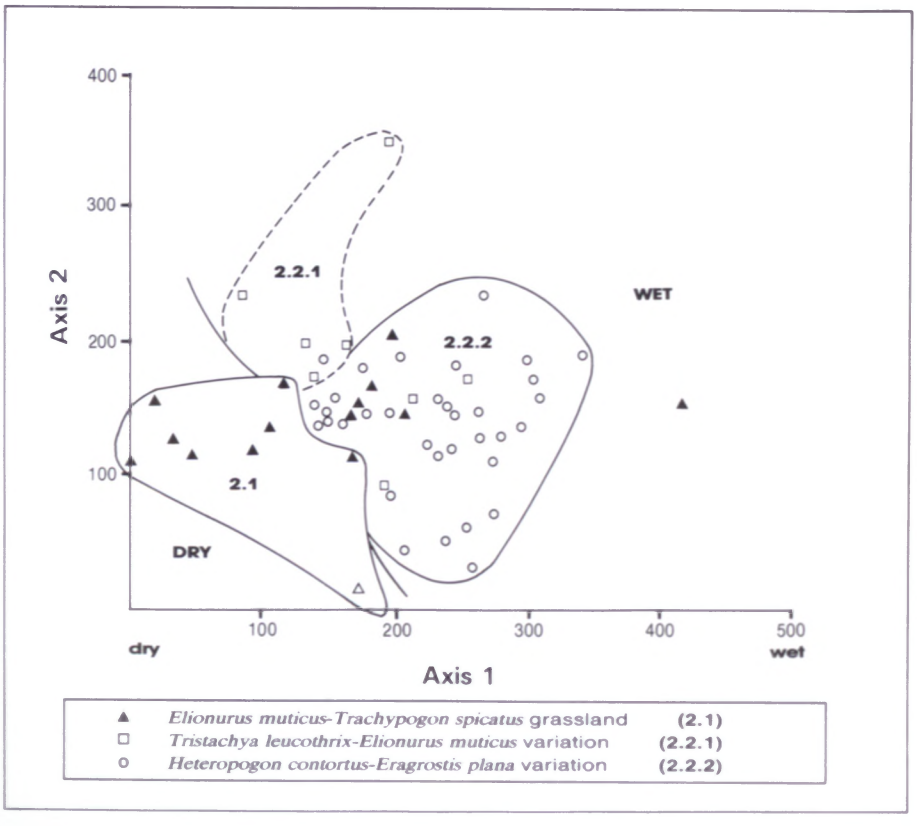


FIGURE 10.—A scatter diagram of the ordination of plant community 2.

If farmers are to benefit practically from the results obtained in this study, it is advisable to bring to their attention the diagram presented in Figure 8. This diagram serves as an important key for the delimitation of vegetation types and habitat units, which are to be managed in accordance with the characteristics of each.

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