

**A PHYTOSOCIOLOGICAL STUDY OF THE SOUTH-EASTERN
TRANSVAAL HIGHVELD GRASSLANDS**

BY

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OCTOBER 1989

Dedicated to my parents

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ABSTRACT

The grassland vegetation in the Amersfoort area of the south-eastern Transvaal is classified into a number of syntaxa using the Braun-Blanquet phytosociological approach. The syntaxa are informally arranged into a hierarchical system of Vegetation Types (4), Units (5), Sub-Units (2) and Variants (29).

The Detrended Correspondence Analysis (DECORANA) ordination supports the results of the classification to the level of the Vegetation Sub-Unit, but does not differentiate between the habitats of the syntaxa. Statistical analysis reveals statistically significant differences in the most commonly occurring habitat features of comparable syntaxa.

There has been a marked deterioration in the species composition of the vegetation since Acocks' (1953) survey, and there is a gradient of increasing vegetation degradation operative within the syntaxa. The present vegetation in the Amersfoort area has developed in response to a history of veld mismanagement.

UITTREKSEL

Die grasveldplantegroei in die Amersfoortgebied van die suidoostelike Transvaal is deur middel van die Braun-Blanquet-fitososiologiese benadering in 'n aantal sintaksons geklassifiseer. Die sintaksons is in 'n informele hiërargiese sisteem van plantegroei-tipes (4), eenhede (5), subeenhede (2) en variante (29) gerangskik.

Die neigingsverwydering ooreenstemmingsanalise (DECORANA) ondersteun die resultate van die klassifikasie tot die vlak van subeenheid, maar differensiëer nie tussen die habitats van die sintaksons nie. Die statistiese analise dui op die statisties betekenisvolle verskille in die habitatsfaktore wat algemeen tussen vergelykbare sintaksons voorkom.

'n Merkwaardige agteruitgang in die spesiesamestelling van die plantegroei het plaasgevind sedert Acocks (1953) se opname en 'n gradiënt van toenemende agteruitgang van plantegroei kom voor. Die huidige plantegroei van die Amersfoortgebied het waarskynlik tot stand gekom as gevolg van 'n geskiedenis van wanbestuur van die veld.

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CHAPTER 1

INTRODUCTION

Sixty percent of South Africa's natural pasturage is considered to be in a poor condition (Aucamp & Danckwerts 1989), with the widespread deterioration of the vegetation having been caused predominantly by agricultural mismanagement such as over-grazing, selective grazing and the misuse of fire (Mentis & Huntley 1982; Tainton 1984; Clinning 1986; Aucamp & Danckwerts 1989).

Not only does the natural pasturage support most of South Africa's domestic livestock (Aucamp & Danckwerts 1989), so contributing substantially to South Africa's production of meat, dairy produce and animal products, but it is also the area where most of the country's grain and timber production are situated (Mentis & Huntley 1982; Clinning 1986; Aucamp and Danckwerts 1989). Furthermore, South Africa's coal and gold reserves fall within this region, with the result that mining and industrial activities have exerted additional pressures on the natural vegetation and have attracted people to the area, to the extent that the areas of natural pasturage house a disproportionately large percentage of South Africa's population (Mentis & Huntley 1982; Clinning 1986; Aucamp & Danckwerts 1989). The advent of urbanization, mining and industry, together with incorrect agricultural practices, have contributed significantly to the deterioration in the condition of the natural grazing lands. With the projected increase in South Africa's population and the consequent increase in the demand for living space and food-stuffs, the pressure on the natural pasturage will increase. It therefore becomes essential that natural pastures be correctly managed to remedy their current degraded condition, and thereafter to effect maximum sustained production.

A major impediment to the institution of measures to improve and then maintain the condition of the natural pastures is a general lack of knowledge of the distribution and ecology of the different types of natural vegetation. One of the measures taken to address this problem was the initiation of the Grassland Biome Project (Mentis & Huntley 1982), which considers only the grassland component of South Africa's natural pasturage. The broad objectives of the Grassland Biome Project are to promote research into grassland ecosystems to develop an understanding of their structure and functioning (Mentis & Huntley

1982; Scheepers 1985). More specifically, one of the objectives of the Grassland Biome Project's research programme is "The analysis, description and interpretation of the characteristics and distribution of grassland ecosystems across gradients of climate, geomorphology and soils within South Africa" (Mentis & Huntley 1982).

Although the present study was undertaken under the auspices of the Department of Agriculture and Water Supply's national natural resource inventory, the results obtained should also make a valuable contribution to the Grassland Biome Project. In the present study use was made of the Braun-Blanquet (1932; Westhoff & van der Maarel 1978; Bredenkamp 1982; Coetzee 1982; Deall 1988) phytosociological approach for the description of the grassland vegetation in the Amersfoort area. The former Botanical Research Institute advocated the use of this approach for all vegetation surveys, to standardize the concepts, methods and terminology used to describe vegetation in South Africa (Tainton 1984), so as to ensure that the results of different surveys are directly comparable.

The objectives of the present study were thus:

- a) to classify and describe the different vegetation communities in the Amersfoort area,
- b) to correlate the distribution of the communities with environmental factors and
- c) to map the distribution of the communities.

The classification of the Amersfoort vegetation will make a contribution not only to our knowledge of grassland ecosystem distribution and functioning, but also to the planned use and management of our natural resources (Rattray 1960; Edwards 1972; Müller 1983).

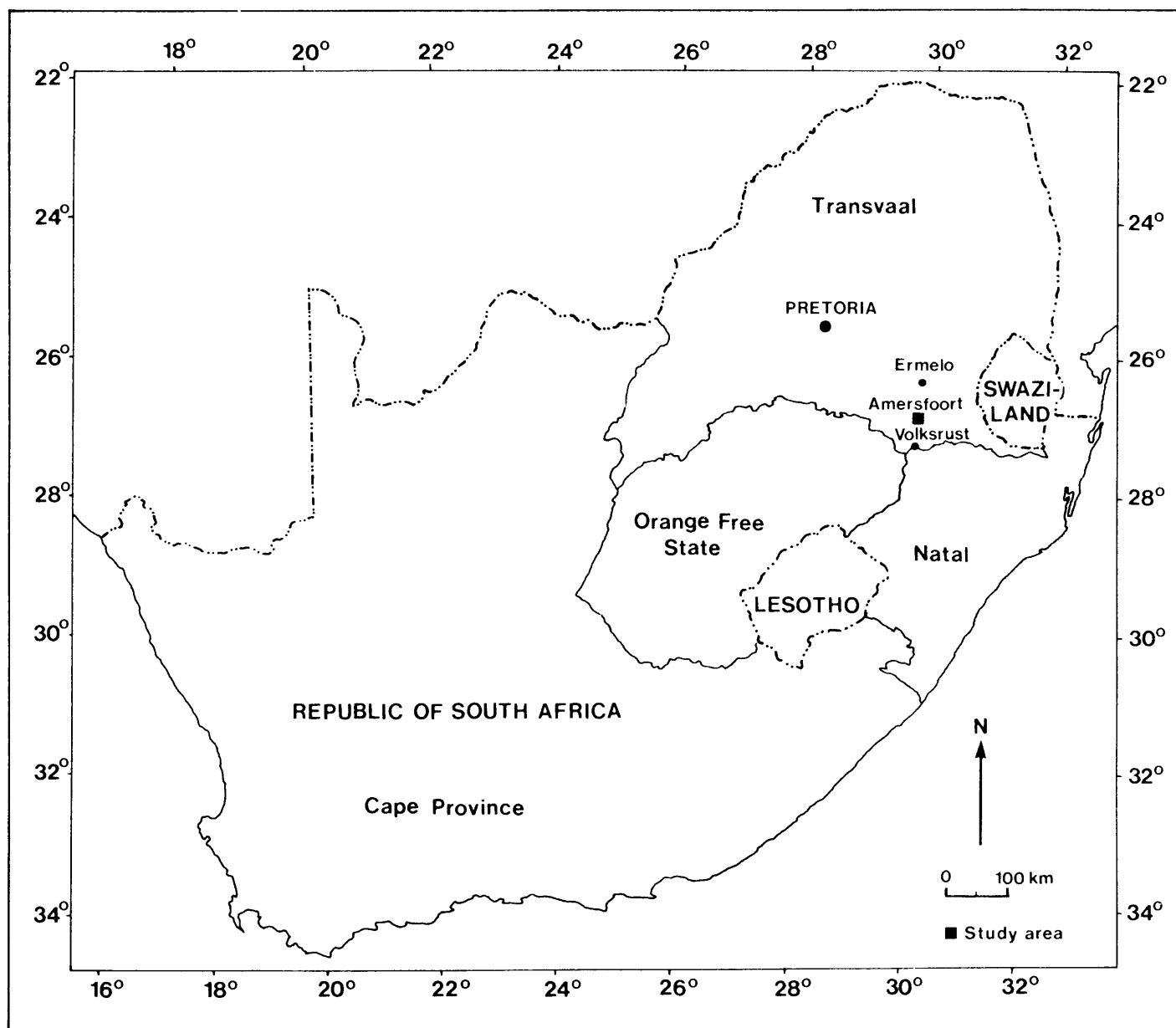


FIGURE 2.1 The locality of the Amersfoort study area in relation to other towns and cities in the Transvaal, Republic of South Africa.

CHAPTER 2

DESCRIPTION OF THE STUDY AREA: ABIOTIC FACTORS

2.1 LOCALITY

The study area surrounds the town Amersfoort in the south-eastern Transvaal, Republic of South Africa (Figure 2.1). Amersfoort is approximately 60km south of Ermelo and 40km north of Volksrust.

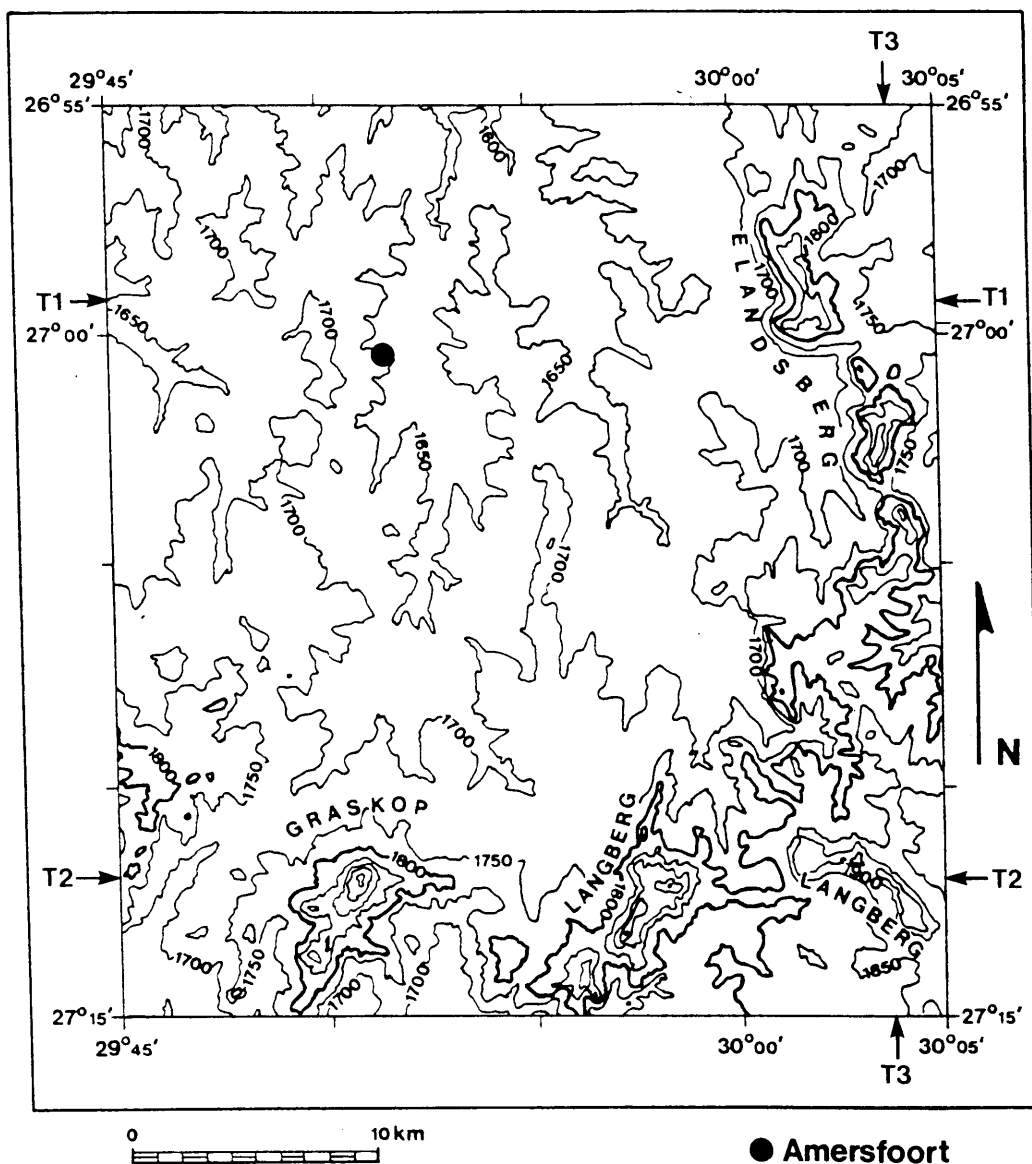
The study area is rectangular in shape and occupies 1,7 quarter degree squares. Its boundaries are formed by latitudes 26°55'S and 27°15'S, and by longitudes 29°45'E and 30°05'E. It encompasses an area of 1 221km² (122 100ha) (South Africa, 1:50 000 Sheet 1970, 1971, 1976, 1979).

2.2 PHYSIOGRAPHY

2.2.1 TOPOGRAPHY

The topography of the study area is described according to the relief class system of Scheepers (1988). The north-western and central regions (Figure 2.2) have an undulating landscape of low hills and shallow valleys, with altitudes ranging from ca 1 500m to 1 700m.

In the south and east the area becomes more hilly and mountainous, being only ca 25km from the edge of the Eastern Escarpment. The high hill, the Elandsberg, attains an altitude of 1 940m, and the low mountains Langberg and Graskop respectively have maximum altitudes of 2 028m and 2 033m (South Africa, 1:50 000 Sheet 1970, 1971, 1976, 1979).



Contour interval: 50m

T1 to T3: Transects 1 to 3

FIGURE 2.2 Topographic map of the Amersfoort study area in the south-eastern Transvaal. Based on South Africa, 1:50 000 Sheet (1970, 1971, 1976, 1979). (See Figure 2.7 for explanation of transects).

2.2.2 DRAINAGE

The study area forms part of the Vaal River's catchment and is well-drained (Figure 2.3), although the greater proportion of the rivers are non-perennial.

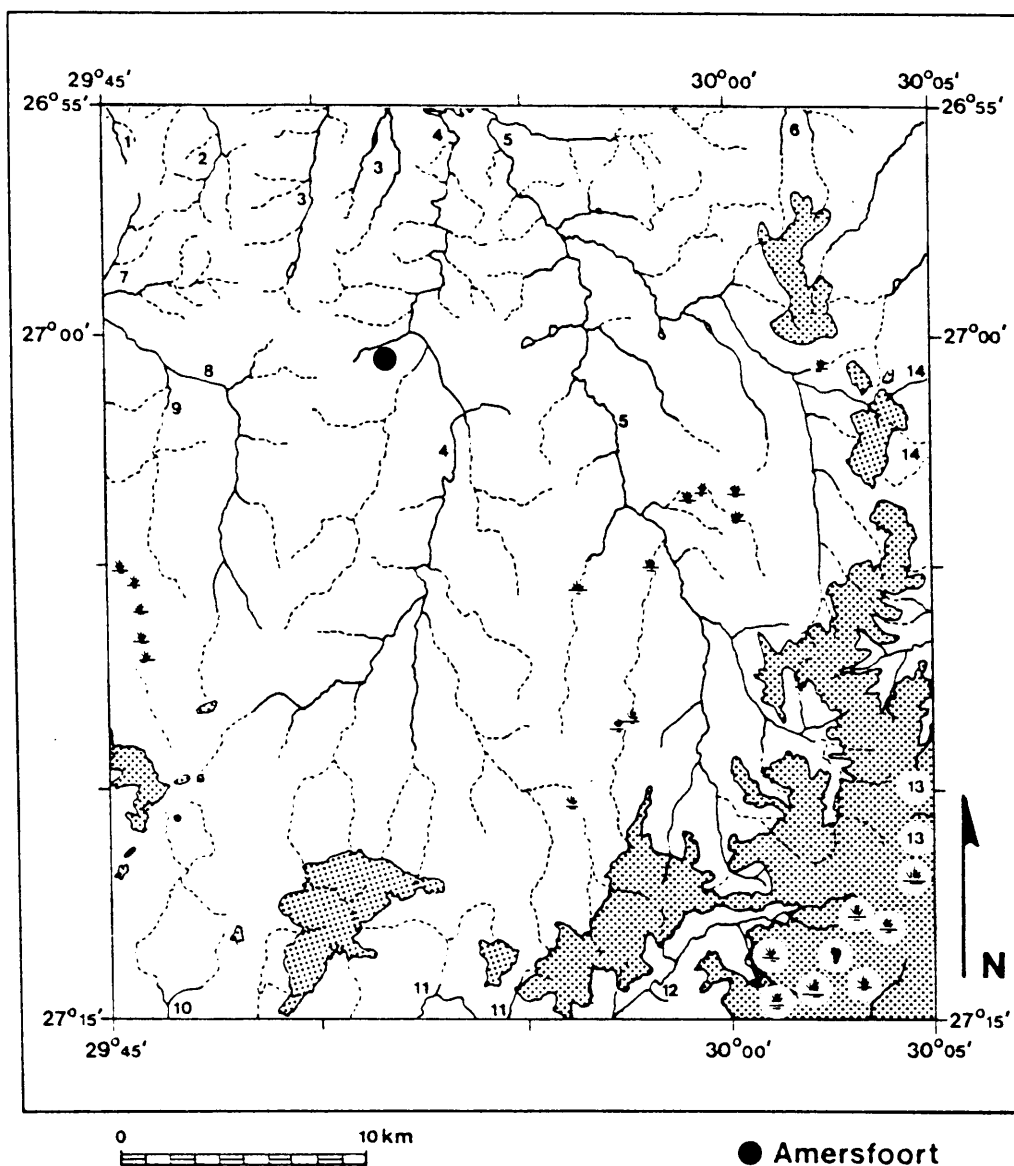
Most of the rivers arising in the high lands within the study area flow into the Vaal River which is situated to the north of Amersfoort. The Assegai River, however, flows eastwards into the Usutu River in Swaziland (South Africa, 1:50 000 Sheet 1970, 1971, 1976, 1979).

2.3 GEOLOGY

The nomenclature used to describe the lithology of the study area follows the updated stratigraphic classification of the South African Committee for Stratigraphy (SACS) (1980). For reference purposes both the revised and the old stratigraphic terminology are given in Table 2.1.

The geological strata present in the study area are all of the Karoo Sequence (Figure 2.4). Karoo rocks are widespread in South Africa, covering approximately half of the country (Haughton 1969). They occur in the more southern and eastern areas of South Africa, but spread westwards as far as Calvinia and Prieska, and northwards to the Johannesburg-Pretoria area (Haughton 1969; Truswell 1977). Most of the Karoo rocks are of a sedimentary nature. The earliest deposits were formed by glacial action and successive deposits occurred under continental fluvial and deltaic conditions. The rocks of the Clarens Sandstone Formation (Stormberg Group) are probably of an aeolian origin, and the youngest rocks of the Karoo, the Drakensberg Basalt Formation/Group, are the result of volcanic action. During this period of volcanic action all strata of the Karoo Sequence were extensively intruded by dolerite (du Toit 1954; Haughton 1969; Truswell 1977; SACS 1980).

The youngest Karoo rocks found in the study area are those of the Estcourt Formation (Beaufort Group) (Table 2.1, Figure 2.4), the younger rocks of the Beaufort Group and all rocks of the Stormberg Group being absent. The geological formations represented in the study area are between 345 and 230 million years old (Table 2.1), being of the Carboniferous and Permian Periods of the Palaeozoic Era, which falls within the Phanerozoic Eonothem (SACS 1980; Geological Map



LEGEND

- 1 Wasgoedspruit
- 2 Krogspruit
- 3 Sterkspruit
- 4 Skulpspruit
- 5 Wielspruit
- 6 Vaalbankspruit
- 7 Boompiespruit
- 8 Witbankspruit
- 9 Geelklipspruit
- 10 Waterval River
- 11 Sandspruit
- 12 Gelykwater
- 13 Baberskuile
- 14 Assegai River

-  Altitude $\geq 1800\text{m}$
-  Marshes and vleis
-  Perennial pan
-  Perennial rivers
-  Non-perennial rivers

FIGURE 2.3 Map of the drainage pattern in the Amersfoort study area in the south-eastern Transvaal. Based on South Africa, 1:50 000 Sheet (1970, 1971, 1976, 1979).

1984). The dolerite intrusions occurred during the early Jurassic Period, ca 195 million years ago (du Toit 1954; SACS 1980).

2.3.1 THE DWYKA FORMATION

The tillite constituting the Dwyka Formation is a glacial deposit. The rock consists of a fine argillaceous (clayey) matrix, usually blue or green, in which are embedded unsorted rock fragments. The nature of such fragments is determined by the nature of the bedrock over which the glacier moved and the fragments vary in size from small particles to large boulders (du Toit 1954).

In the Transvaal outcroppings of the Dwyka Formation are not common since in this area the tillite is deposited in small, isolated pockets and the rocks of the Eccca Group (Table 2.1) tend to overlies those of the Dwyka Formation (du Toit 1954; Truswell 1977; SACS 1980). This formation is not exposed in the study area (Figure 2.4).

2.3.2 THE ECCA GROUP

2.3.2.1 The Pietermaritzburg Shale Formation

A large proportion of the study area consists of the sedimentary rocks of the Eccca Group (Figure 2.4). The oldest formation of the Eccca, the Pietermaritzburg Shale Formation (Table 2.1), is not exposed in the study area and the next formation, the Vryheid Formation, thus lies either on the Dwyka Formation, or where this is absent, on older, pre-Karoo rocks (du Toit 1954; Haughton 1969; Truswell 1977; SACS 1980).

2.3.2.2 The Vryheid Formation

The Vryheid Formation consists primarily of thick bands of sandstone and grit alternating with softer, argillaceous shales, and coal seams are also present (du Toit 1954; Haughton 1969; Truswell 1977; SACS 1980). The rocks of this formation are thought to have been deposited under deltaic conditions (du Toit 1954; Truswell 1977) which is consistent with the pattern of upward-coarsening deposits in a sequence of shales, shales alternating with fine sandstones followed by sandstones coarsening to massive grits (Truswell 1977).

TABLE 2.1 The chronology and lithology of the Karoo Sequence.
After SACS (1980) & Geological Map (1984). (Old
stratigraphic terminology is given parentheses).

E O N O T H E M	E R A	P E R I O D	*G E O L O G I C A L T I M E	T H E K A R O O S E Q U E N C E (Karoo Series)	
P H A N A E R O Z O I C	M E S O Z O I C	J U R A S S I C	195	S G T R O O R U M P B E R G	D I N T E R U S T I O N S
		T R I A S S I C	230	DRAKENSBERG BASALT FORMATION/GROUP (Drakensberg Beds)	
				CLARENS SANDSTONE FORMATION (Cave Sandstone)	
	P A L A E O Z O I C	P E R M I A N	345	ELLIOT FORMATION (Red Beds)	
				MOLTENO FORMATION (Molteno Beds)	
				TARKASTAD SUBGROUP (Upper Beaufort)	
		C A R B O N I F E R O U S		ADELAIDE SUBGROUP & ESTCOURT FORMATION (Lower Beaufort)	
				E G C R C O A U P	
				VOLKSRUST SHALE FORMATION (Upper Ecce Beds)	
				VRYHEID FORMATION (Middle Ecce/Coal Measures)	
				PIETERMARITZBURG SHALE FORMATION (Lower Ecce Beds)	
				DWYKA FORMATION (Dwyka Tillite)	

*Geological time in millions of years

The finer sandstones are generally white and they may alternate or merge with fissile (cleavable) micaceous sandstones and sandy shales that are usually darkly coloured - grey, brown or black (du Toit 1954). The coarser sandstones are yellow or white in outcrop and they have irregular grains that may develop into massive grits, and they are frequently feldspathic (du Toit 1954; Haughton 1969).

The coal seams found in the Vryheid Formation extend over a large area, occurring in Natal, the Orange Free State, the Transvaal and in Swaziland (Haughton 1969). Although the seams are not particularly numerous per unit area, individual seams may be very long. In the Transvaal they attain thicknesses of 3-6m and they may extend a considerable distance laterally (du Toit 1954; Haughton 1969). The coal seams generally rest upon a sandstone layer and the coal is purest at the base of the seams. Higher up, especially in the thicker seams (Haughton 1969), low-grade, shaly coal and layers of shale are found (du Toit 1954; Haughton 1969).

The total thickness of the Vryheid Formation is ca 350m in the Volksrust area (Haughton 1969). There are few exposures of this formation in the study area (Figure 2.4).

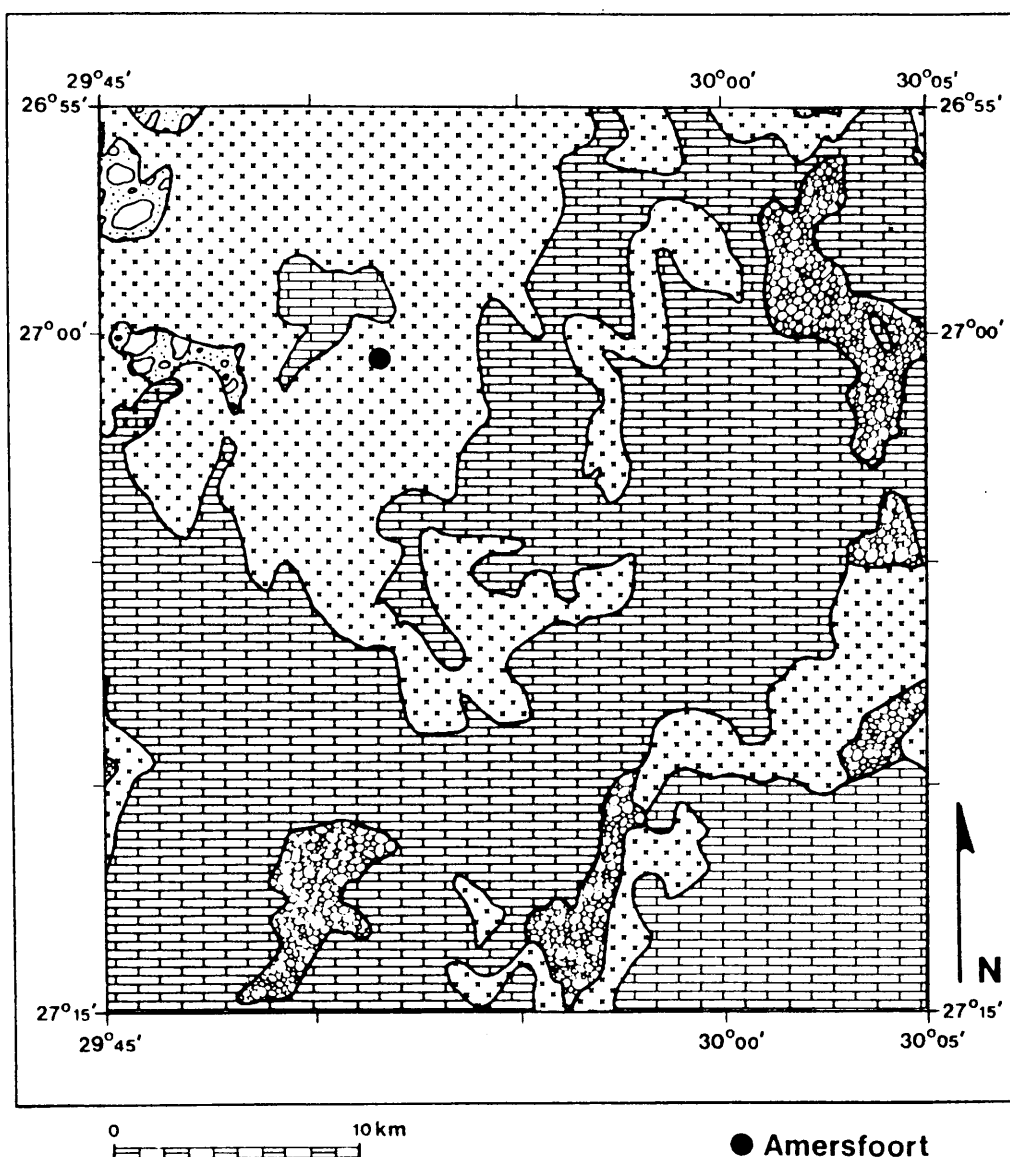
2.3.2.3 The Volksrust Shale Formation

The Volksrust Shale Formation overlies the Vryheid Formation (Table 2.1) and it is a layer of mainly dark shales (grey or black) interspersed with some sandstone horizons. In the Swaziland and Utrecht-Newcastle areas to the east and south of the study area this layer is ca 130m thick (Haughton 1969). A large proportion of the study area consists of exposures of the Volksrust Shale Formation (Figure 2.4).

This formation is the youngest layer of the Eccca Group and it is overlain by rocks of the Beaufort Group (Table 2.1).

2.3.3 THE BEAUFORT GROUP

The Beaufort Group comprises two Subgroups, the Adelaide and Tarkastad, but the Estcourt Formation has also been included in the Beaufort (Table 2.1) since it is the lateral equivalent of the Adelaide Subgroup which occurs in the Cape (SACS 1980). Only the Estcourt Formation occurs within the study area (Figure 2.4).



LITHOLOGY



Sandstone, shale, coal
(Ecce Group, Vryheid Formation)



Shale
(Ecce Group, Volksrust Formation)



Mudstone, sandstone
(Beaufort Group, Estcourt Formation)



Karoo dolerite

FIGURE 2.4 Geological formations in the Amersfoort study area in the south-eastern Transvaal. Based on South Africa, Geology (1970).

2.3.3.1 The Estcourt Formation

This formation is ca 400m thick and it consists mainly of laminated, carbonaceous shales with some sandstones and thin coal seams (SACS 1980). Exposures of this formation are associated with the mountainous regions in the south and east of the study area (Figure 2.4).

2.3.4 THE KAROO DOLERITES

The youngest rocks of the Karoo Sequence were formed by igneous activity when lavas were extruded to form the volcanic beds of the Drakensberg Basalt Formation/Group (Table 2.1). During this period, the Karoo sediments were extensively intruded by dolerites, known as the Karoo dolerites (du Toit 1954; Haughton 1969; Truswell 1977; SACS 1980).

Whilst the Drakensberg Basalt Formation/Group is not represented in the study area, the Karoo dolerites are widespread (Figure 2.4).

The dolerites take the form of either sills (concordant, or nearly so, with the bedding planes of the intruded rocks) or dykes (discordant with, or cutting across, the bedding planes of the intruded rocks), with sills being the more common form (du Toit 1954; Haughton 1969; Truswell 1977; SACS 1980).

The sills are extremely variable with respect to their thickness, ranging from less than 1m to over 300m thick (du Toit 1954; Truswell 1977), and they may cover areas of up to 14 000km² (Truswell 1977). Although the sills are usually horizontal they may be inclined or undulate and so cut across bedding planes (du Toit 1954; Truswell 1977; SACS 1980).

Dykes are generally thinner bodies, from 2-10m wide (Truswell 1977), forming straight or sinuous lines for distances commonly 1-6m long, although dykes 85km long do occur (du Toit 1954; Truswell 1977). In the Eastern Transvaal the dykes usually run in a north-easterly direction (du Toit 1954).

The Karoo dolerites generally show little differentiation except for the thicker sills where some differentiation may have occurred, since these bodies cooled more slowly than the smaller bodies (Truswell 1977; SACS 1980). The dolerites

are dark-coloured, basic igneous rocks (SACS 1980) composed of calcic plagioclase and varieties of pyroxene, although olivine may also be present (Truswell 1977).

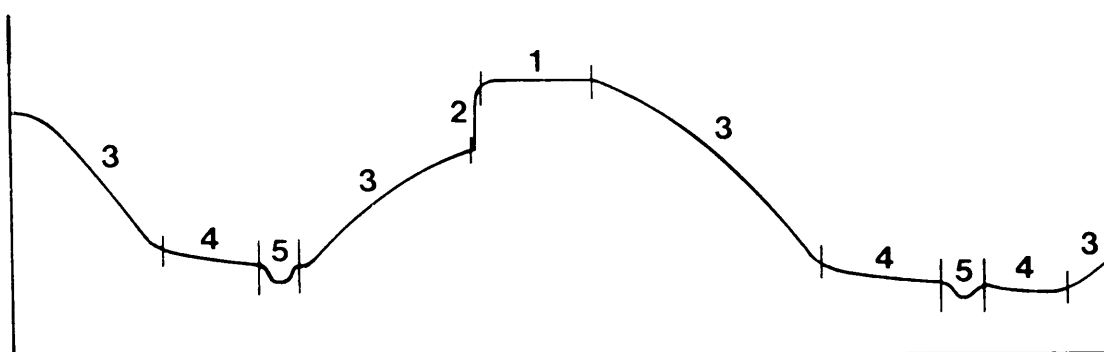
Dolerite intrusions are uncommon in the Dwyka Formation. In the Eccra there are numerous sills that are predominantly horizontal, and dykes are either scarce or absent. There are also numerous sills in the Beaufort but these tend to be inclined at 15-50°, and dykes are more common in the Beaufort than in the Eccra (Agricultural Extension, Highveld Region 1985).

The geology of the study area is the principle factor determining its physiographic features, as modified by erosional processes. Five rock types occur within the study area: shale, mudstone, sandstone, grit and dolerite, with mudstone and grit being of infrequent occurrence.

Shales are not very resistant to weathering and therefore tend to give rise to a flattish landscape of gentle rises and valleys. Sandstone does not erode easily and tends to form structural features such as table mountains and peaks. Dolerite is also resistant to weathering, and where it is present in the form of numerous dykes and/or sills, it tends to give rise to a flat landscape similar to that of the shales. However, where few dolerite dykes and/or sills are present, the landscapes formed resemble those formed by the sandstones (Technical Note EC 9 1986).

The central and north-western regions of the study area are composed chiefly of shales of the Volksrust Formation, and dolerite (Figure 2.4). Physiographically, this is a flattish area of low hills and shallow valleys.

Along the southern and eastern borders of the study area the land becomes more hilly and mountainous as a result of the combination of dolerite plus the sandstones of the Estcourt Formation and the Volksrust Formation. Although shales are present in both of these formations, they would appear to play a subordinate structural rôle to the sandstones. The dolerite thus contributes to the mountains and hilly land in this area, as opposed to its assuming a flatter form in the more northern regions of the study area.



Terrain unit

- 1 crest/ plateau**
- 2 scarp/ cliff**
- 3 midslope**
- 4 footslope**
- 5 valley bottom**

FIGURE 2.5 Profile sketch showing the terrain units in a landscape. Adapted from Agricultural Extension, Highveld Region (1985) & Land Type Survey Staff (1985).

2.4 LAND TYPES AND SOILS

The land types and soils of the study area are described in detail by the Land Type Series (1979a, 1979b, 1979c, in prep.) and the associated Memoirs (Land Type Survey Staff 1985, 1986).

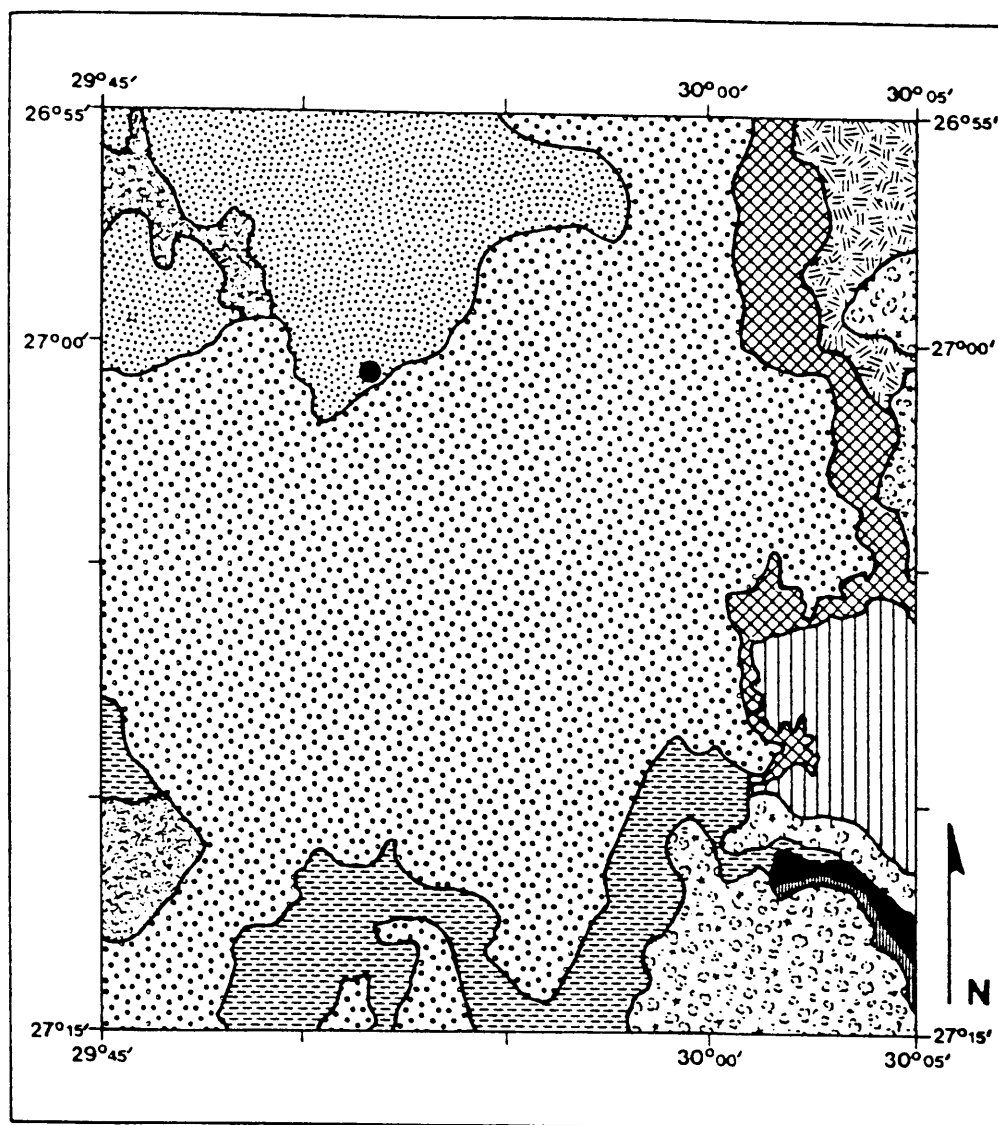
A land type is a unit delineating areas of land that are markedly similar in their terrain form, soil patterns and climate (Land Type Survey Staff 1985). Similar land types are grouped together according to broad soil patterns as map units (Land Type Survey Staff 1985). There are thus numerous land types in the map unit Ca, of which land types Ca2 and Ca17 occur within the study area.

The terrain form (landscape) can be divided into separate terrain units (Figure 2.5) that are used as the basis for describing soil occurrence (Land Type Survey Staff 1985), since a change in the terrain unit is usually accompanied by a change in the soil type or form (Agricultural Extension, Highveld Region 1985). Terrain units are defined as "any part of the land surface with homogeneous form and slope" (Land Type Survey Staff 1985). The soils in the study area will be discussed according to terrain units, with terrain units 1, 2 and 3 combined to give the upland soils, and terrain units 4 and 5 combined to give the lowland or valley bottom soils.

The Land Type Survey Staff (1985, 1986) list the soils found to occur within each land type, but only those soils encountered during their survey are recorded and other soils besides these may also occur (Land Type Survey Staff 1985, 1986). The soils are described according to the binomial classification system of MacVicar et al. (1977).

2.4.1 MAP UNIT Ca

Approximately 62% of the study area consists of map unit Ca, comprising two land types, namely Ca2 and Ca17 (Figure 2.6). The two land types differ in terms of their geology, macroclimate and pedology. The Ca2 soils are derived from shale and sandstone of the Eccca Group, and Karoo dolerite, whereas the Ca17 soils are derived predominantly from Volksrust Formation shale, with sandstone, shale and mudstone of the Beaufort Group, and Karoo dolerite (Land Type Survey Staff 1985).



LAND TYPES

	Ac39		Ea25
	Ca2		Fa24
	Ca17		Fa360
	Ea22		Fa361
	Ea23		Fa393

FIGURE 2.6 Land type map of the Amersfoort study area in the south-eastern Transvaal. Based on Land Type Series (1979a, 1979b, 1979c, in prep.)

The map unit Ca is defined as a "plinthic catena with upland duplex and/or marginalitic soils common", with gleyed soils in the lowlands (Land Type Series 1979a).

The upland duplex soils in land type Ca2 are the Estcourt, Kroonstad and Valsrivier Forms, with the Kroonstad being the most common. The marginalitic Arcadia Form occurs only in the lowlands, and is therefore not diagnostic. The plinthic Avalon and Westleigh Forms occur in the uplands and there are gleyed soils (Willowbrook and Rensburg Forms) in the lowlands. Other upland soils recorded belong to the Cartref, Clovelly, Glenrosa, Hutton and Mispah Forms, and the Kroonstad and Valsrivier Forms are also recorded in the lowlands (Land Type Survey Staff 1985).

In land type Ca17 the upland duplex and marginalitic soils are respectively the Kroonstad and Bonheim Forms. The plinthic soils (Wasbank and Avalon Forms) occur in the uplands and the lowlands, but the gleyed soils of the Katspruit and Willowbrook Forms are restricted to the lowlands. Other upland soils recorded belong to the Cartref, Clovelly, Glenrosa, Griffin, Hutton and Mispah Forms, with soils of the Kroonstad and Wasbank Forms in the lowlands.

2.4.2 MAP UNIT Ea

Map unit Ea covers ca 19% of the study area and has three land types, namely Ea22, Ea23 and Ea25 (Figure 2.6). The only difference between land types Ea22 and Ea23 is in the macroclimate, whereas land type Ea25 differs from the two former land types in terms of macroclimate, terrain form and pedology (Land Type Survey Staff 1985). Geologically, land types Ea22 and Ea23 occur on Eccra sandstone, grit and shale, and Karoo dolerite, whereas land type Ea25 occurs on Eccra sandstone, shaly sandstone and shale, and Karoo dolerite (Land Type Survey Staff 1985).

The map unit Ea is defined as having one or more of vertic, melanic or red structured diagnostic horizons (Land Type Survey Staff 1985).

The vertic (Arcadia and Rensburg Forms) and melanic (Mayo, Bonheim and Milkwood Forms) soils occur in both the uplands and the lowlands of land types Ea22 and Ea23. No red structured soils are recorded. Other soils recorded in the uplands

belong to the Swartland and Mispah Forms, and the Avalon, Hutton, Kroonstad and Valsrivier Forms occur in both the uplands and the lowlands.

Land types Ea22 and Ea23 have 7,5% rock occurrence as opposed to 49% rock occurrence in land type Ea25. In addition, in land type Ea25 the vertic soils (Rensburg Form) are restricted to the lowlands, the melanic soils (Mayo, Bonheim and Milkwood Forms) occur predominantly in the uplands and the red structured soils (Shortlands Form) occur in the uplands. The other soils found in the uplands of this land type belong to the Glenrosa and Hutton Forms, with the Arcadia Form in both the uplands and the lowlands.

2.4.3 MAP UNIT Fa

Map unit Fa constitutes ca 16% of the study area, comprising land types Fa24, Fa360, Fa361 and Fa393 (Figure 2.6). Land types Fa360 and Fa361 differ from each other in terms of their macroclimate and the remainder differ in terms of their macroclimate, terrain form and geology (Land Type Survey Staff 1986).

Land Type Fa24 occurs on Karoo dolerite, mudstone and sandstone of the Beaufort Group and shale of the Volksrust Formation (Ecca Group). Land types Fa360 and Fa361 occur most frequently on the sandstone, shale and mudstone of the Beaufort Group, and Karoo dolerite. A small amount of Volksrust Formation (Ecca Group) shale may also occur. Land type Fa393 is found principally on Karoo dolerite and less frequently on shale and sandstone of the Volksrust Formation (Ecca Group) (Land Type Survey Staff 1986).

The Fa landscapes are pedologically young. Rock weathering is the principle soil-forming process and this results in the formation of orthic topsoils which, together with clay illuviation, results in the formation of lithocutanic B horizons. The Glenrosa and Mispah Forms characterize this land type (Land Type Survey Staff 1986).

Soils of the Mispah Form as well as lithocutanic soils (Cartref, Glenrosa and Mayo Forms) are recorded for all of these land types. Soils of the Bonheim, Clovelly, Shortlands and Swartland Forms are also recorded for land type Fa24. Land types Fa360 and Fa361 record the Bonheim and Katspruit Forms in the lowlands, and the Clovelly, Hutton, Longlands, Shortlands and Wasbank Forms in the uplands. In the uplands, land type Fa393 has soils of the Hutton, Milkwood and

TABLE 2.2 Slope magnitude and length in different terrain units of the land types in the Amersfoort study area in the south-eastern Transvaal (Land Type Survey Staff 1985, 1986).

TERRAIN UNITS

LAND TYPES	1	2	3	4	5
Ca2	2-8° 200-1000m		3-12° 200-1000m		0-2° 200-1000m
Ca17	0-3° 600-1800m		3-12° 600-1200m		0-2° 20-1000m
Fa393	2-4° 30-130m		3-16° 300-1200m		3-16° 3-50m
Ea22 Ea23	3-8° 200-600m		4-15° 300-800m	3-6° 50-200m	0-2° 30-100m
Ac39	0-8° 200-1000m		6-15° 200-1000m		0-1° 30-150m
Ea25	1-12° 200-400m	50->100° 10-50m	8-50° 500-1500m		4-30° 10-50m
Fa360 Fa361	2-8° 150-500m		12-60° 300-1800m		12-60° 5-30m
Fa24	5-15° 300-600m		8-30° 1000-2000m		3-20° 10-300m

Swartland Forms, with soils of the Arcadia, Katspruit and Oakleaf Forms in the lowlands, and the Bonheim Form occurs throughout.

2.4.4 MAP UNIT Ac

Map unit Ac occupies ca 3% of the study area and is represented by land type Ac39 (Figure 2.6). Karoo dolerite is common in this land type and shale and sandstone of the Eccra Group are also present (Land Type Survey Staff 1986).

This map unit consists of "red-yellow apedal freely drained soils" that may be dystrophic and/or mesotrophic (Land Type Series 1979a). These red and yellow soils have a high base status, do not have a water table and the land does not qualify as a plinthic catena (Land Type Survey Staff 1986).

Soils of the Hutton and Shortlands Forms (red soils) as well as the Clovelly, Glencoe and Griffin Forms (yellow soils) occur in land type Ac39, but it is not possible to state whether they are mesotrophic or dystrophic. Other soils recorded are the Glenrosa and Mispah Forms in the uplands and the Bonheim, Longlands, Mayo, Milkwood, Swartland and Valsrivier Forms which occur throughout.

By definition the land types incorporate areas of similar geology, soils and terrain form (Land Type Survey Staff 1985) and each land type is therefore associated with a specific landscape (terrain form). The slope magnitudes and lengths of the constituent terrain units give an indication of the landscape associated with each land type.

The slopes of land type Ca2 are generally shallow and may attain considerable lengths (Table 2.2), forming a system of shallow plinthic catenas that give rise to the flat to gently undulating landscape of the central region of the study area (Figures 2.6 & 2.7)

Land type Ca17 has a gently undulating landscape similar to that of land type Ca2 (Figure 2.7). Whilst the magnitude of the slopes of the terrain units are of a similar order to those of land type Ca2 (Table 2.2), the lengths of the slopes are longer in land type Ca17, giving rise to a more elongated series of dips and rises in this land type (Figure 2.7).

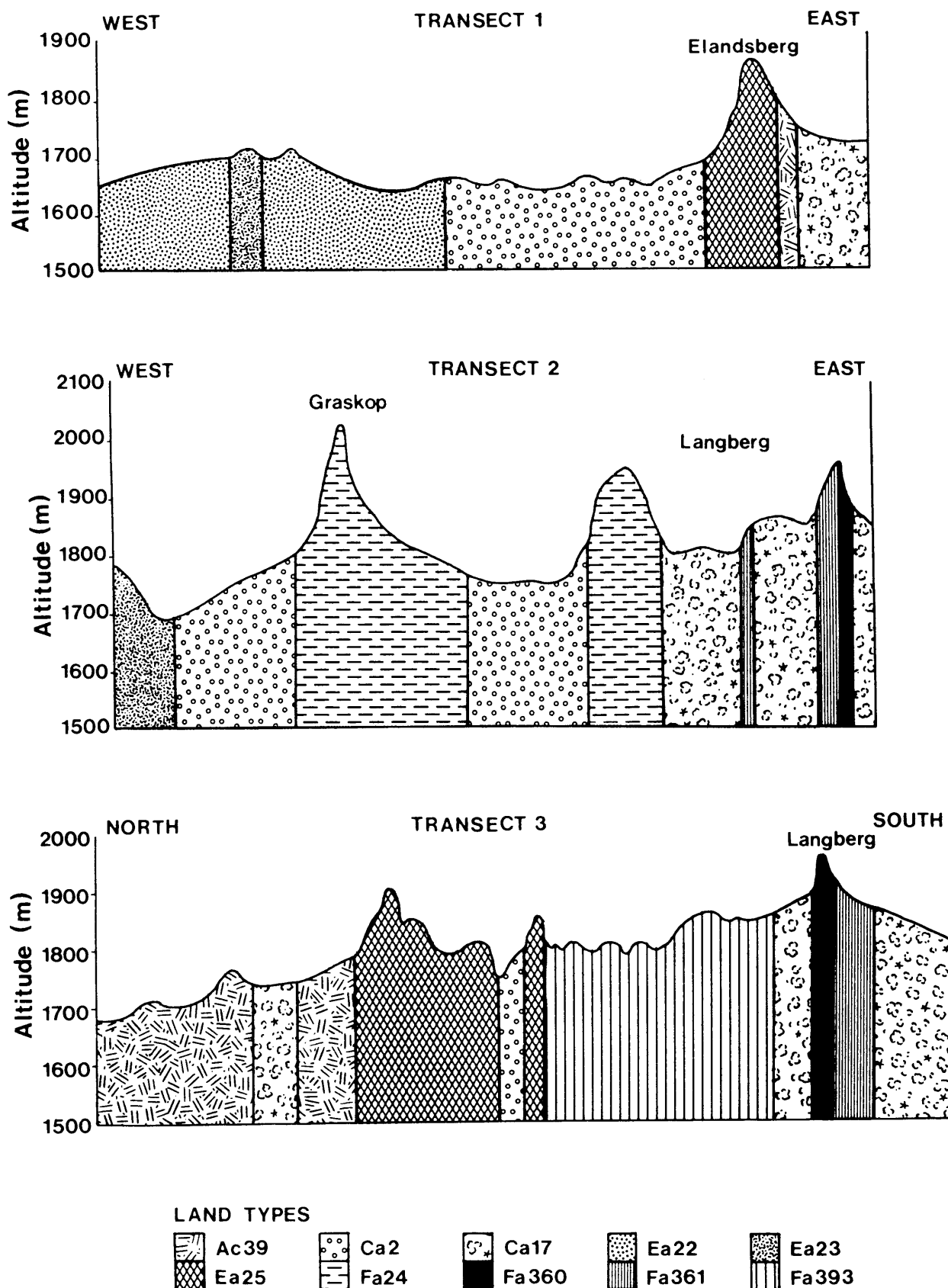


FIGURE 2.7 Profile sketches of transects taken through the Amersfoort study area in the south-eastern Transvaal, showing the landscape form and the associated land types. (The positions of the transects are shown in Figure 2.2). Based on South Africa, 1:50 000 Sheet (1970, 1971, 1976, 1979) & Land Type Series (1979a, 1979b, 1979c, in prep.)

The landscapes of land types Fa393, Ea22, Ea23 and Ac39 also resemble those of land type Ca2, being of a flattish, gently undulating nature (Figure 2.7). Land type Fa393 generally has shorter slopes than land type Ca2 (Table 2.2), resulting in the development of a hillier landscape (Figure 2.7). Land types Ea22 and Ea23 have a landscape which is very similar to that of Ca2 (Figure 2.7), although the slopes tend to be shorter (Table 2.2). These are the only land types in which terrain unit 4 (the footslope) is recorded (Table 2.2). In land type Ac39 the hillier landscape (Figure 2.7) may arise as a result of the slightly greater slope magnitude in terrain unit 3 and the shorter slope lengths of terrain units 3 and 5 (Table 2.2).

Land types Fa24, Ea25, Fa360 and Fa361 are all associated with the mountainous areas in the south and east of the study area (Figure 2.6). This is correlated with the increased slope magnitudes of the terrain units occurring within these land types (Table 2.2).

The slopes of terrain units 3 and 5 in land type Ea25 may become very steep (Table 2.2), respectively attaining maximum slopes of 50° and 30°. This is the only land type in the study area where cliffs (terrain unit 2) were found to occur, and although they are short, the cliffs are very steep (Table 2.2). The high hill, the Elandsberg, occurs within this land type (Figure 2.7).

Land types Fa360 and Fa361 occupy the steepest positions on the low mountain, the Langberg (Figure 2.7). The midslope (terrain unit 3) may become very steep (60°) with slope lengths of up to 1 800m (Table 2.2).

Land type Fa24 occurs in similar mountainous terrain, but has gentler slopes that may be very long (Table 2.2). The low mountain, Graskop, falls within this land type (Figure 2.7).

2.5 CLIMATE

The climate of an area describes the average conditions with respect to climatic factors such as precipitation, light, temperature, humidity and wind.

The principle factors causing broad-scale climatic variation are the latitude, the position of a site relative to the distribution of land masses and the sea,

TABLE 2.3 Particulars of the weather stations at Ermelo, Amersfoort and Volksrust in the south-eastern Transvaal (Pretoria Weather Bureau).

WEATHER STATION	ERMELO (Nooitgedacht)	AMERSFOORT	VOLKSRUST
STATION NUMBER	422/811	443/201	406/682
ALTITUDE (m)	1694	1646	1652
LATITUDE	26°31'S	26°51'S	27°22'S
LONGITUDE	29°58'E	30°07'E	29°53'E

and the altitude. Other factors that may affect climate are the pattern of atmospheric circulation and any disturbances thereof, the surface temperature of ocean currents, the overall physiography of the area surrounding a given site and the nature of the vegetation in the area (Weather Bureau, S.A. 1968).

Moisture, temperature and, to a lesser extent, light (solar radiation) are generally considered to be the most important climatic factors affecting the growth, survival and distribution of plants (Odum 1971; Krebs 1972; Schulze & McGee 1978; Walter 1979).

Climatic data for Amersfoort are limited to 76-year rainfall data and 2-year temperature data. These data will be discussed, but in order to obtain a more complete description of all climatic parameters prevailing, data from Ermelo (ca 60km north of Amersfoort) and Volksrust (ca 40km south of Amersfoort) will also be considered (Table 2.3). It is not possible to directly extrapolate climatic data from surrounding stations to Amersfoort, since climatic conditions are very local and change with distance, altitude and the precise locality. However, such data can be used to indicate the probable range of climatic conditions likely to prevail in Amersfoort. Temperature and rainfall data for Amersfoort are compared with the data for Ermelo and Volksrust (Figures 2.10 & 2.14) and whilst the curves in these graphs are not exactly the same, they are of a similar order. It is therefore unlikely that, with respect to other climatic factors, conditions in Amersfoort will diverge greatly from those at Ermelo and Volksrust.

Some of the data discussed in this section were obtained directly from the Pretoria Weather Bureau¹, and are referred to accordingly.

2.5.1 INSOLATION

Solar radiation regulates photosynthesis and influences the photoperiodic and phototrophic responses of plants, and the vertical zonation of a stand of vegetation (Schulze & McGee 1978). An important secondary effect of solar radiation is the heating effect that it has on plants (see Section 2.5.2) and soils. Variations in soil properties and their locality result in areas of soil having different temperatures, and the soil temperature affects the rate of soil development and mineralization, and water and nutrient availability. These

¹Pretoria Weather Bureau, Private Bag X193, Pretoria, 0001.

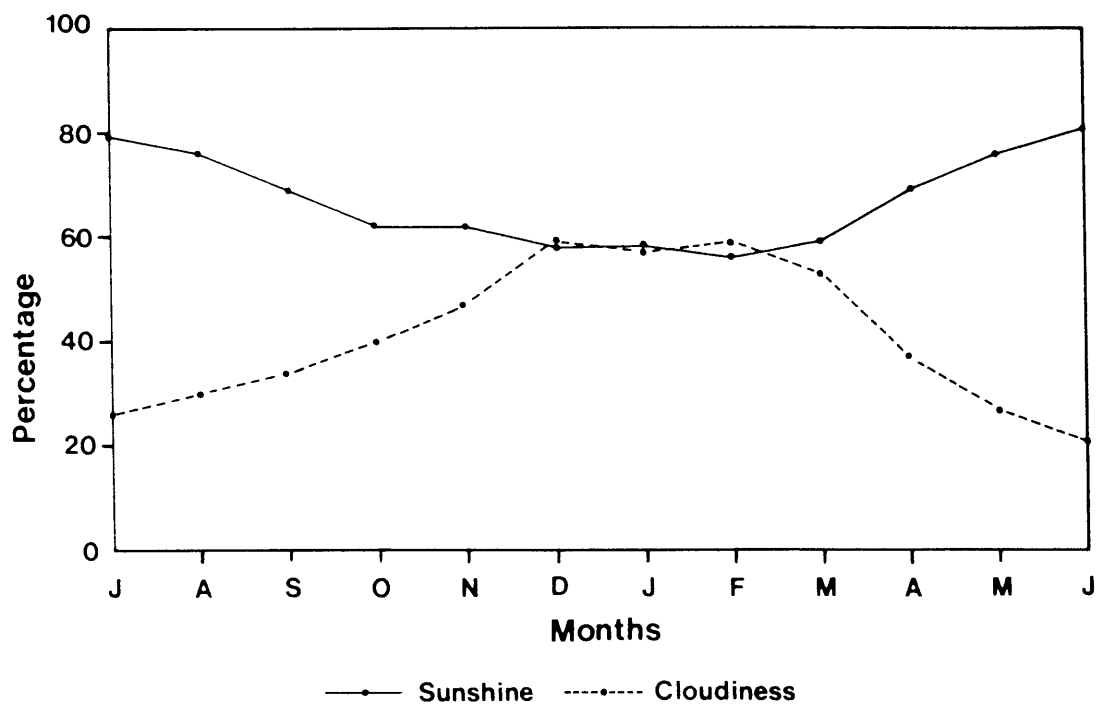


FIGURE 2.8 The mean monthly percentages of possible sunshine duration and the mean cloudiness at 08:30 for Ermelo (1935-1941) (Weather Bureau, S.A. 1950, 1965).

factors, together with the actual soil temperatures, greatly influence plant growth and species distribution (Rorison & Sutton 1975).

Insolation may be measured directly in terms of radiation flux densities, or indirectly as periods of sunshine duration (Deall 1985).

2.5.1.1 Incoming Radiation Flux Densities

In the general study area the average annual total radiation is ca $450 \text{ cal.cm}^{-2} \text{ day}^{-1}$. The total radiation varies seasonally, December receiving an average of ca $550 \text{ cal.cm}^{-2} \text{ day}^{-1}$ and June receiving only ca $300 \text{ cal.cm}^{-2} \text{ day}^{-1}$ (Weather Bureau, S.A. 1965).

Not all of the incoming (total) radiation reaches the surface of the earth. Moist and cloudy conditions result in a high water vapour content of the atmosphere which, together with dust, absorbs and reflects up to 55% of the total radiation. The reflected (diffuse) radiation levels thus vary with atmospheric moisture conditions. Amersfoort receives an average annual diffuse radiation of ca $150 \text{ cal.cm}^{-2} \text{ day}^{-1}$, which is 33% of the quantity of total radiation received (Weather Bureau, S.A. 1965; Daubenmire 1974; Schulze & McGee 1978).

The amount of direct radiation received is affected by topography, aspect and the slope magnitude, owing to the directional nature of this type of radiation. Diffuse radiation is less directional and therefore topographical interference is less pronounced (Pope & Lloyd 1975). In the southern hemisphere north-facing slopes tend to receive the most direct radiation and are thus relatively warm and dry, as opposed to south-facing slopes which are cooler and moister as a result of their receiving lower levels of insolation (Pope & Lloyd 1975; Schulze 1975; Schulze & McGee 1978).

2.5.1.2 Sunshine Duration

Ermelo receives ca 70% of the possible sunshine annually. The duration of daily sunshine received varies with the seasons, with the greatest percentage of possible sunshine being received in winter (Figure 2.8). The winter months (June, July and August) receive ca 80% of the possible sunshine, whereas the summer months (December, January and February) receive only ca 60% of possible sunshine (Weather Bureau, S.A. 1950). The high percentage of cloud cover during summer (the wet season) is chiefly responsible for the lower sunshine reception

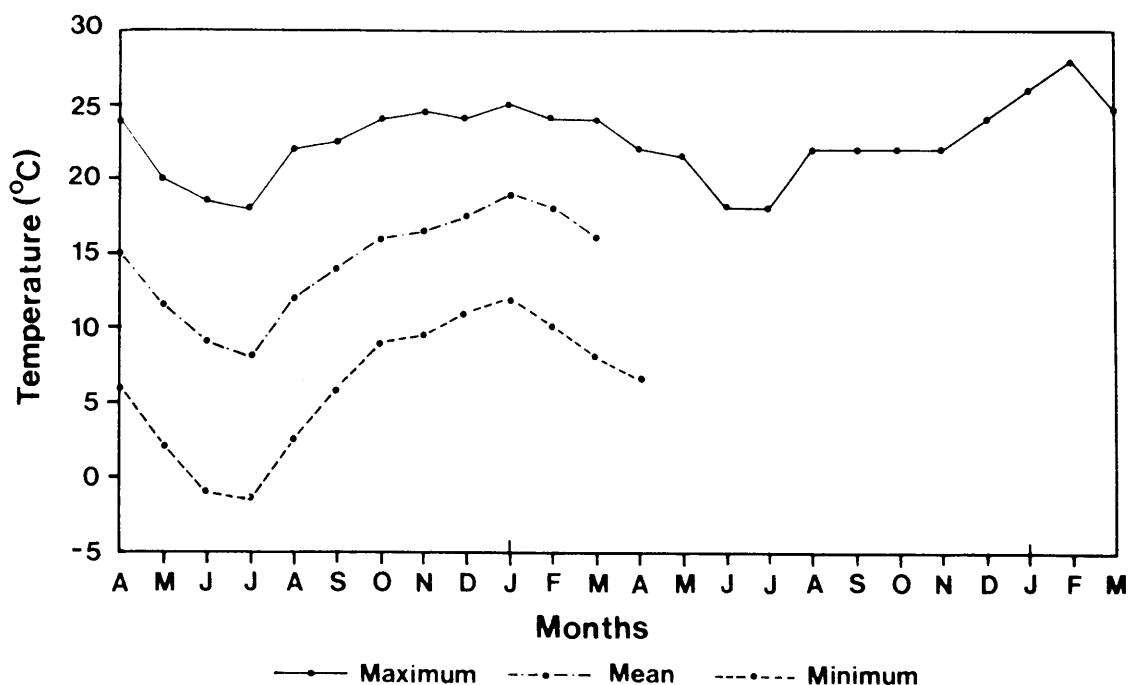


FIGURE 2.9 The monthly maximum, mean and minimum temperatures for Amersfoort (1985-1987) (Pretoria Weather Bureau).

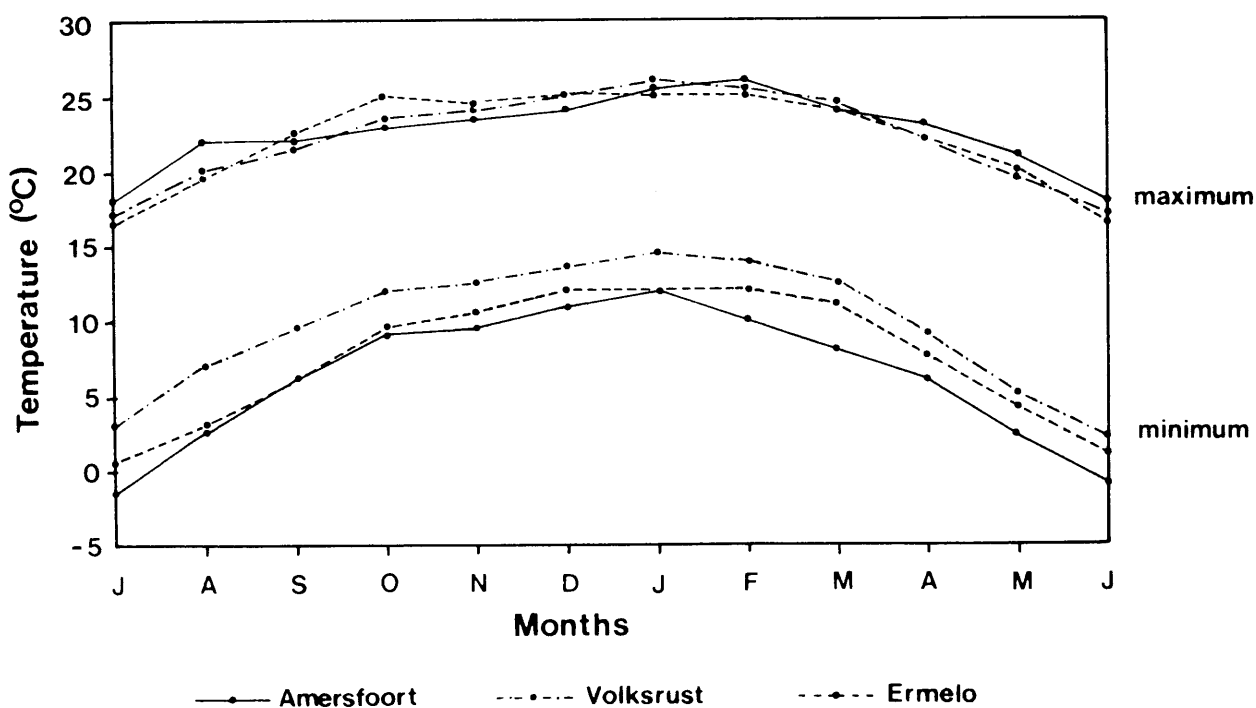


FIGURE 2.10 The mean monthly maximum and minimum temperatures for Amersfoort (1985-1987), Volksrust (1978-1986) and Ermelo (1896-1945) (Pretoria Weather Bureau; Weather Bureau, S.A. 1954).

during this season. At 08:30 in summer there is an average of ca 60% cloud cover (Figure 2.8), whereas during winter there is only 30% cloud cover at the same time of day. Although cloud cover estimates at only 08:30 are not an exact reflection of daily conditions, they are a fairly accurate approximation (Weather Bureau, S.A. 1950).

Owing to the high cloud cover summer has the highest percentage of dull and overcast days (receiving <10% of the possible sunshine). In summer there are on average 13% of dull days per month, with an average of only ca 3% per month during winter. Conversely, the highest percentage of bright days (receiving $\geq 90\%$ of the possible sunshine) occur during winter. Winter receives an average of 30% bright days per month and summer averages only ca 10% per month. During both summer and winter maximum sunshine reception occurs around midday (Weather Bureau, S.A. 1950, 1965).

2.5.2 TEMPERATURE

The earth's primary source of heat is the sun. The heat energy contained in solar radiation raises the temperature of the atmosphere and any intercepting surfaces. The temperature of the atmosphere is not uniform throughout but varies locally, being influenced by factors such as altitude, latitude and local relief (Jackson 1951).

The ambient temperature affects a plant's rate of transpiration, evaporation and other physiological processes (Daubenmire 1974; Schulze & McGee 1978). These processes affect rates of germination, growth, maturation and reproduction, and the vigour of the plant in turn affects such aspects as its competitive ability and resistance to disease (Krebs 1972; Daubenmire 1974; Schulze & McGee 1978).

Temperature interacts with other climatic factors to create environmental conditions that may limit the distribution of a plant species. It is possible that the most important temperature effect is in its influence on the water balance (Krebs 1972), and the ranges and extremes of temperature are likely to have the greatest effect on plants. The severity of frost and low minimum temperatures during winter, the high summer maximum temperatures and the length of the frost-free period are possibly the most important direct temperature effects (Papadakis 1961; Daubenmire 1974; Schulze & McGee 1978).

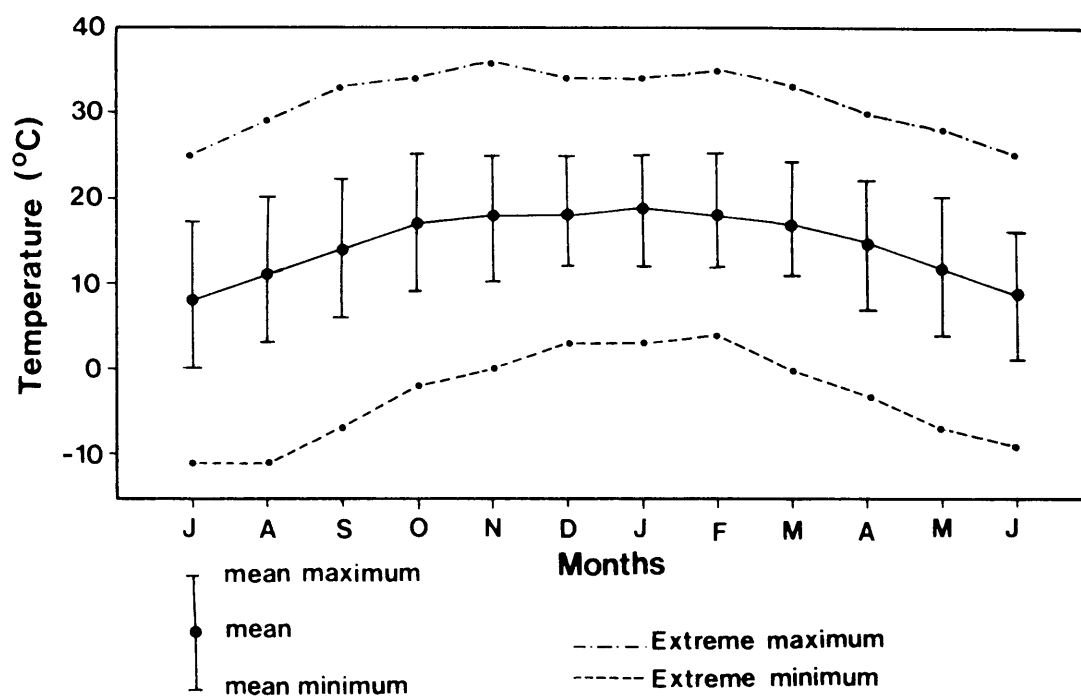


FIGURE 2.11 The mean and extreme monthly temperatures for Ermelo (1896-1945) (Weather Bureau, S.A. 1954).

Only 2-year temperature data are available for Amersfoort (Figure 2.9). These data are not a reliable reflection of the long-term average temperature conditions in Amersfoort, but do serve to give an indication of the temperature conditions that may occur. The maximum and minimum temperatures follow a similar annual pattern, with temperatures being lowest during winter (June and July) and highest during summer (October to March for maximum temperatures, October to February for minimum temperatures).

The mean monthly maximum and minimum temperature data for Amersfoort are compared with mean monthly data for Ermelo and Volksrust (Figure 2.10). These data are not strictly comparable because the data have been recorded for different lengths of time at each station, and Amersfoort's data is short-term. Nevertheless, these data are compared for want of any other data, to allow a rough comparison of the conditions at these stations.

The general pattern of temperature increase and decrease is similar at all three stations, although Amersfoort shows the greatest range of temperature variation annually. Ermelo has a range of 25°C (0,4°C to 25,4°C) with a mean annual temperature of 14,7°C. Volksrust has a range of 23,9°C (1,9°C to 25,8°C) with a mean annual temperature of 15,9°C. Mean maximum data have been determined from the limited data available for Amersfoort (Figure 2.9) and these data indicate a 27,4°C annual temperature range, from -1,6°C to 25,8°C, with a mean annual temperature of 14,4°C.

Detailed, long-term temperature data are available for Ermelo only (Figure 2.11). January has the highest mean temperature at 19°C, and July the lowest at 8°C. The greatest fluctuation in temperature occurs during the winter months, especially in July which has a difference of 17°C between the mean maximum and minimum values. Temperature ranges are least (13°C) during the warmer months of December to March.

Extreme maximum and minimum temperatures may greatly exceed the mean values (Figure 2.11). For example, July has a mean minimum temperature of 8°C, but temperatures as low as -11,1°C have been recorded. In contrast to this, the mean maximum temperature is 17°C, but may range from 3,3°C to 25,1°C. January has a mean minimum temperature of 12°C, but a minimum of 3,3°C has been recorded and the mean January maximum temperature is 25°C, but extremes of 11,7°C to 34,4°C have been recorded (Weather Bureau, S.A. 1954, 1965).

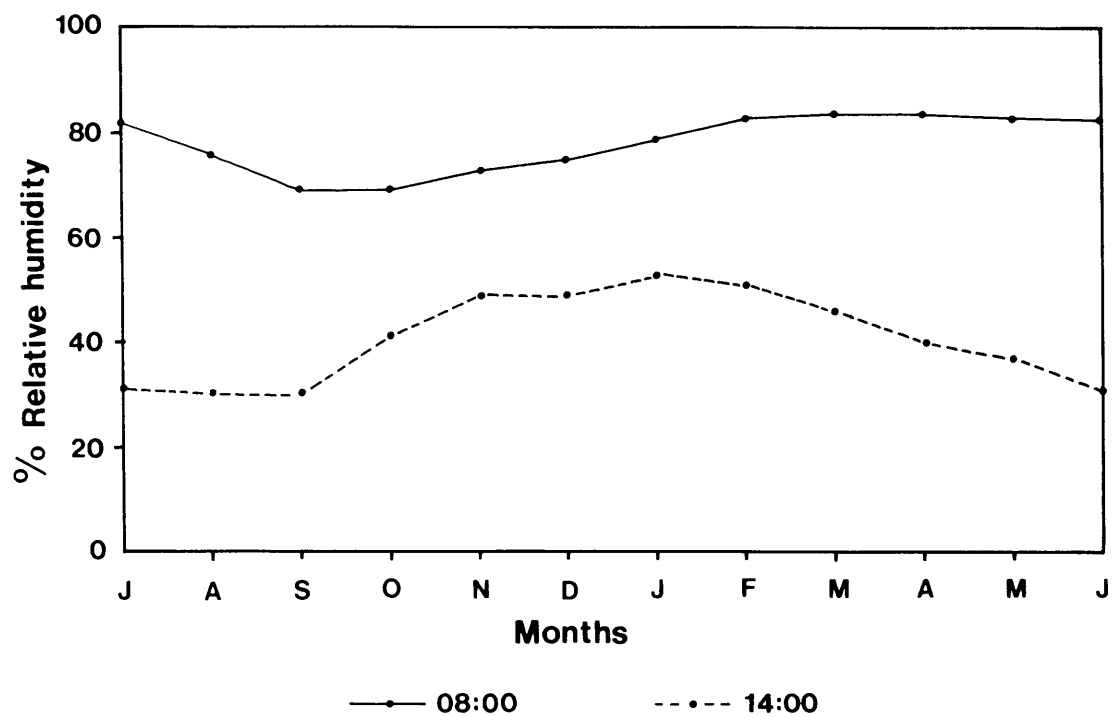


FIGURE 2.12 The mean monthly relative humidity at 08:00 and 14:00 for Ermelo (1951-1984) (Pretoria Weather Bureau).

2.5.2.1 Frost

Amersfoort is situated on the interior plateau of South Africa, an area that frequently experiences some of the most severe frosts in the country (Jackson 1951; Weather Bureau, S.A. 1965). The frost usually takes the form of crystal-line hoar frost, but with an influx of very cold air from the south, a black frost may occur. During a black frost the moisture in the plant freezes, resulting in the rupturing of the cells with consequent blackening and wilting of the plant tissues (Weather Bureau, S.A. 1965). Frost formation is favoured when temperatures are less than 0°C and the atmosphere is dry with clear skies, a frequently occurring condition during winter.

In Ermelo frosts usually occur from May to September, although early and late frosts have been recorded during March and October. The frost period usually lasts 113 days with an average of 25,8 days of frost per year. In the 25 years for which data have been recorded in Ermelo, frost occurred every year (Weather Bureau, S.A. 1954).

There are no official records of frost occurrence in Amersfoort, but it falls into the area that usually receives frost from May to September, with an average of 120 frost days per year (Schulze 1980). Local farmers report that heavy frosts occur frequently during the winter, and that a very severe and unseasonal black frost occurred in Amersfoort on 25 December 1985.

2.5.3 RELATIVE HUMIDITY

Relative humidity is a direct measurement of the moisture in the atmosphere, irrespective of the ambient temperature (Weather Bureau, S.A. 1965). There is, however, an inverse relationship between temperature and humidity, in that the relative humidity decreases with an increase in temperature, and vice versa.

Relative humidity data are available for Ermelo only (Figure 2.12). For all months of the year, relative humidity is highest in the early morning (08:00) and decreases from then until just after midday (14:00). This decrease in relative humidity is related to the increase in temperature from early morning to midday, and towards evening, when temperatures begin to drop, the relative humidity begins to increase (Odum 1971; Daubenmire 1974). The greatest range in relative humidity values from 08:00 to 14:00 occurs during the winter months, which months

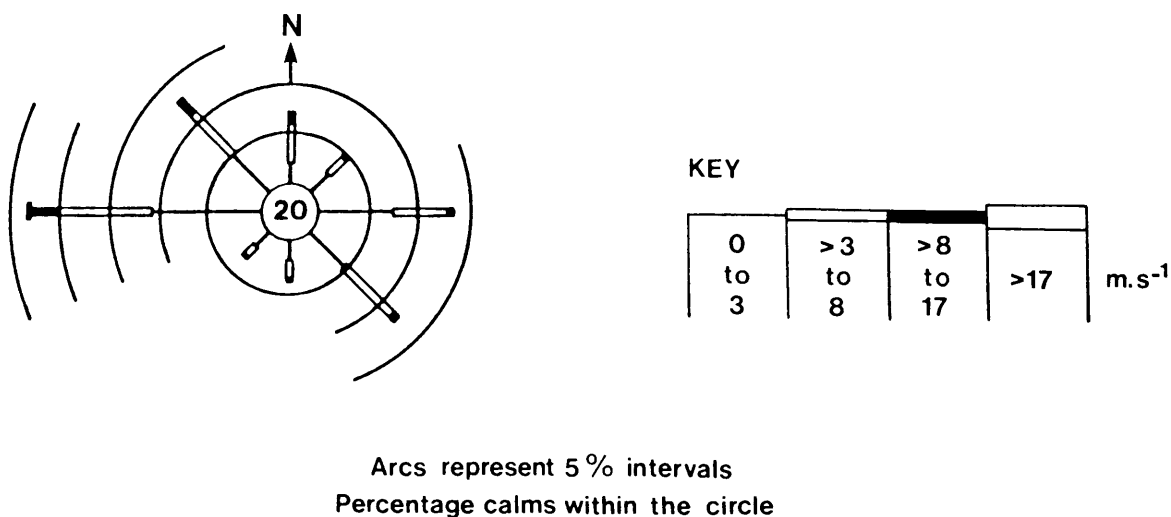


FIGURE 2.13 The annual wind direction and speed for Ermelo (1939-1945) (Weather Bureau, S.A. 1960).

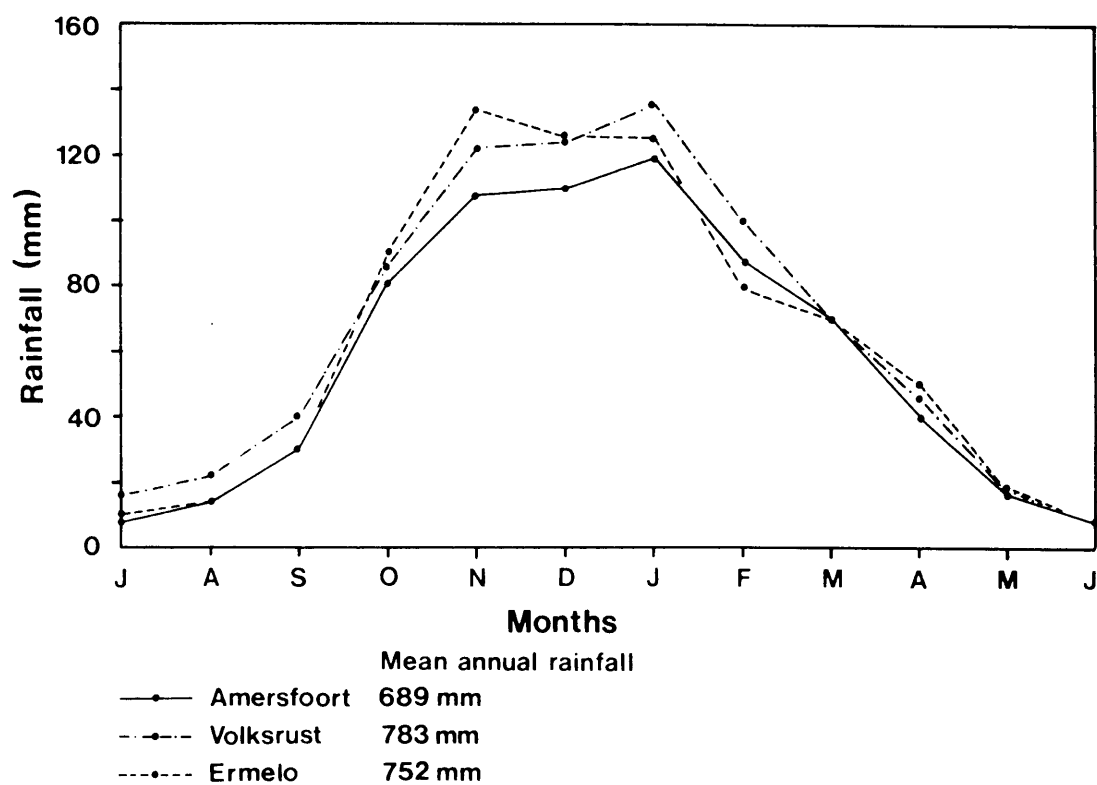


FIGURE 2.14 The mean monthly rainfall for Amersfoort (1911-1986), Volksrust (1951-1984) and Ermelo (1951-1984) (Pretoria Weather Bureau).

also have the greatest range from daily minimum to maximum temperatures (Figure 2.11).

The levels of relative humidity are directly related to the wet and dry seasons (or to the amount of rainfall and cloud cover). Relative humidity at 14:00 is highest during the wet season which has a high rainfall and a high cloud cover, and lower during the dry winter (Figure 2.12). The four wettest months of the year are October to January (Figure 2.14) and the four months of the year with the mean highest relative humidity at 14:00 are November to February. There is thus a slight time-lag in the increase of relative humidity in response to a large increase in the monthly rainfall.

In South Africa as a whole, relative humidity at 14:00 tends to reach its maximum in March and then decreases steadily until September, after which it begins to rise again. This and the rainfall pattern (see Section 2.5.5.1) is indicative of a monsoonal type of climate (Weather Bureau, S.A. 1965). In Ermelo (Figure 2.12) the relative humidity at 14:00 peaks two months earlier, in January, and then decreases to September before increasing once more.

The prevailing level of relative humidity has an important influence on the water balance of a plant. When relative humidity is low there is a stronger vapour-pressure gradient between the atmosphere and moist plant surfaces, resulting in an increase in the rates of evaporation and transpiration. This in turn results in a faster rate of water usage and loss (Daubenmire 1974).

2.5.4 WINDS

On the interior plateau of South Africa the prevailing winds during summer are the on-shore winds (S, SE and E) which are moisture laden and turbulent, and are frequently associated with thunderstorms (Jackson 1947). The winter winds are predominantly off-shore (N, NW and W) and they are dry and their low water vapour content allows rapid release of radiation to the atmosphere, resulting in large diurnal temperature fluctuations (Jackson 1947). This is reflected by the temperature data for Ermelo (Figure 2.11) where the greatest diurnal temperature fluctuations occur in winter.

In the general Amersfoort area the strongest winds occur during spring, i.e. September to November (Weather Bureau, S.A. 1965). In Ermelo the summer half-

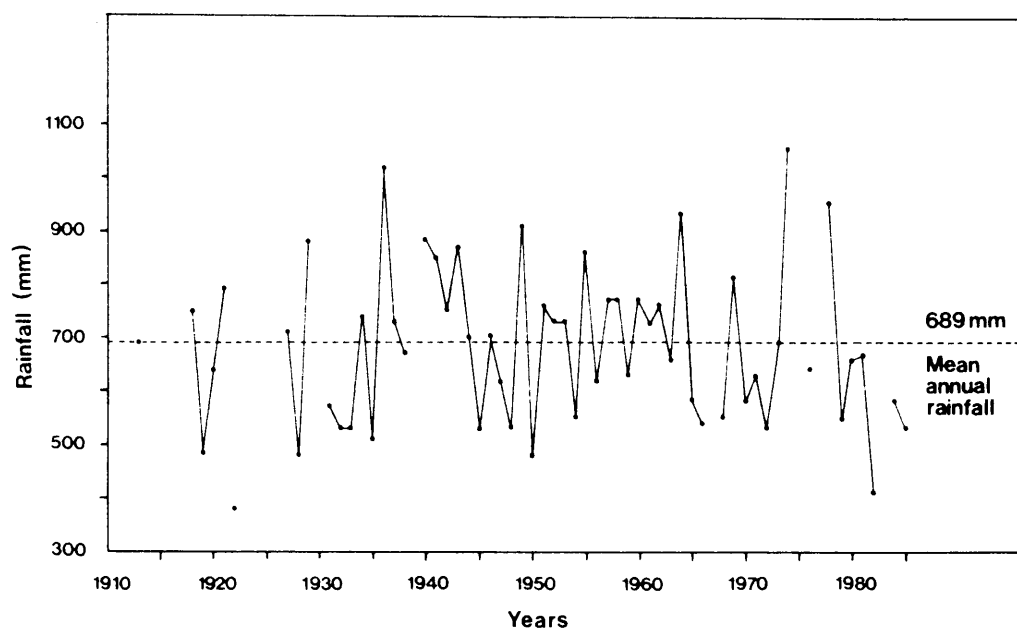


FIGURE 2.15 The annual variation in the total annual rainfall for Amersfoort (1913-1986) (Pretoria Weather Bureau).

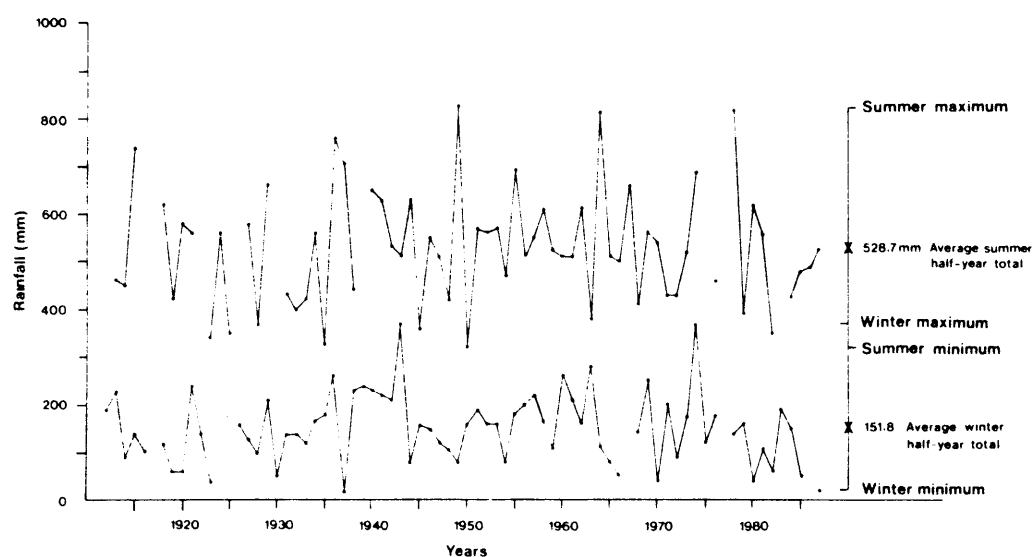


FIGURE 2.16 The annual variability of the total summer half-year (September-February) and winter half-year (March-August) rainfall for Amersfoort (1912-1987) (Pretoria Weather Bureau).

year (September-February) is windier than the winter half-year (March-August), with the least windy month of the year being May. The windiest month is September, i.e. early spring (Weather Bureau, S.A. 1960). Data for Ermelo (Figure 2.13) show that the westerly wind is most frequently the strongest wind experienced, although it rarely attains speeds exceeding 61km.hr^{-1} (Weather Bureau, S.A. 1960).

The windiest period of the day during winter is usually at midday or in the early afternoon. In summer there are frequently two windy periods, in the early morning and late afternoon (Weather Bureau, S.A. 1965).

Many plants, particularly the grasses, are wind pollinated and their seeds may also be wind dispersed. Wind may affect the physiology of a plant by influencing its heat and water balance, by increasing transpiration rates and raising or lowering the temperature of plant tissues (Daubenmire 1974).

2.5.5 PRECIPITATION

Precipitation is one of the most important climatic factors affecting plants (Odum 1971; Krebs 1972; Schulze & McGee 1978; Walter 1979). Of crucial importance is the water balance which is affected by the balance between the moisture gained by precipitation and the moisture lost by evaporation and transpiration (Odum 1971). The limits of a species' tolerance to the prevailing moisture conditions may affect its distribution (Krebs 1972), since under conditions outside of its normal range of tolerance a species may not be able to survive, or it may not be vigorous enough to compete successfully.

Water is vitally important for the physiological and chemical processes operative within plants, such as germination, growth and reproduction (Krebs 1972; Schulze & McGee 1978). Water is the solvent via which soluble soil nutrients move from the soil into the plant (Daubenmire 1974; Schulze & McGee 1978) and substances such as plant nutrients, growth substances and photosynthates are transported within the plant in solution. A lack (or in certain instances, an excess) of water will impair the ability of a plant to function normally.

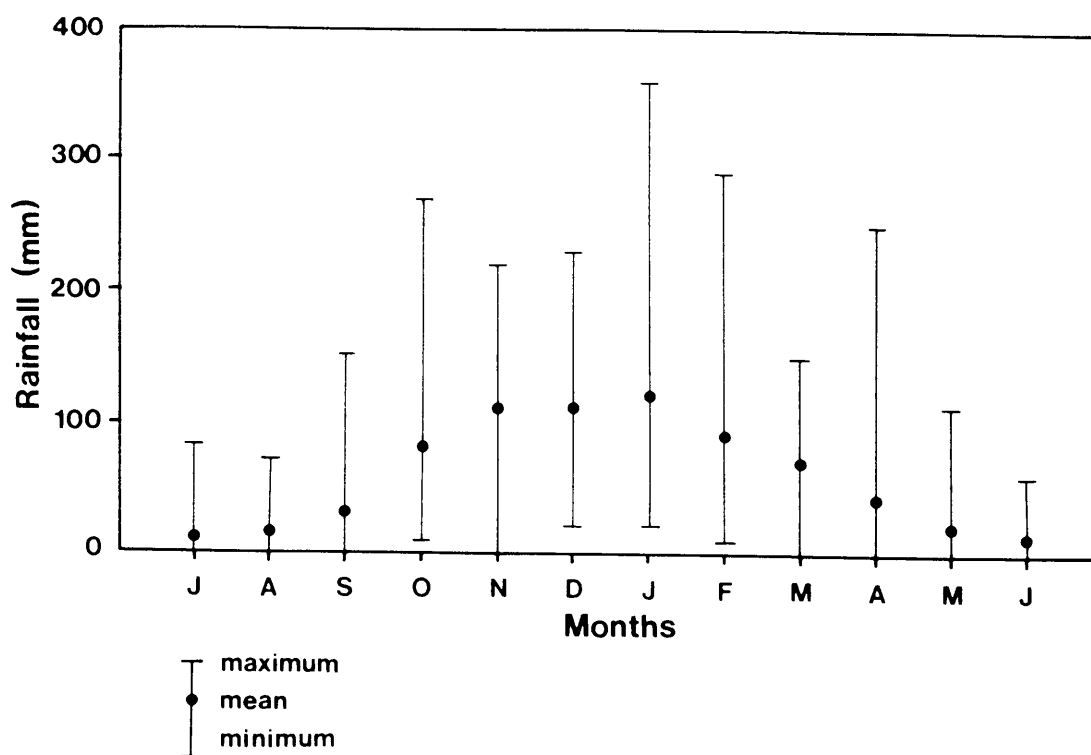


FIGURE 2.17 The maximum, mean and minimum monthly rainfall for Amersfoort (1911-1986) (Pretoria Weather Bureau).

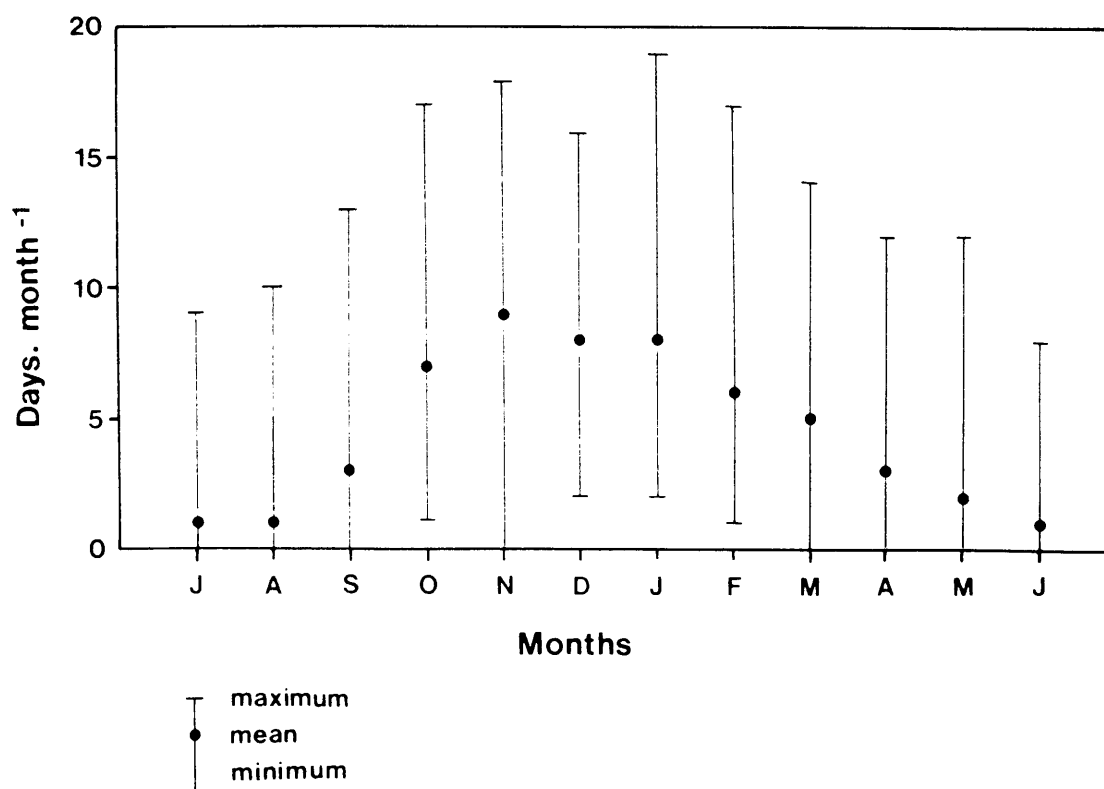


FIGURE 2.18 The maximum, mean and minimum number of rainy days per month for Amersfoort (1911-1986) (Pretoria Weather Bureau).

2.5.5.1 Rainfall

In South Africa the greatest proportion of precipitation takes the form of rainfall. Amersfoort (Figure 2.14) has a monsoonal type of rainfall, where the maximum is recorded in mid-summer (January) (Weather Bureau, S.A. 1965). The pattern of rainfall in Volksrust is very similar, but that of Ermelo differs in that the rainfall peaks at the end of spring, in November (Figure 2.14). Thunderstorms are the most common form of rainfall, although instability showers and light orographic rain also occur frequently (Weather Bureau, S.A. 1965).

Amersfoort has a mean annual rainfall of 689mm (Figure 2.15), although this is variable, ranging from 377mm to 1 064mm. Although the data used to compile Figure 2.15 are discontinuous, there are no obvious cycles of high and low rainfall.

Amersfoort falls within the summer rainfall area and receives 78% of the mean annual rainfall during the summer half-year (September-February) (Figure 2.14). The total amount of summer rainfall varies from 332mm to 830mm (Figure 2.16), with a mean of 529mm. The four wettest summer months are from November to February (Figure 2.14), during which period ca 80% of the average total summer rainfall occurs. Total rainfall during the winter half-year (March-August) is far more variable than during the summer (Figure 2.16), ranging from 21mm to 372mm, with a mean of 152mm.

The total rainfall for a given month may vary greatly (Figure 2.17). For example, November is usually one of the four wettest months of the year, yet no rainfall was recorded in November 1971, and 221,3mm (over double the mean monthly rainfall) were recorded in November 1936. Variation in total monthly rainfall is even greater during the winter: July has a mean total rainfall of 8mm (Figure 2.17) although there is frequently no rainfall during this month. In July 1963, however, 80mm were recorded.

The number of rainy days per month and the quantity of rainfall during each rainfall episode are important because they give an indication of the intensity and effectiveness of the rain. A minimum of 10mm of rainfall are considered to be agriculturally important (Weather Bureau, S.A. 1965), therefore rainfall episodes of less than 10mm are generally of lesser significance, and very heavy falls may be ineffective as much of the water may be lost through surface run-off (Walter 1971).

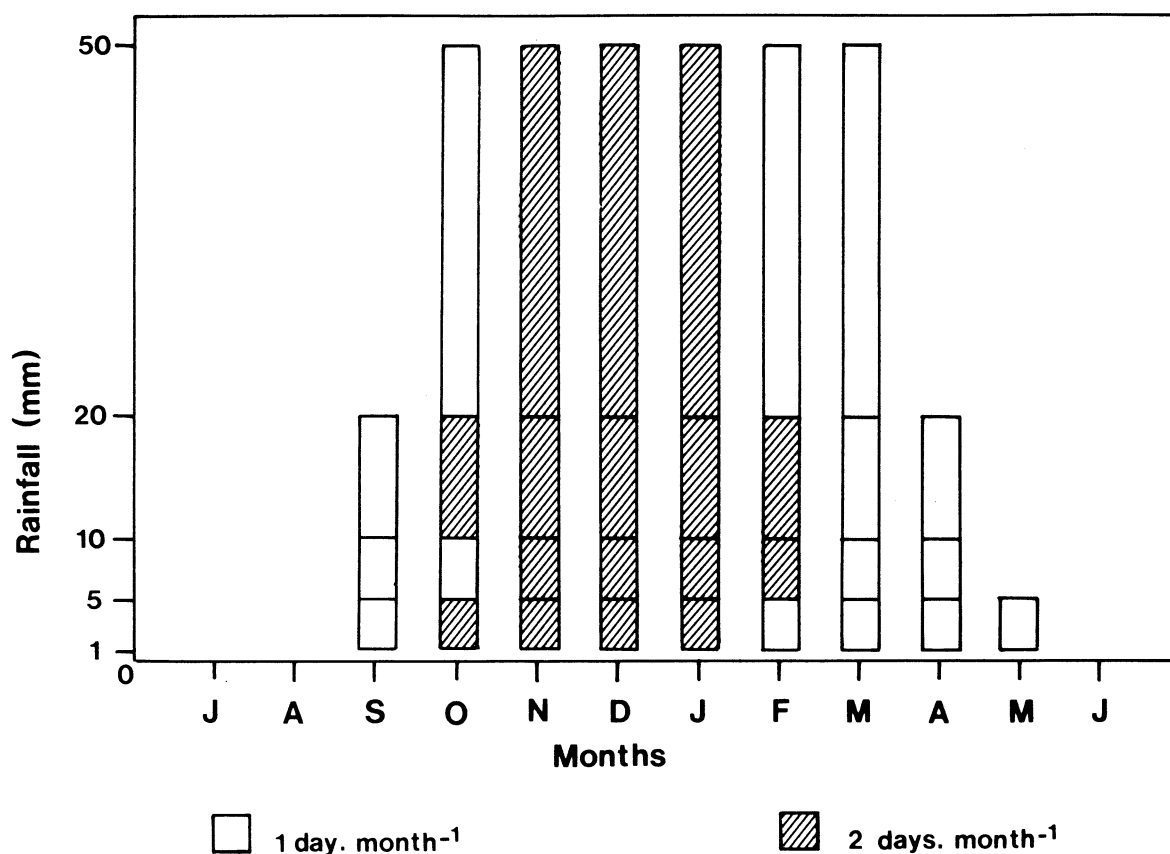


FIGURE 2.19 The mean number of days per month with rainfall in different rainfall intervals for Amersfoort (1911-1986) (Pretoria Weather Bureau).

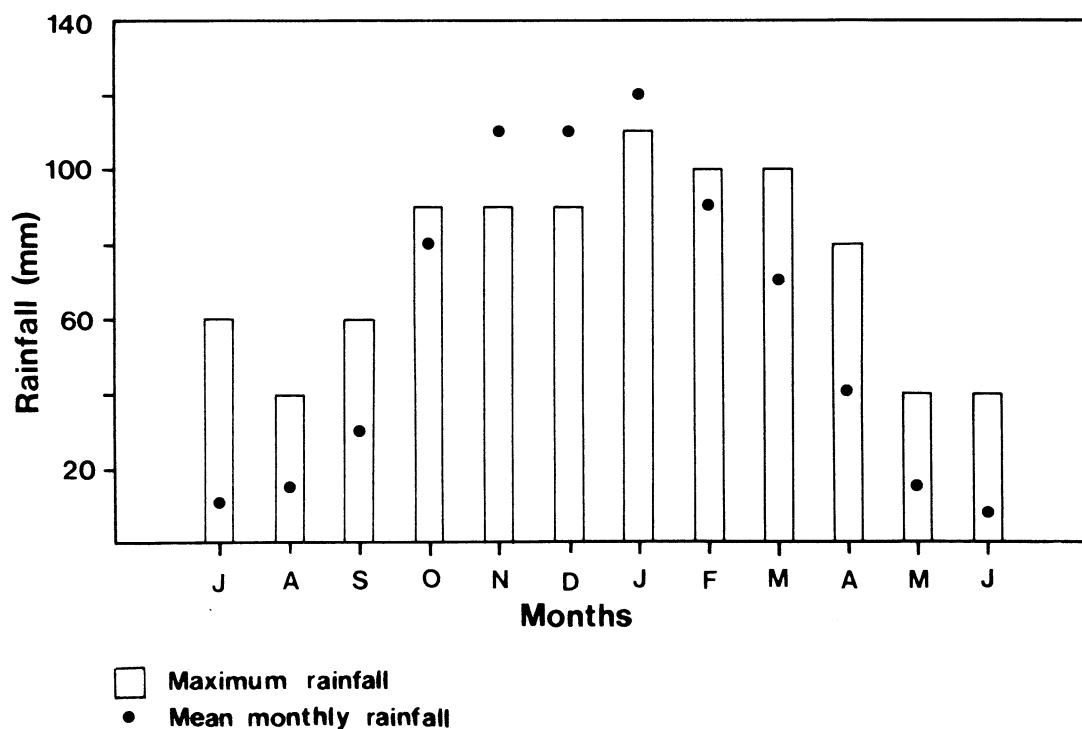


FIGURE 2.20 Comparison of the mean monthly rainfall with the maximum rainfall recorded during a 24-hour period for Amersfoort (1911-1986) (Pretoria Weather Bureau).

Summer rainfall is more effective than winter rainfall, since there are a greater number of rainfall episodes in summer (Figure 2.18) and the quantities of rain are fairly evenly dispersed between all of the rainfall intervals represented (Figure 2.19). There is, therefore, a high percentage of "good" rain that falls during this season, being neither too little nor too much. In the winter there are far fewer rainfall episodes (Figure 2.18), and the showers are far lighter (Figure 2.19), with the result that much of the rain that does fall is likely to be of little consequence to the vegetation.

There is considerable variation from the mean occurrences of rainfall in the intervals shown in Figure 2.19, in that exceptionally heavy rainfall may be recorded in a single day (Figure 2.20). In the summer half-year, rainfall has been recorded in 24 hours which is nearly equivalent to, or exceeds the mean total rainfall for a given month. The degree to which the mean total rainfall for a month may be exceeded by heavy rainfall during 24 hours is even greater during the winter half-year (Figure 2.20), to the extent that six times the mean monthly rainfall was recorded in 24 hours in July 1963.

On an annual basis, Amersfoort has ca 47 rainy days per year, with only 47% of the rainfall episodes recording over 10,0mm (Pretoria Weather Bureau).

Schulze & McGee (1978) classify the dry season as those months with a mean monthly rainfall from 0,1mm to 10,0mm and the wet season as those months having a mean monthly rainfall of ≥ 50 mm. According to this classification, the dry season in Amersfoort corresponds to June and July (Figure 2.14), with the wet season beginning in October and ending in March. During April and May moisture levels decrease with the approach of the dry season, and there is an increase in moisture levels during August and September with the approach of the wet season. Periods of low or no rainfall do, however, occur out of season. In Amersfoort no rainfall has been recorded for all months except January, February, October and December, and only January and December have minimum total monthly rainfall values over 10mm (Pretoria Weather Bureau).

Since a minimum of 10mm of rain are considered important for agriculture (Weather Bureau, S.A. 1965), extended periods receiving less than 10mm of rainfall constitute stress or a "relative drought" period for the vegetation. The percentage frequency and duration of periods of low rainfall (≤ 10 mm) are shown in Figure 2.21, for periods of two or more consecutive months. These periods are of frequent occurrence, having occurred in 55 out of the 60 years investigated.

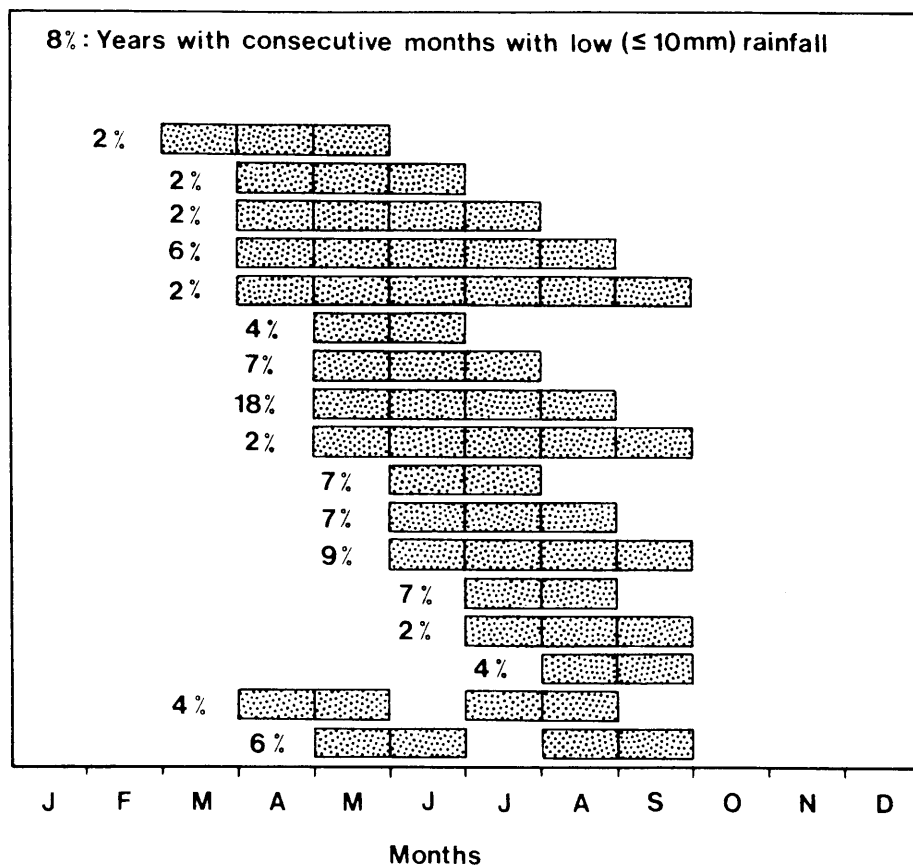


FIGURE 2.21 The frequency and duration of consecutive months having low ($\leq 10\text{mm}$) rainfall for Amersfoort (1911-1986) (Pretoria Weather Bureau).

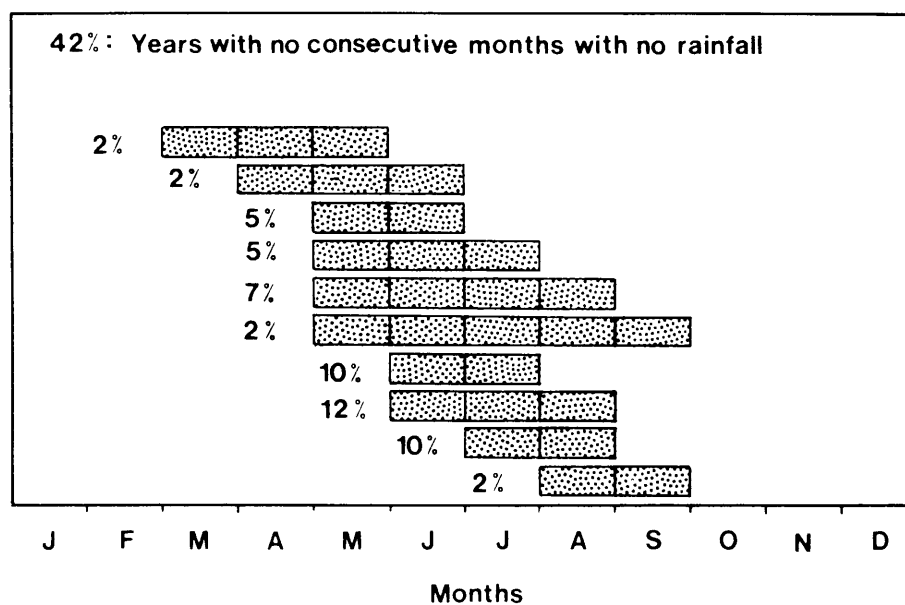


FIGURE 2.22 The frequency and duration of consecutive months having no rainfall for Amersfoort (1911-1986) (Pretoria Weather Bureau).

Extended periods of low rainfall occur from March to September (i.e. from the end of summer to the end of winter), with the most frequent period receiving low rainfall being the four winter months, May to August.

True drought conditions are experienced when no rain falls at all (Figure 2.22). Of the 60-year records investigated it was found that two or more consecutive months with no rainfall occurred in 35 years. These periods are most frequently of two or three months duration with the May to August period being the most frequently involved. The longest continuous period of low or no rainfall lasted six months in 1946. Less than 10mm were recorded in April, and from May to September no rainfall at all was recorded (Pretoria Weather Bureau).

2.5.5.2 Fog and Dew

Fog is formed when air close to or at the land surface is cooled. If the air is cooled further, condensation of the fog droplets continues until they are sufficiently large to precipitate out of the atmosphere, to be deposited on the soil or on plant surfaces (Daubenmire 1974).

Fog has been recorded in Ermelo and Volksrust during all months of the year (Figure 2.23a) with respectively 90% and 69% of the fog occurring during the winter half-year. A mean total of ca 9 days of fog per year occur at these stations.

Went (1955), Fabricius (1969, in Schulze & McGee 1978) and Schulze & McGee (1978) report that fog and dew are potentially very important additional sources of water for plants. Fabricius (1969, in Schulze & McGee 1978) measured the moisture deposited by fog in the Northern and Eastern Transvaal and found that the quantities could greatly exceed (by up to ca 300%) the rainfall of an area. No quantitative measurements of moisture deposition by dew appear to have been made, but Went (1955) reports that dew depositions may greatly increase the quantity of moisture available to plants. Both fog and dew occur frequently in Amersfoort (personal observation) and hence it is feasible that the rainfall may be considerably enhanced by these additional sources of moisture.

2.5.5.3 Hail

Thunderstorms in the Transvaal are often violent and accompanied by lightning, strong south-westerly winds and hail (Weather Bureau, S.A. 1965). Ermelo has an

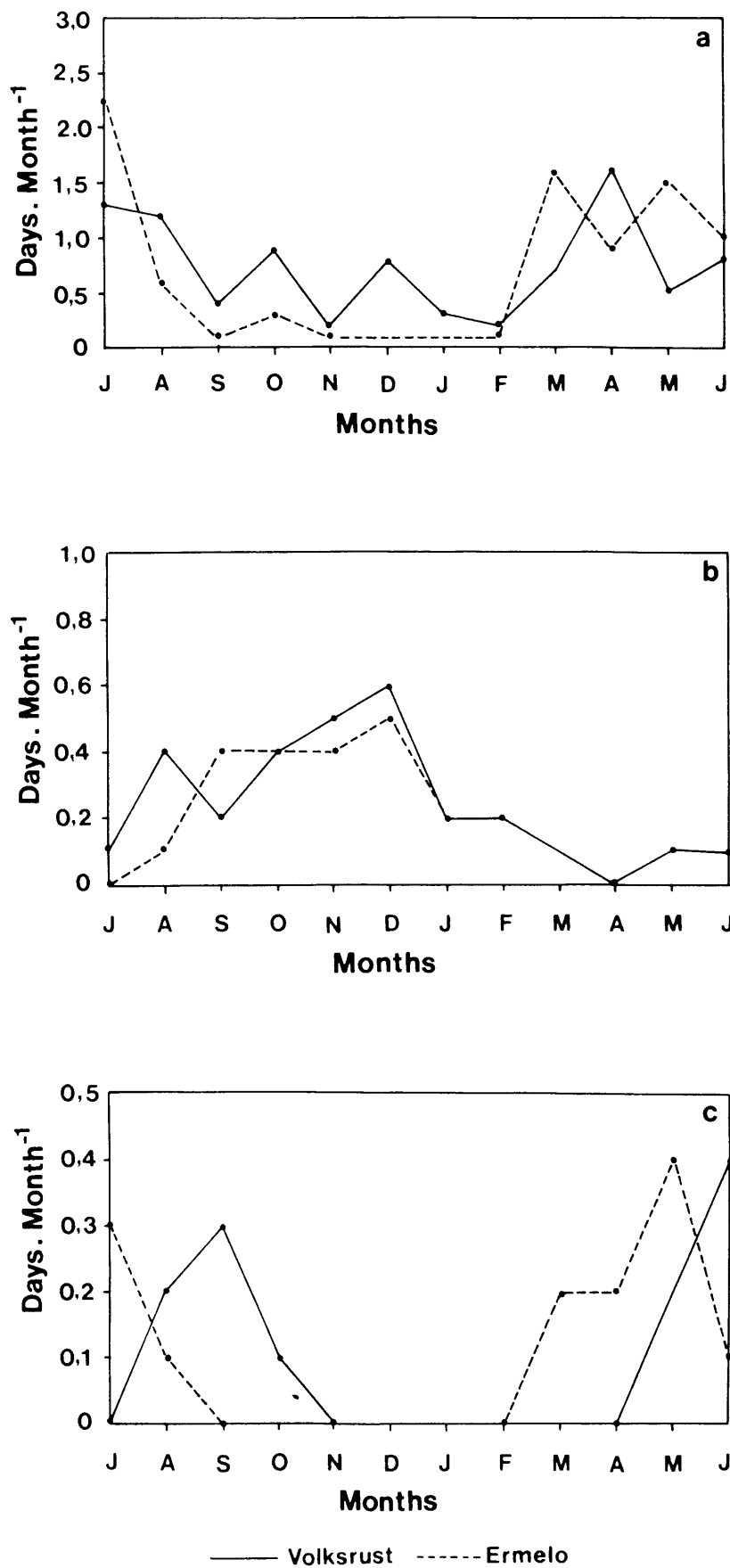


FIGURE 2.23 The mean monthly occurrence of fog (a), hail (b) and snow (c) for Volksrust and Ermelo (1951-1984) (Pretoria Weather Bureau).

average of 2,5 days with hail per year and Volksrust averages 2,9 days per year (Pretoria Weather Bureau). Hail occurs most frequently during the summer (Figure 2.23b) with a maximum in December, although hail has been recorded during the winter as well. The grassland biome as a whole records the highest hail frequencies in South Africa, having from four to seven hail episodes per year (Schulze 1980).

Amersfoort farmers report that the hail storms are frequently severe, with large hail stones that either destroy or do extensive damage to their crops.

2.5.5.4 Snow

Snow falls in the Amersfoort area approximately once a year. Ermelo averages 0,8 days of snow per year and Volksrust averages 1,2 days per year (Pretoria Weather Bureau). Snow falls are most frequent during winter (Figure 2.23c) but have been recorded as late as October (mid-spring).

2.5.6 CLIMATIC CLASSIFICATIONS

Numerous researchers have classified and described the vegetation of various regions of the world, and have then attempted to correlate their vegetation units with the prevailing climatic conditions. This resulted in descriptions of local climates, followed by more elaborate, regional or global systems of climatic classification (e.g. Köppen 1900, in Schulze & McGee 1978; Bolus 1905; Burt-Davy 1905; Pole Evans 1922a, 1922b; Thornthwaite 1948; Jackson 1951; Holdridge 1959; Walter & Leith 1967, in Walter 1971; Phillips 1983).

Köppen (1900, in Schulze & McGee 1978) developed a climatic classification which has been used for correlation with vegetation units. According to this system, Amersfoort falls into the Cwb climate which is described as:

C: a warm temperate climate where the coldest month has a mean temperature between 18°C and -3°C

w: the dry season occurs during winter

b: the warmest month has a mean temperature below 22°C, but at least four months have mean temperatures above 10°C

(after Köppen & Geiger 1936, in Schulze & McGee 1978).

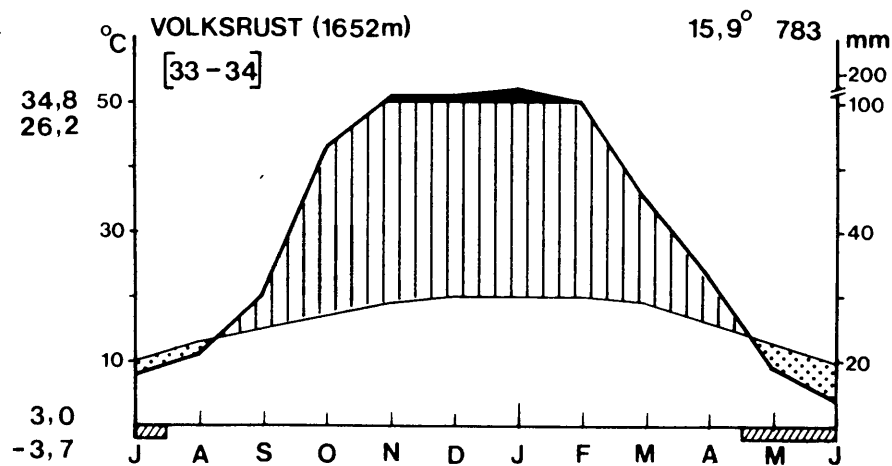
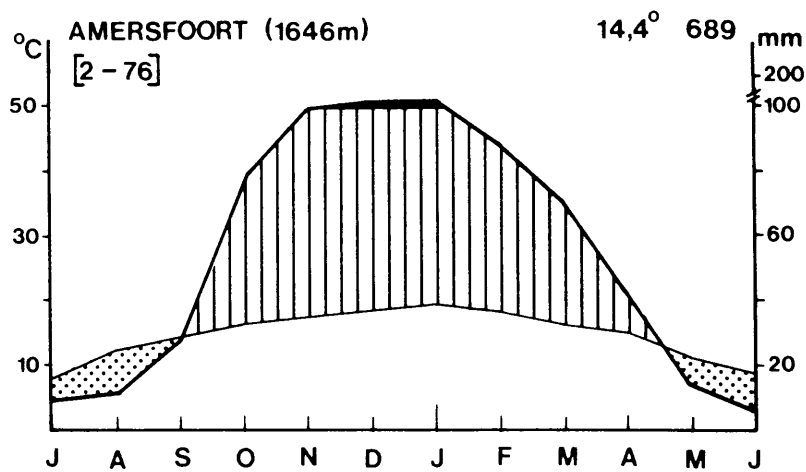
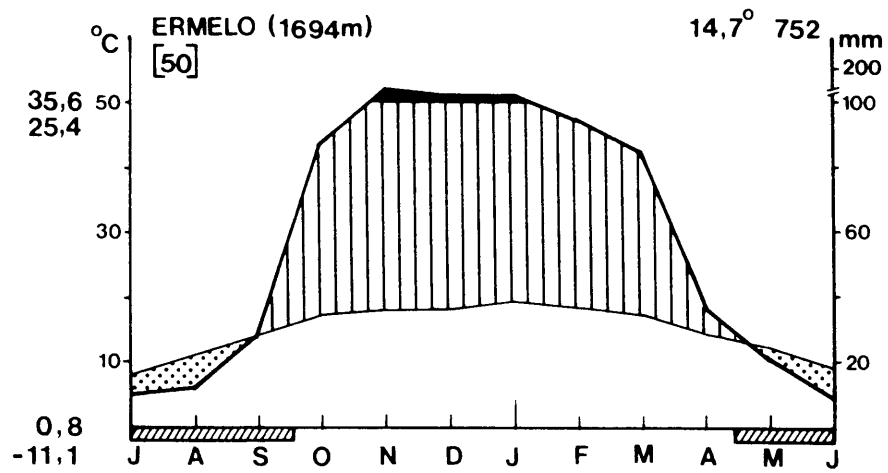


FIGURE 2.24 Climate diagrams for Ermelo, Amersfoort and Volksrust. After Walter & Leith (1967, in Walter 1971) (Pretoria Weather Bureau).

This system has been criticized by Mather (1974, in Schulze & McGee 1978) for not considering the water budget. This decreases the value of this classification system with respect to vegetation as a result of the importance of the water balance to plants.

Other climatic classifications have been proposed, such as the Holdridge Life Zone System (Holdridge 1959; Holdridge et al. 1971, in Schulze & McGee 1978) that is based on temperature, precipitation and potential evapotranspiration, and the climatic classification of Thornthwaite (1948) that is based on a "climatic water budget". These and other systems of climatic classification all have their limitations.

Perhaps the system of describing climate best suited to ecological work is that of Walter & Leith (1967, in Walter 1971; Walter 1979; Larcher 1983), where the climate is described graphically in a climate diagram, showing the change in climatic conditions from one month to the next, to give a seasonal and an annual overview (Figure 2.24). Temperature and precipitation data are used, giving an indication of periods of relative aridity (the dotted areas in the diagrams) and relative humidity (the vertically shaded areas in the diagrams). The duration of these periods is indicated by the width of the shaded/dotted areas; their intensity is indicated by the height of the shaded/dotted areas. The superhumid period, when the total monthly rainfall is in excess of 100mm, is indicated by the black areas. In these diagrams the temperature curve also serves to roughly indicate the potential evapotranspiration (Larcher 1983), which gives an idea of the water balance (Walter 1971). The months when frost usually occurs are indicated by the diagonally hatched areas on the abscissa of the diagram.

Climate diagrams for Amersfoort (using what climatic data are available), Ermelo and Volksrust are shown in Figure 2.24, and the diagrams for the three stations are very similar. The summer half-year is warm and relatively humid, with the majority of the year's rainfall occurring during this period. An excessively wet superhumid period occurs from October/November (mid- to late spring) to January/February (mid- to late summer). A positive moisture balance is maintained from approximately the beginning of spring (September) until late autumn (April/May). The relatively humid period is usually frost-free, giving a long season that is favourable for plant growth.

The remainder of the year (May/June to August) is cold, dry and frequently has frost (and snow), and although rain may fall, it is insufficient to maintain a

positive water balance. The winters are thus harsh and do not favour plant survival.

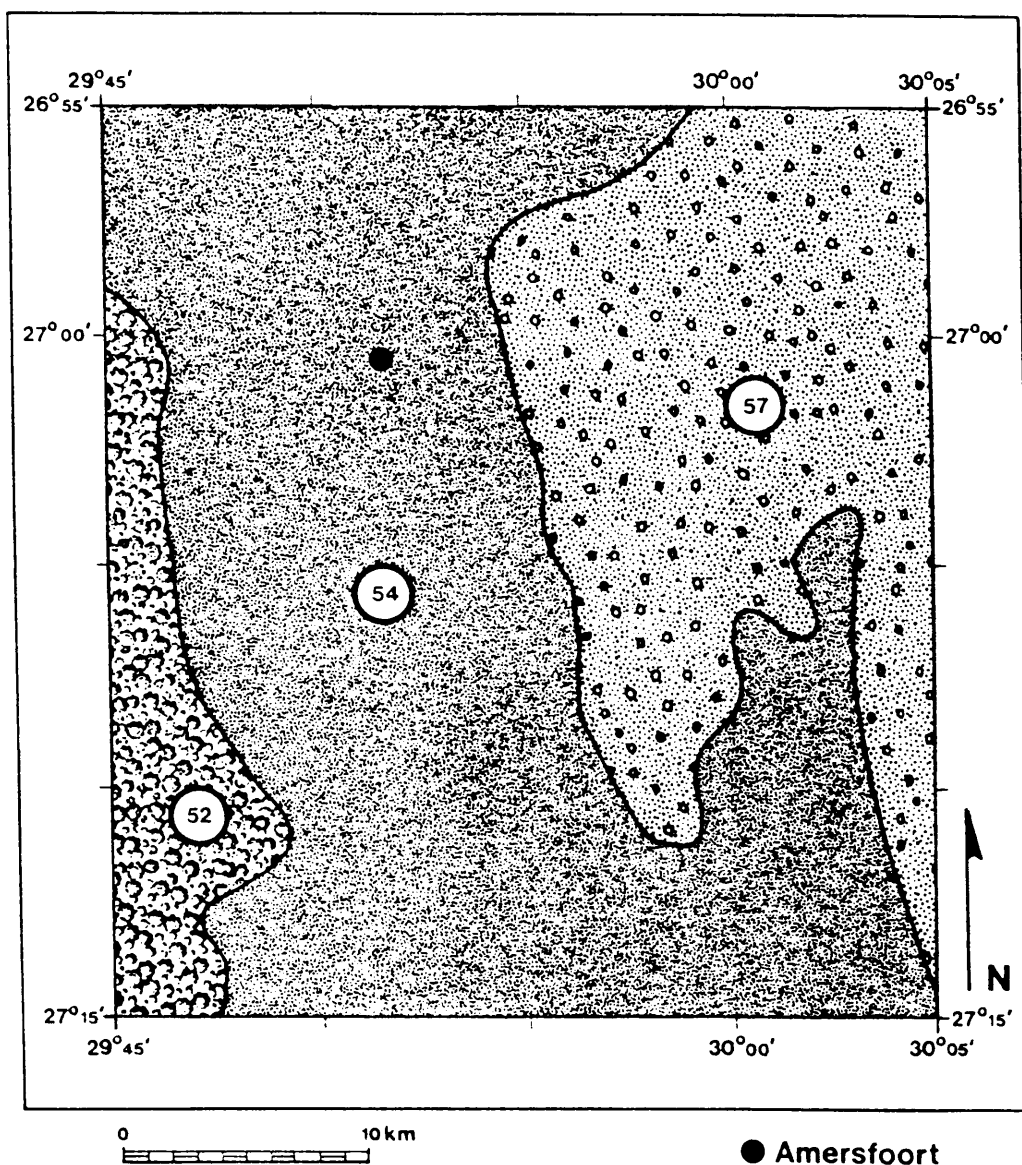


FIGURE 3.1 Veld type map of the Amersfoort study area in the south-eastern Transvaal. Based on Acocks (1970).

CHAPTER 3

DESCRIPTION OF THE STUDY AREA: BIOTIC FACTORS3.1 **FLORA**

Very little botanical work has been done in the sour grassland vegetation of the study area. PRECIS (the computerized record of the plant specimens housed at the National Herbarium, Pretoria) records that only 96 plant specimens were collected in the study area in the period ca 1903-1980.

Burtt-Davy (1905) published a map and a description of the vegetation of the then Transvaal Colony, and many maps and descriptions of the vegetation of South Africa have subsequently been published. In these accounts the vegetation of the study area has been variously described as: Highveld or High Veld (Burtt-Davy 1905; Pole Evans 1920, 1922b, 1931; Adamson 1938), Grassland Proper/High Veld (Pole Evans 1917), Eastern Grassveld Region (Bews 1918), High Veld of the South African Steppe and Forest Province (Pole Evans 1922a) and Short Grass (Pole Evans 1936). Acocks (1953, 1988) produced the most detailed account of the South African vegetation, and he recognizes three veld types in the study area (Figure 3.1).

A relatively small section of the study area comprises **Themeda** Veld or Turf Highveld (Veld Type 52) (Figure 3.1) which is described as being completely dominated by **Themeda triandra** (Acocks 1988). Other species that occur throughout the area are (in order of decreasing abundance): **Heteropogon contortus**, **Eragrostis racemosa**, **Tristachya leucothrix**, **Elionurus muticus**, **Setaria nigrirostris**, **Brachiaria serrata**, **Cymbopogon plurinodis**, **Eragrostis chloromelas**, **Eragrostis plana**, **Eragrostis capensis**, **Anthospermum pumilum** subsp. **rigidum** and **Digitaria diagonalis**.

The bulk of the study area comprises Veld Type 54, the Turf Highveld to Highland Sourveld Transition (Figure 3.1). This veld type is also dominated by **Themeda triandra**, but to a lesser degree than in the **Themeda** Veld (Acocks 1988). Other species that occur throughout the area are (in order of decreasing abundance): **Heteropogon contortus**, **Tristachya leucothrix**, **Harpochloa falx**, **Digitaria**

tricholaenoides, *Setaria flabellata*, *Elionurus muticus*, *Eragrostis racemosa*, *Microchloa caffra*, *Eragrostis capensis*, *Helichrysum rugulosum*, *Eragrostis chloromelas*, *Digitaria monodactyla*, *Andropogon appendiculatus*, *Brachiaria serrata*, *Eragrostis plana*, *Diheteropogon amplexans*, *Cymbopogon plurinodis*, *Andropogon schirensis* and *Aristida junciformis* subsp. *junciformis*. Acocks (1988) also mentions that a scrub forest of *Leucosidea sericea* occurs on mountain sides at the upper margin of this veld type.

The third veld type described for the study area is Veld Type 57, the North-Eastern Sandy Highveld (Near-Highland Sourveld Variation) (Figure 3.1). *Themeda triandra* is again described as being the dominant grass (Acocks 1988) and other species of general occurrence are (in order of decreasing abundance): *Tristachya leucothrix*, *Digitaria tricholaenoides*, *Heteropogon contortus*, *Eragrostis racemosa*, *Trachypogon spicatus*, *Microchloa caffra*, *Andropogon appendiculatus*, *Rendlia altera*, *Monocymbium ceresiiforme*, *Andropogon schirensis*, *Elionurus muticus*, *Brachiaria serrata*, *Alloteropsis semialata*, *Aristida junciformis* subsp. *junciformis*, *Harpochloa falx* and *Helichrysum rugulosum*.

A number of species of alien plants occur in the study area. Besides some small orchards of fruit trees near homesteads, there are wattle (*Acacia* spp.) and gum (*Eucalyptus* spp.) trees, usually planted as wind-breaks around homesteads but occurring elsewhere as well. Another alien plant usually associated with homesteads is the sweet prickly pear (*Opuntia ficus-indica*).

In the damper areas associated with rivers and streams there are some fairly extensive stands of the grey poplar (*Populus x canescens*) with the weeping willow (*Salix babylonica*) growing on many of the river and stream banks (Henderson & Musil 1987).

In the grasslands themselves, two alien species that have spread to occupy quite extensive areas are the shrub *Stoebe vulgaris* and the grass *Pennisetum villosum*.

The continued survival of a number of both plant and animal (see Section 3.2) species occurring in the study area is threatened (Skinner et al. 1977; Hall et al. 1980; Brooke 1984; Smithers 1986; Skelton 1987; Branch 1988b), primarily as a result of habitat destruction resulting from, e.g. agricultural and mining practices and industrialization (see Section 3.3). The threatened species are categorized as follows (Smithers 1986; Skelton 1987):

ENDANGERED (E): "Species in danger of extinction and whose survival is unlikely if the causal factors continue operating."

VULNERABLE (V): "Species believed likely to move into the Endangered category in the near future if the causal factors continue operating."

RARE (R): "Species with small or restricted populations which are not at present endangered or vulnerable but which are at risk."

INDETERMINATE (I): "Species that are suspected of being threatened but for which insufficient information is currently available."

OUT OF DANGER or SAFE (S): "Species formerly included in one of the threatened categories and which are now considered to be relatively secure".

Two plant species occurring in the study area are potentially at risk, both species being endemic to southern Africa (Hall et al. 1980):

- | | | |
|---|-------------------------------|------------------|
| I | <i>Nerine platypetala</i> | (Amaryllidaceae) |
| R | <i>Gladiolus robertsoniae</i> | (Iridaceae) |

3.2 **FAUNA**

A large variety of animals occur in the Amersfoort study area, two of which are considered to be in danger of extinction while the continued existence of numerous other species is at risk (Skinner et al. 1977; Hall et al. 1980; Brooke 1984; Smithers 1986; Skelton 1987; Branch 1988b) (see Section 3.1).

3.2.1 **FISH**

It is difficult to establish the number of fish species occurring in the Amersfoort area but ca 13 species are known to occur in the Vaal-Orange River system (Jubb & Farquharson 1965; Jubb 1967; Bowmaker et al. 1978), and the study area falls within the catchment area of the Vaal River (see Section 2.2.2). However, none of South Africa's threatened fish species is known to occur in the study area (Skelton 1987).

3.2.2 AMPHIBIANS

Twenty one species of amphibians (frogs and toads) are recorded in the study area (Passmore & Carruthers 1979), none of which are threatened (Branch 1988b).

3.2.3 REPTILES

One species of terrapin, 29 species of snakes and 14 species of lizards occur in the study area (Branch 1988a), of which two species are threatened and two species are out of danger (Branch 1988b):

R	Striped harlequin snake	<i>Homoroselpas dorsalis</i>
V	Giant girdled lizard	<i>Cordylus giganteus</i>
S	Rock or White-throated monitor	<i>Varanus exanthematicus</i>
S	Nile or Water monitor	<i>Varanus niloticus</i>

The reptiles have been named and arranged according to Branch (1988a).

Cordylus giganteus is protected in the Transvaal and individuals have been relocated to the nature reserve adjoining Majuba Power Station near Amersfoort (see Section 3.3.1), with the result that ca 1 500 *C. giganteus* burrows have been established in the reserve (Branch 1988b).

3.2.4 BIRDS

A total of ca 330 species of birds have been recorded in the general locality of the study area, of which ca 80% are breeding residents (Maclean 1985). The continued survival of 18 of these species is threatened and one species is out of danger (Brooke 1984):

R	Little bittern	<i>Ixobrychus minutus</i>
V	Bittern	<i>Botaurus stellaris</i>
R	White stork	<i>Ciconia ciconia</i>
I	Black stork	<i>Ciconia nigra</i>
R	Yellowbilled stork	<i>Mycteria ibis</i>
S	Bald ibis	<i>Plegadis falcinellus</i>
I	Greater flamingo	<i>Phoenicopterus ruber</i>

I	Lesser flamingo	<i>Phoenicopiterus minor</i>
V	Cape vulture	<i>Gyps coprotheres</i>
V	Martial eagle	<i>Polemaetus bellicosus</i>
R	Peregrine falcon	<i>Falco peregrinus</i>
E	Blackrumped buttonquail	<i>Turnix hottentotta</i>
E	Wattled crane	<i>Grus carunculata</i>
I	Baillon's crake	<i>Porzana pusilla</i>
I	African finfoot	<i>Podica senegalensis</i>
V	Stanley's bustard	<i>Neotis denhami</i>
I	Grass owl	<i>Tyto capensis</i>
I	House martin	<i>Delichon urbica</i>
V	Yellowbreasted pipit	<i>Anthus chloris</i>

The birds have been named and arranged according to Maclean (1985).

3.2.5 MAMMALS

Twelve of the ca 50 species of mammals recorded in the study area (Skinner et al. 1977; Rautenbach 1982; Smithers 1986) are threatened (Smithers 1986):

R	South African hedgehog	<i>Atelerix frontalis</i>
V	Rough-haired golden mole	<i>Chrysospalax villosus</i>
I	Sclater's golden mole	<i>Chlorotalpa sclateri</i>
I	Zulu golden mole	<i>Amblysomus iris</i>
V	White-tailed mouse	<i>Mystromys albicaudatus</i>
R	Aardwolf	<i>Proteles cristatus</i>
R	Brown hyaena	<i>Hyaena brunnea</i>
V	African wild cat	<i>Felis lybica</i>
R	Serval	<i>Felis serval</i>
R	Striped weasel	<i>Poecilogale albinucha</i>
V	Antbear	<i>Orycteropus afer</i>
V	Oribi	<i>Ourebia ourebi</i>

The mammals have been named and arranged according to Smithers (1983, 1986).

The European fallow deer (*Cervus dama*) is an introduced species (Smithers 1983) which occurs on many of the farms in the study area. According to local farmers the deer graze the planted crops (especially maize) and cause considerable crop damage.

3.3 ANTHROPOGENIC INFLUENCES

3.3.1 LAND USE

It is estimated that 40-50% of the study area is under cultivation (South Africa, 1:50 000 Sheet 1970, 1971, 1976, 1979), with maize being the main crop, but other crops such as grain sorghum, sunflowers, winter wheat and beans are also grown. Some planted pastures, e.g. *Eragrostis curvula* and *Eragrostis tef*, are maintained, but domestic livestock are predominantly supported by the natural pasturage. The most common domestic animals are cattle (beef and dairy) and Merino sheep, with some farmers maintaining game such as blesbok and ostriches as well.

In the western section of the study area a large power station (Majuba Power Station) is being built, and as a result of the construction of roads, dams and buildings, plus quarrying activities and ashing sites, much of the natural vegetation has been destroyed in this area. A 300ha nature reserve in the **Themeda** Veld has, however, been declared on this land. Coal mining also occurs in the study area but the destruction of the natural vegetation is on a far smaller scale than in the case of the power station.

3.3.2 FIRE

Fire, started either by lightning or by man, and grazing, either by wild or domestic animals, are pressures with which the grasslands of South Africa have co-evolved (Scott 1970; Daubenmire 1974; Tainton 1981, 1984; Stuart-Hill & Mentis 1982; Trollope 1989).

The grasslands of Amersfoort are fire climax vegetation (as opposed to climatic climax vegetation) (Tainton 1981) where fire (together with grazing) maintains the grass cover and prevents the establishment of shrubs and trees. Fire has long been a tool used by the pastoralist in the management of his vegetation but its use has also been seriously abused, resulting in the deterioration in the condition of the vegetation (Tainton 1981; Trollope 1989). The principle misuse of fire has been the practice of burning the veld to obtain green growth for out-of-season grazing (Tainton 1981; Trollope 1989). This practice has the effect of reducing the vigour, canopy cover and basal cover of the grass vegetation, as

well as of increasing the run-off of rain and increasing soil erosion (Trollope 1989).

The judicious use of fire can, however, be highly advantageous to the vegetation. In the sour grasslands many of the grasses mature rapidly and become unpalatable relatively early in the growing season (Tainton 1981), with the result that by the end of the season there may be an accumulation of material that is unacceptable to the grazers. Fire may then be used to remove such material and also to prevent the grasses from becoming moribund (Trollope 1989).

CHAPTER 4

METHODS AND PROCEDURE4.1 PHYTOSOCIOLOGICAL CLASSIFICATION

Plants are seldom distributed in a completely random manner (Becking 1957; Greig-Smith 1964; Kershaw 1964; Daubenmire 1968). Groups of species tend to occur in association with each other, as determined by each species' range of ecological tolerance and its interactions with other plants growing near it. A phytosociological classification seeks to investigate the interrelationships between plant species and to determine the pattern of their distribution by defining and describing the distinctive plant communities that are formed by specific species combinations.

The classification of the vegetation was based on the Braun-Blanquet (1932) approach, modified from the descriptions of the methodology given by Mueller-Dombois & Ellenberg (1974), Werger (1974), Westhoff & van der Maarel (1978), Bredenkamp (1982), Coetzee (1982) and Deall (1988). This approach was advocated by the Ecology Division of the former Botanical Research Institute in Pretoria (most of the personnel of which are now associated with the Grassland Research Centre in Pretoria), to ensure that the results of different surveys are directly comparable (Tainton 1984), and has been used by many researchers in South Africa (e.g. Werger et al. 1972; Werger 1973; Coetzee 1974, 1975; Coetzee et al. 1976; Bredenkamp & Theron 1978, 1980; Westfall 1981; McDonald 1983; Westfall et al. 1983; Deall 1985). It has been found that the method works well, identifying communities that show a good correlation with specific environmental conditions, so producing a sound ecological classification of the vegetation (Werger et al. 1972; Werger 1974; Bredenkamp & Theron 1978; Westfall et al. 1983).

The procedure followed in a phytosociological classification comprises two phases. The first phase is the analytical phase, when floristic and environmental data are collected in the field. These data are classified during the synthetic phase, to result in the delimitation of communities based on their floristic similarities and differences. The communities are then ordinated along environmental gradients (Moore et al. 1970; Westfall et al. 1983; Deall 1985;

Bloem 1988) to determine the chief environmental factors contributing towards the differentiation of each community.

4.2 ANALYTICAL PHASE

4.2.1 RECONNAISSANCE

In the Braun-Blanquet approach, as originally postulated, sampling sites are chosen subjectively and hence considerable emphasis is placed upon doing a thorough reconnaissance of the study area prior to the initiation of sampling (Braun-Blanquet 1932; Cain & Castro 1959; Mueller-Dombois & Ellenberg 1974; Knapp 1984). Having done the reconnaissance, a phytosociologist is then able to choose his sampling sites confident that all of the communities represented in the area have been sampled. Since in this study sampling sites were chosen completely objectively, a reconnaissance for the above reasons was not necessary. The emphasis was laid, rather, on a general familiarization with the study area and its landscape, and the period of one growing season was used to become familiar with and to make collections of the local flora. A good working knowledge of the flora, and in particular the grass flora, was thus acquired. Sampling trials to determine the sampling procedure to be used during the survey were also conducted during this period.

4.2.2 SAMPLING STRATEGY

The approach whereby sampling sites are chosen subjectively (Braun-Blanquet 1932) has been both criticized and endorsed (Poore 1955; Becking 1957; Werger 1974). The critics point to personal bias and preconceived ideas that may disadvantageously affect the final classification, and the proponents claim that subjective sampling (without preconceived ideas) produces results that are not dissimilar from those obtained by more objective methods (Coetzee & Werger 1973; Mueller-Dombois & Ellenberg 1974). The current trend in phytosociological work in South Africa is, however, towards using more objective methods (e.g. Theron 1973; Coetzee 1974, 1975; Bredenkamp & Theron 1978; Westfall 1981; Craig 1983; Deall 1985; Bloem 1988), such as random, systemic or stratified random sampling.

The disadvantage of strictly random sampling is that this approach may result in the over-sampling of some vegetation types and the under-sampling or the exclusion of other vegetation types (Moore et al. 1970). The advantage is that random sampling allows the calculation of mean values and any variation can be tested for significance using statistical tests (e.g. the standard error of the mean) (Greig-Smith 1964; Mueller-Dombois & Ellenberg 1974).

Systemic sampling is objective but over-sampling may occur and no measure of the precision nor the significance of any variation may be made (Greig-Smith 1964).

A stratified random sampling method was thus used, since it is more precise than strictly random sampling (Cain & Castro 1959) yet combines the best features of strictly random and strictly systemic sampling (Mueller-Dombois & Ellenberg 1974). With stratified random sampling over-sampling and under-sampling or the exclusion of certain vegetation types is less likely to occur, and the data may still be subjected to statistical tests (Greig-Smith 1964). Mueller-Dombois & Ellenberg (1974) advocate the use of random sampling when "vegetation patterns are non-distinct or unclear". This is largely the case in grassland vegetation which generally has a rather uniform physiognomy and where changes in species composition tend to be less obvious than in e.g. bushveld or forest, where the larger and more distinctive bushes and trees allow more rapid visual detection of major changes in the species composition. The incorporation of randomness into the sampling strategy is thus considered appropriate.

4.2.2.1 Stratification of the study area

Aerial photographs were not used to stratify the study area as has been done by some recent workers (e.g. Coetzee 1974, 1975; Morris 1976; Bredenkamp & Theron 1978; Westfall 1981; Craig 1983; Bloem 1988). A physiognomic-physiographic stratification (after Ludick pers. comm.¹) of the aerial photographs for the study area resulted in an excessively high number of small stratification units, which was not in keeping with the working scale of the study (1:100 000 scale).

A more broad-scale stratification was therefore used, comprising a combination of the land type and geological maps for the study area, which gave 15 different stratification units. The combined factors of climate, terrain form and soil types (from the land type maps), and geology were considered to constitute a reasonable first approximation of likely plant community boundaries since

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previous studies have indicated the rôle of such factors in delimiting communities (Coetzee 1974; Westfall 1981; McDonald 1983; Bezuidenhout 1988).

4.2.2.2 Size of the sample stands

In accordance with the 1:100 000 working scale the stand size was calculated (Rutherford & Westfall 1986) to have an area of ca 3ha, which is equivalent to a circular area with a radius of 100m.

4.2.2.3 Location of the sampling sites

Sampling sites were located by plotting random pairs of numbers generated by the PHYTOLOC program (Westfall 1986) in the form of degrees of latitude and longitude, using a 4mm grid on the relevant 1:50 000 maps (South Africa, 1:50 000 Sheet 1970, 1971, 1976, 1979) of the study area (Rutherford & Westfall 1986). Extra sampling sites were generated and plotted so that unsuitable sites could be excluded from sampling (e.g. sites falling in areas under cultivation, on roads, within homesteads or within the town of Amersfoort). The numerical order in which the sampling sites were generated by PHYTOLOC was recorded on the maps.

Insufficient sampling sites were located in some of the smaller stratification units, and in these instances extra random numbers were plotted. A numerical grid was overlain over an outline of the stratification units concerned and random numbers were plotted and their numerical order recorded, until sufficient extra points fell within the units. These points were then transferred to the 1:50 000 maps.

Within each stratification unit sampling sites were sampled in the numerical order in which they were generated, until sufficient stands had been sampled. A minimum of five stands were sampled in the smaller stratification units and a maximum of ten stands were sampled in the larger units. A total of 127 stands were surveyed during the survey.

4.2.2.4 Sub-samples

A sub-sampling procedure was used since sampling trials indicated that a series of sub-samples, comprising a number of randomly situated small quadrats, were more efficient than a single, large quadrat in terms of the amount of information gathered (number of species recorded) for the area studied.

TABLE 4.1 The percentage of the total number of species expected to occur in an area of 1ha that were recorded in successive sub-samples of increasing total area, at seven different sampling sites during sampling trials in Amersfoort.

SUB-SAMPLE NUMBER	TOTAL SUB-SAMPLE AREA	SAMPLING SITE NUMBER							MEAN PERCENTAGE RECORDED
		1	2	3	4	5	6	7	
1	2m ²	14	13	15	18	21	13	15	16
2	4m ²	18	18	22	21	32	20	18	21
3	6m ²	19	18	26	29	34	23	23	26
4	8m ²	19	18	27	31	35	27	24	26
5	10m ²	23	24	31	33	41	36	26	31
6	12m ²	25	27	32	35	41	36	29	32
7	14m ²	28	29	34	35	41	36	30	33
8	16m ²	28	31	35	37	42	36	32	34
9	18m ²	35	33	36	38	44	36	34	37
10	20m ²	35	35	38	39	44	36	36	38
11	22m ²	39	37	40	40	44	36	39	39
12	24m ²	40	39	40	41	45	36	42	40

A rectangular rather than a square quadrat was used since the former is generally accepted to be significantly more efficient (Oosting 1956; Cain & Castro 1959; Knapp 1984) and there is less variance between rectangular quadrats than there is between square quadrats (Greig-Smith 1964). If a rectangular quadrat is used an area of approximately half the size of a square quadrat need be examined to record the same number of species (Oosting 1956).

Werger (1972) states that the total number of species calculated to occur in a stand of vegetation 1ha in size represents the 100% information level, and the percentage of information recorded when sampling a part of the stand can then be calculated. The levels of information recorded in successive sub-samples at Amersfoort are shown in Table 4.1.

During the sampling trials a 1m x 2m (2m^2) quadrat was used. For the survey, however, a slightly larger quadrat of 1,5m x 3m ($4,5\text{m}^2$) was used in order to reduce the edge effect of the quadrat (Cain & Castro 1959; Greig-Smith 1964; Kershaw 1964; Knapp 1984; Westfall et al. 1987). A minimum of three sub-samples were examined per stand since the sampling trials (Table 4.1) indicated that three of the $4,5\text{m}^2$ sub-samples (totalling $13,5\text{m}^2$) would detect approximately 33% of the species expected to occur in 1ha. This was considered to give an adequate representation of the vegetation of the stand.

4.2.2.5 The sub-sampling procedure

The sampling sites plotted on the 1:50 000 maps were taken as representing the center of the stand to be sampled. In the field this point was located as accurately as possible and marked with a pole, and the quadrat for the first sub-sample was located at this point. All quadrats were orientated such that the long axis was parallel to the slope of the stand, i.e. perpendicular to the contour lines (Cain & Castro 1959; Greig-Smith 1964; Westfall et al. 1987).

The positions of the quadrats for subsequent sub-samples were determined using a set of random number pairs generated by PHYTOLOC (Westfall 1986), with the random numbers restricted to prevent any sub-samples being placed outside of the 100m stand radius. From the central pole, the distance (first random number) was paced (in approximately meter-long steps) in the given compass direction (second random number), thus locating the position of the quadrat. This procedure was repeated to position the quadrat for each sub-sample.

When sampling a list was made of all of the species in each quadrat (sub-sample). If the number of new species recorded in the third sub-sample was less than 10% of the total number of species recorded in the two preceding sub-samples, sampling was stopped. If more than 10% new species were recorded, sampling continued until a sub-sample contained less than 10% new species (Westfall et al. 1987).

4.2.3 DATA RECORDED

4.2.3.1 Stand data

A colour slide was taken of a representative section of the vegetation of the stand. The following data were recorded to give an average representation of conditions pertaining to the whole sampling stand.

1. Relevé number and Date

2. Location

The grid reference, precise locality in degrees, minutes and seconds of latitude and longitude, and the farm name were recorded from the 1:50 000 maps for the study area (South Africa, 1:50 000 Sheet 1970, 1971, 1976, 1979).

3. Altitude

Altitude to the nearest 50m was recorded from the 1:50 000 maps for the study area (South Africa, 1:50 000 Sheet 1970, 1971, 1976, 1979).

4. Veld type

Recorded from an enlargement of Acocks' (1970) 1:1 500 000 map of the veld types of South Africa.

5. Land type

Recorded from enlargements of the 1:250 000 land type maps for the study area (Land Type Series 1979a, 1979b, 1979c, in prep.).

6. Geology

Recorded from an enlargement of the 1:1 000 000 geological map of South Africa (South Africa, Geology 1970).

7. Vegetation formation

Edwards' (1983) system for vegetation classification was used.

8. Rock type

Where rock outcrops were present, the rock type was recorded.

9. Geomorphology

The geomorphological classification system of Scheepers (1988) was followed. The landscape is divided into two major classes, namely facets (planes) and segments (curves). Further sub-divisions are made according to the position in the landscape (uplands and bottomlands) and the magnitude of the slope (flats, slopes and cliffs). Within these sub-divisions distinction is made between e.g. scree, talus and detrital slopes, and between wet and dry bottomland flats and floodplains.

10. Degree of exposure

Rated according to the following scale:

- 0: very sheltered :narrow kloof
- 1: :flat land enclosed by high land
- 2: :open flat land
- 3: :intermediate slopes
- 4: :high land
- 5: highly exposed :summit

11. Land use

Whenever possible, a record was made as to the types of animals (e.g. cattle and sheep) that had been utilizing the vegetation.

12. Grazing

Rated according to the following scale:

- 0: no grazing evident
- 1: selectively grazed (short.)
- 2: evenly grazed
- 3: heavily grazed (very short)

13. Fire

A record was made of whether there were any signs of the stand having been burnt.

14. Browsing

A record was made of whether there were any signs of the vegetation having been browsed, when applicable.

15. Erosion

Rated according to the following scale:

- 0: no signs of erosion
- 1: sheet erosion
- 2: donga erosion
- 3: donga and sheet erosion

16. Total cover

The canopy cover of all vegetation strata (combined) in the stand was measured using a cover meter (Westfall & Panagos 1984) which uses the Domin-Krajina (Mueller-Dombois & Ellenberg 1974) cover-abundance scale.

17. Vegetation stratification

The vegetation strata were described according to Edwards' (1983) system of structural classification. The dominant and characteristic species in each of the height strata were recorded, together with the total canopy cover for each stratum, measured with a cover meter (Westfall & Panagos 1984).

18. Percentage rock cover

The total percentage rock cover for the whole stand was estimated.

4.2.3.2 Quadrat data

The following data were recorded separately for each of the sub-samples examined.

1. Aspect

The aspect was measured in degrees along the line of the long axis of the quadrat, using a Suunto compass. Measurements were corrected for an 18° magnetic declination west of true north.

2. Slope

The slope was measured in degrees along the line of the long axis of the quadrat, using a Suunto inclinometer.

3. Percentage rock cover

The percentage rock cover within the quadrat was estimated.

4. Litter

The average depth and the percentage litter cover within the quadrat was estimated.

5. Soil data

The soil was sampled using a Johnson's soil auger with either an open or a closed bucket head. The sample was taken immediately outside the quadrat, and always positioned at the same corner of the quadrat.

Soil form

The soil form was identified using the soil classification system of MacVicar et al. (1977).

Soil colour

Determined for each horizon, using Munsell Soil Color Charts (1954).

Soil texture

Determined for each horizon, using the "sausage" method (Agricultural Extension, Highveld Region 1985; Technical Note EC 9 1986).

Soil depth

The depth to bedrock or to a maximum depth of 1,2m was determined for each soil profile. The depth of each horizon was also recorded.

Where soils were too shallow to allow augering (e.g. Mispah soils) the depth was measured using a depth spike, to a maximum depth of 270mm. One reading was taken at each corner of the quadrat (within the quadrat) and one was taken in the center of the quadrat, and the average depth was recorded.

Depth of watertable

When present, this depth was recorded from the auger hole.

6. Floristic list

A complete list of the permanently recognizable species rooted within each sub-sample was made. An estimate of cover-abundance, using the Domin-

Krajina scale (Mueller-Dombois & Ellenberg 1974), was noted for each of the species recorded. When a species could not be identified in the field it was collected for later identification, either personally or by the staff of the National Herbarium, Pretoria (PRE). In such instances, the collection number of the species was recorded in the floristic list.

4.2.3.3 Relevé and sub-sample relevé data

The data were loaded onto the computer in two different ways:

A. Relevé data

The stand data for each relevé were loaded unaltered, but the quadrat data for all of the sub-samples done at one stand were combined. Mean values of the sub-sample data were calculated, except in the following instances:

Aspect: Degrees aspect were converted to vectors and the mean vector was calculated using the computer program HABIMEAN (Westfall pers. comm.²). The mean vector was then converted to degrees aspect.

Soil form: All of the soil forms identified at one stand were retained.

Soil colour: All of the soil colours identified at one stand were retained.

Soil texture: The mean soil texture was determined using the midpoint values of each soil texture class interval.

Floristic list: The data of all of the sub-samples for one relevé were combined, resulting in each relevé having a single species list and one cover-abundance value. Where one species occurred in two or more sub-samples of the relevé, the cover-abundance values were averaged using the class midpoints of the Domin-Krajina scale (Westfall 1981).

B. Sub-sample relevé data

It became necessary (see Section 4.3.3) to load the data such that each sub-sample represented a separate relevé. All of the sub-samples of one of the original relevés therefore had the same stand data but differed with respect to their quadrat data (see Sections 4.2.3.1 & 4.2.3.2).

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4.3 SYNTHETIC PHASE

Two different methods of data analysis, namely classification and ordination, were used to synthesize the data, with the assistance of the computer programs PHYTOTAB - a package of numerous different programs (Westfall et al. 1982; Westfall & de Wet 1988; Westfall in prep.), TWINSpan (Hill 1979b) and DECORANA (Hill 1979a).

4.3.1 CLASSIFICATION

In classificatory procedures floristically similar relevés are grouped together to form discrete units (communities) that are identified by diagnostic species. Diagnostic species are species whose distribution is restricted to one community, or species that occur predominantly in one community (Greig-Smith 1964; Grunow et al. 1969; Whittaker 1978).

In order to classify the field data, the two computer programs that were used the most frequently were PHYTO21 and TWINSpan (Two-way Indicator Species Analysis: Hill 1979b). Both of these programs employ a polythetic divisive technique whereby the entire data set is examined and then divided into successively smaller groups, based on floristic criteria (the presence and absence of species, although TWINSpan can also analyze quantitative values). Both the relevés and species are classified and are put into a specific order (Noy-Meir 1973; Hill 1979b; Greig-Smith 1980; Gauch & Whittaker 1981; O'Connor & Campbell 1986; Westfall & de Wet 1988).

The difference between PHYTO21 and TWINSpan is that PHYTO21 performs a rudimentary classification, with the number of divisions restricted to the formation of three groups only. Refinement of the ordering of the relevés and species in these groups to form smaller groups must then be done manually. TWINSpan performs a complete classification. A repeated dichotomization of the data results in a hierarchical division of all groups into the smallest groups that can be distinguished by TWINSpan. It is also possible for the user to stipulate to what level of divisions TWINSpan should proceed (Hill 1979b; O'Connor & Campbell 1986; van der Maarel et al. 1987).

In addition to PHYTO21 the PHYTOTAB program package also contains an automatic classification program, PHYTO23, that produces a complete classification of the data, similar to that of TWINSpan. The difference between PHYTO23 and TWINSpan is that PHYTO23 uses an agglomerative technique (Westfall pers. comm.). All units (relevés or stands) are considered individually and similar units are grouped together to form successively larger groups. PHYTO23 orders both relevés and species.

The PHYTOTAB package comprises numerous different programs, of which the following were used: PHYTO10, PHYTO30, PHYTO40, PHYTO50, PHYTO60 (Westfall et al. 1982); PHYTO15 and PHYTO21 (Westfall & de Wet 1988) and PHYTO23 and PHYTO39 (Westfall in prep.). The different functions of these programs are as follows:

PHYTO10: Checks and edits raw data, and prints the initial species/relève matrix or raw table.

PHYTO15: Allows the user to extract specified relevés and species from the original data file. By running PHYTO10 a new, separate raw data file and matrix for the selected relevés and species is produced. Other programs may then be run on this data to refine the arrangement.

PHYTO21: Creates a preliminary classification with the relevés divided into three groups with their diagnostic species, as well as species common to any two groups and species common to all of the groups. The table/matrix is printed using PHYTO30.

PHYTO23: Automatically produces a final classification from the raw data, identifying numerous relève groups with their diagnostic species, species common to two or more groups, and species common to all groups. The user may specify the minimum number of relevés that may be used to form a community, e.g. a minimum of 2, 4 or 6 relevés. The table/matrix is printed using PHYTO30.

PHYTO30: Prints a table/matrix according to a user specified sequence of relevés and species, or it uses files generated by PHYTO21 or PHYTO23 that specify these sequences.

PHYTO39: Correlates communities with specific environmental parameters once all of the environmental data for each relève have been loaded.

PHYTO40: Prints the final table in a form suitable for publication, incorporating headings and descriptions.

PHYTO50: Produces a synoptic table from the finalized matrix in which communities have been delineated. All of the relevés in a community are reduced to one column where the cover-abundance values for each species is expressed as a

percentage constancy code. This code is calculated by expressing the number of relevés of the community in which a species occurs as a percentage of the total number of relevés in that community. For species occurring in 0-<20% of the relevés of a community, the percentage constancy code is 1. Similarly, species in 20-<40% of the relevés have a code of 2 and species in 80-100% of the relevés have a code of 5. A blank is used where a species is absent.

PHYTO60: Converts the data used for the PHYTOTAB programs into a format that allows the user to run the programs DECORANA and TWINSpan on the original data.

The PHYTOTAB programs are used to produce a phytosociological table comprising a species/relevé matrix. The species are situated down the left hand side of the matrix with the relevés across the top of the matrix. Within the matrix, each relevé is represented by a column, each species by a row, and the cover-abundance value for a given species in a given relevé is reflected in the body of the matrix.

The objective of a classification and hence the phytosociological table is to group together the relevés that are floristically the most similar. A measure of the success of such groupings is given by the total number of separation units in a phytosociological table, where "the spaces between the first and last occurrence of a species in a phytosociological matrix are regarded as separation units" (Westfall & de Wet 1988). The lower the total number of separation units for the whole table, the better the arrangement of the relevés since the most similar relevés will then be positioned close to one another.

4.3.2 ORDINATION

The data were ordinated using the computer program DECORANA (DEtrended CORrespondence ANalysis: Hill 1979a). DECORANA is a direct, multivariate, eigenvector technique (Whittaker & Gauch 1978; Hill 1979a; Hill & Gauch 1980; Whittaker 1987) that uses a re-iterative weighting procedure for axis construction (Hill 1979a; Whittaker 1987). The superiority of the DECORANA ordination over other ordination techniques lies in the fact that:

- a) there is no relationship between the first axis and any of the other axes since the other axes are formed completely independently of the first axis (Hill 1979a; Hill & Gauch 1980; Whittaker 1987)

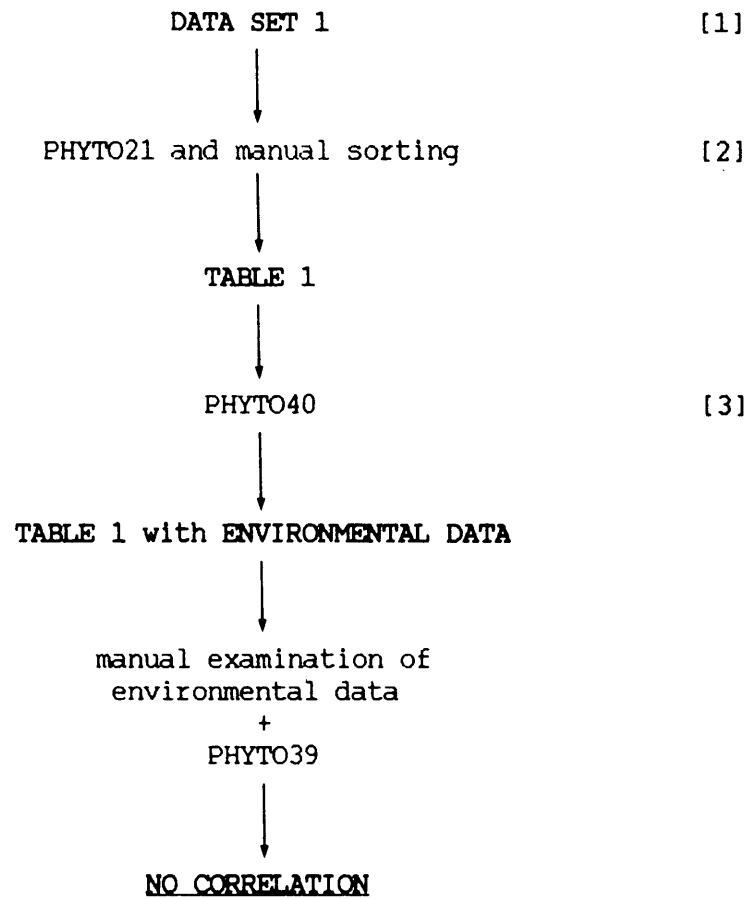


FIGURE 4.1 Flow chart of data synthesis procedure, steps 1 - 3 of section 4.3.3 [the step number is indicated in parentheses].

- b) in axis construction there is no distortion of the relative distances between stands or species, since the distances along the axes correspond, or are equal, to the differences in species composition along the environmental gradient that the axis represents (Greig-Smith 1964; Grunow et al. 1969; Whittaker 1978; Hill 1979a; Hill & Gauch 1980; Whittaker 1987).

The DECORANA ordination, which has been described as "the best general purpose technique now available for ecological data" (Hill 1979a; Hill & Gauch 1980; Gauch & Whittaker 1981), is considered to be the ideal supplement to the classification since it permits ecological interpretation of the data (relevés or the communities determined by the classification) (Hill 1979a; Hill & Gauch 1980; Lahti & Väisänen 1987). The interpretation of the DECORANA output is described in Chapter 6.

4.3.3 PROCEDURE FOLLOWED DURING DATA SYNTHESIS

1. The species data for the 127 relevés were loaded onto a Burroughs B7900 computer of the Department of Agriculture and Water Supply, and PHYTO10 was run. The necessary corrections were made until there were no mistakes in the raw data set (Data Set 1: Figure 4.1). These data were then checked against the field records to ensure that all entries were correct.
2. PHYTO21 was run to obtain a preliminary classification, with the relevés divided into two large groups and one smaller group. PHYTO21 was run separately on each of the two larger groups (using PHYTO15) to refine the classification. Extensive manual sorting, facilitated by the use of a tabellar marker (Müller et al. 1972), was then necessary for further refinement of the table (Table 1).
3. Once the table had been finalized, the environmental data were loaded and by using PHYTO40, a table incorporating both the floristic data and the environmental data was produced. Examination of the environmental data for each community showed that there was no correlation between the communities and their environmental parameters. PHYTO39 was also run on the data, with the same result.

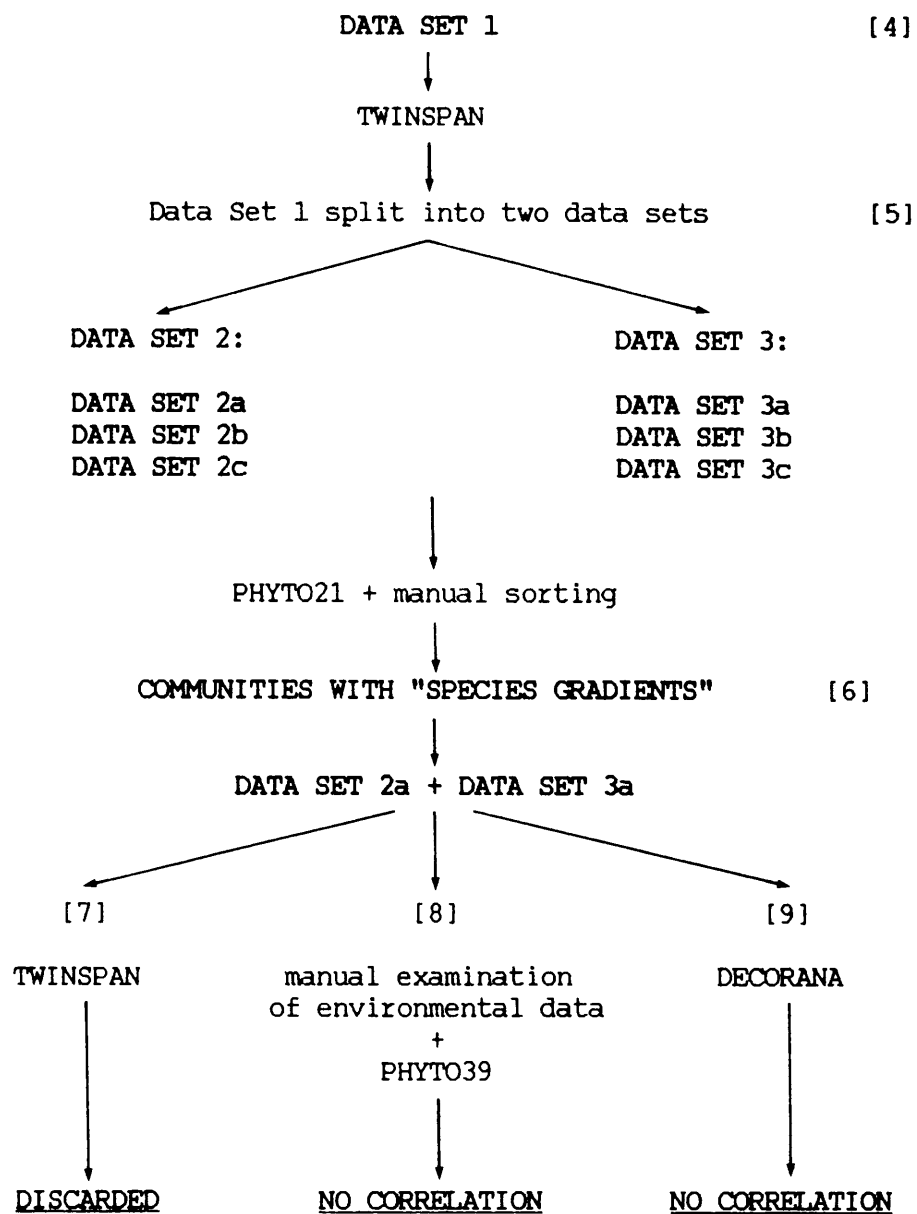


FIGURE 4.2 Flow chart of data synthesis procedure, steps 4 - 9 of section 4.3.3 [the step number is indicated in parentheses].

4. In an attempt to obtain a better classification, TWINSpan was run on Data Set 1 (Figure 4.2), resulting in a very clear division of the data into two large groups, which were then further sub-divided.

5. On the basis of TWINSpan's first division, Data Set 1 was divided into two separate data sets, Data Sets 2 and 3. In the original data split performed by TWINSpan (Step 4), two relevés were immediately separated from the remainder of the relevés, which indicated that these two relevés (relevés 83 and 84) were in some respect "very different" from all of the other relevés. In order to determine into which data set these relevés would best fit, the following data sets were created:

a) Data Set 2 with relevé 83 and Data Set 3 with relevé 84

b) Both Data Sets 2 and 3 with both relevés 83 and 84

c) Both Data Sets 2 and 3 with neither relevé 83 nor relevé 84

This resulted in the formation of six different data sets. Both species and environmental data were re-loaded for these data sets, and six different tables were produced by running PHYTO21 and by manual sorting (as described in Step 2).

6. It was not possible in any of the six tables to form distinct communities that were identified by a number of diagnostic species that occurred in all or most of the relevés within the community. Rather, most of the communities were diagnosed by a number of species that only occurred in a few of the relevés of the community, forming a "species gradient" (Table 4.2). Community definition was thus not very good.

7. In an attempt to improve community definition, TWINSpan was run on each of the two data sets described in Step 5a (i.e. Data Sets 2a and 3a). TWINSpan's relevé order and group limits were used to form two new tables, and diagnostic species were established for each of the communities. In both tables the TWINSpan analysis resulted in the formation a small number of large communities that were poor in diagnostic species, and those species that were diagnostic occurred in "gradients" (Table 4.2) within each of the communities. For this reason, the TWINSpan classification was discarded and attention was returned to the two manually sorted tables described in Step 5a.

TABLE 4.2 Example of a community in a phytosociological table with a "species gradient".

SPECIES	R E L E V E S														
	2	1	1		3		2	1	1			1		3	
	1	4	5	3	8	8	6	7	2	0		5	2	8	
	1	5	3	4	4	4	9	6	0	1	6	4	2	7	9
Themeda triandra	5	4	5												
Helichrysum rugulosum				2	2										
Aristida bipartita					1	+	+								
Heteropogon contortus							3		3	4					
Hermannia cristata		+							+	+					
Solanum panduriforme										1	1				
Berkheya setifera							+		2	1					
Pelargonium luridum		+								1		+			
Setaria nigrirostris						2	1					+		1	

8. Examination of the environmental data (manually and using PHYTO39) for Tables 2a and 3a showed a lack of correlation between the communities and their environmental parameters.
9. In a further attempt to correlate the communities with environmental parameters, DECORANA was run on the two data sets, Data Sets 2a and 3a. All of the six possible axis combinations from the first four DECORANA axes were used, and the positions of the relevés were plotted on these axes (see Chapter 6). The different communities and the values of various environmental parameters were superimposed on each plotted relevé position to determine if any environmental gradients or groupings could be established. The following were plotted:
 - a) the different communities formed in the final tables of the Data Sets 2a and 3a (Step 6), to determine whether DECORANA supported TWINSpan's relevé groups
 - b) the occurrence of the species upon which the initial division of TWINSpan was based (Step 4), to determine whether the DECORANA plot also grouped the relevés based on the same species
 - c) the relevés were divided into four major localities (N, S, E, W) and the locality of each relevé was super-imposed on the DECORANA plot, to determine whether there was any correlation between locality and the DECORANA plot
 - d) the following environmental parameters were plotted: altitude, rainfall, geology, minimum soil depth and slope, to determine whether the DECORANA plot could be correlated with any of these parameters

The DECORANA analysis did not support any of the communities formed, nor were there any obvious groupings or gradients of the environmental parameters.
10. At this stage the automatic classification program PHYTO23 was developed. PHYTO23 was then run on the original data set (Data Set 1: Figure 4.1). Several tables were produced, where 2, 4, 6, 8 and 12 relevés were specified as being the minimum number of relevés per community (see Section 4.3.1).

A large number of communities were delineated in each of these tables, but most of them were defined by the presence of one species only, and not all of the relevés included in a community recorded the diagnostic species for that group. Although these were not considered to be very satisfactory classifications, the environmental data were examined manually and PHYTO39

was run on all of these tables, but no correlation was established. In addition to this, DECORANA was run on the table with a minimum of four relevés per community, but the DECORANA analysis did not support the classification.

11. Since none of the above procedures had produced an acceptable classification of the data, an attempt was made to force the classification by arranging the relevés into pre-determined groups, and then by means of diagnostic species, to further refine the table. The relevés were arranged according to geological groups and in order of increasing altitude. These environmental factors were used since they were considered to be the factors most likely to form the basis of a broad division of the data into major groups. The classification of each of these two tables was refined using PHYTO15, PHYTO21 and by manual sorting. It was found, however, that the major groups were poor in diagnostic species and that the classifications were unacceptable.
12. By combining all of the data from the sub-samples of each relevé (see Section 4.2.3.3), the relevés were heterogeneous with respect to their species and environmental data. In many relevés one or more of the sub-samples had few or no species in common with the other sub-samples of the relevé. Furthermore, the different sub-samples of a relevé frequently occurred on different soil forms and had e.g. different soil depths, slopes and aspects. It was decided that this heterogeneity could be responsible for the lack of environmental correlation with the communities, and it was hoped that by considering each sub-sample as representing a separate relevé, a better classification could be obtained. A trial was done, where the data for one community identified in a previously discussed table were re-entered as sub-sample data. These data were classified using PHYTO21 and by manual sorting, and the result was that the communities formed were better defined in terms of their diagnostic species and there was a far superior correlation with environmental parameters.
13. The data for all 127 relevés was then re-loaded as sub-samples, resulting in 507 sub-sample relevés (Data Set A, Figure 4.3). The data for each sub-sample relevé were checked against the field records to ensure that all entries were correct.

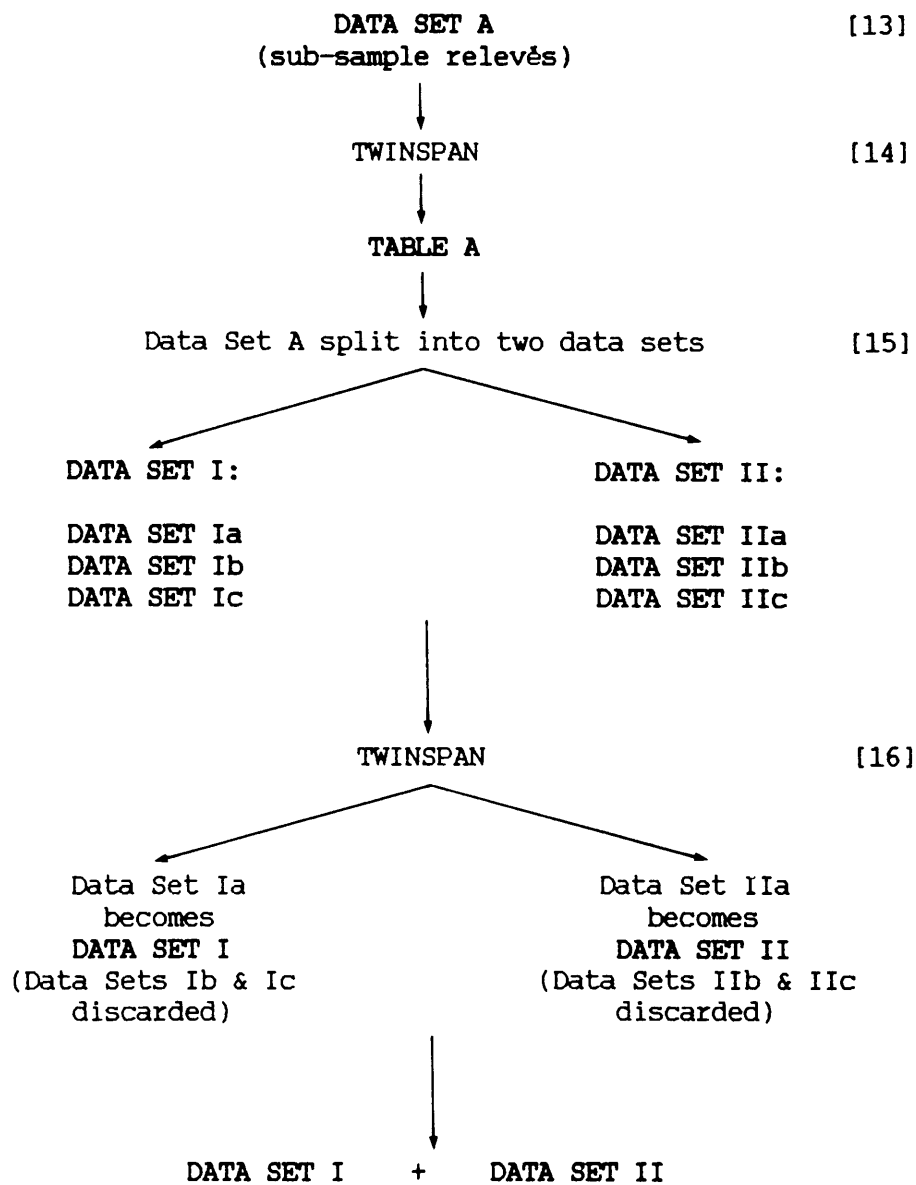


FIGURE 4.3 Flow chart of data synthesis procedure, steps 13 - 16 of section 4.3.3 [the step number is indicated in parentheses]

14. TWINSpan was run on Data Set A and a table (Table A) was generated with the sub-sample relevés in the order determined by TWINSpan. Diagnostic species were established for the communities.
15. The most striking feature of Table A related to TWINSpan's first division of the sub-sample relevés into two groups. These two groups were supported by the fact that a number of species had a strong presence (often with high cover-abundance values) in the one group, but were completely absent, or nearly so, in the other group. On this basis Data Set A was split in two (Data Sets I and II) and the data were re-loaded.

As was found when TWINSpan was run for the first time (Step 5), when TWINSpan was run on the entire sub-sample relevé data set some "very different" sub-sample relevés were immediately separated from all of the other sub-sample relevés. These "very different" sub-sample relevés were the sub-samples comprising the original relevés 83 and 84 (Step 5). A similar approach to that used in the previous instance was used with these data and the following data sets were created:

- a) Data Set I with the sub-sample relevés from the original relevé 83, and Data Set II with the sub-sample relevés from the original relevé 84
- b) Both Data Sets I and II with both groups of sub-sample relevés
- c) Both Data Sets I and II with neither of the two groups of sub-sample relevés

16. TWINSpan was run on all three variations of Data Sets I and II. It was found that in all instances the "very different" sub-sample relevés were maintained as separate groups and that they did not affect the groupings or divisions of the remaining sub-sample relevés. For this reason, the two data sets described in Step 15a were retained for further usage, and are hereafter referred to as Data Sets I and II, with their respective Tables I and II.
17. PHYTO21 was run on Data Sets I and II (Figure 4.4) and in both instances two large groups and one small group were formed. The large groups were poor in diagnostic species and many of the sub-sample relevés in these groups did not have any of the diagnostic species. When PHYTO21 was run separately on each of the large groups, a similar result was obtained, and this method of refining the classifications was therefore discarded.

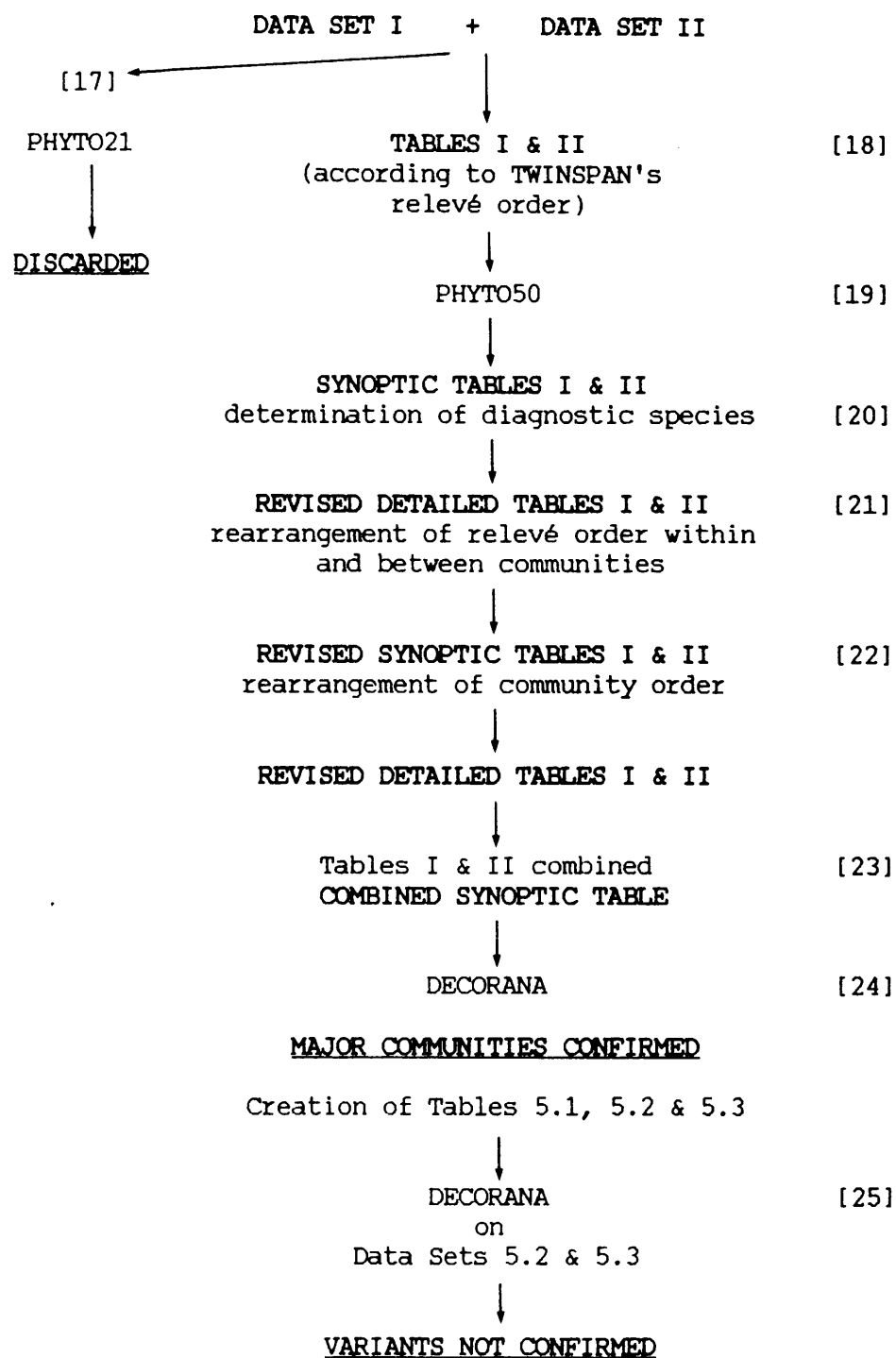


FIGURE 4.4 Flow chart of data synthesis procedure, steps 17 - 24 of section 4.3.3 [the step number is indicated in parentheses].

18. A table was produced for each data set with the relevés in the order given by TWINSpan (Step 16), using PHYTO30. This was done in order to find diagnostic species for each community and to improve the classification by manual means. It was found, however, that the size of the tables made visual assessment and manual sorting extremely difficult (after a final decision was made with respect to the placement of the "very different" sub-sample relevés, Table I had 352 sub-sample relevés and Table II had 155 sub-sample relevés).
19. It was therefore decided to use PHYTO50 to produce synoptic tables (see Section 4.3.1) for each data set, to facilitate further sorting. It was also decided that any species with a percentage constancy code of "1" (see Section 4.3.1) in the synoptic table was "noise" and was therefore ignored, excepting in those instances where such species occurred in one community only and could be used as diagnostic species. A species also had to occur at least twice in one community for it to be considered. One occurrence of a species in a community comprising 4 sub-sample relevés would therefore be considered "noise", despite the fact that it would have a percentage constancy code of 2 in the synoptic table.
20. By means of the synoptic tables it was possible to determine the diagnostic species for the different communities and to determine species that were common to two or more communities.
21. Having established the diagnostic species for each community, new PHYTO30 tables were generated (i.e. a complete, detailed tables and not synoptic tables). The sub-sample relevés within each community were then shuffled (manually and using PHYTO21) to improve their arrangement. It was found that many of the sub-sample relevés within a community did not have any of the diagnostic species for that group. If a given sub-sample relevé did not have any of the diagnostic species for the community in which it was placed, but did have a diagnostic species for one or more of the other communities, this sub-sample relevé was moved to each of these other communities in turn. If the sub-sample relevé fitted into another community with a decrease in the total number of separation units (see Section 4.3.1) for the table, it was permanently moved into that community. If there was no other community into which the sub-sample relevé could be moved, it was returned permanently to the community in which TWINSpan had placed it, regardless of the fact that it did not have any of the diagnostic species for that community.

22. The moving of sub-sample relevés from one community to another meant that the original synoptic tables were no longer valid. These tables were then re-generated and the community order was rearranged to reduce the total number of separation units for the table (see Section 4.3.1). The communities could then be combined into major units (representing higher hierarchical levels), identified by species common to all of the constituent communities. Revised detailed tables with the adjusted relevé and community ordering were then produced.
23. The entire complement of 507 sub-sample relevés (Step 13) were then arranged into a combined detailed table. The sub-sample relevés were placed in the order determined for Table I and Table II, with the sub-sample relevés of Table I first, followed by those of Table II. From this table a combined synoptic table was created, and was used to re-arrange the species into a suitable order (some species were diagnostic for communities in each half of the table and hence the species could not be merely arranged in the order in which they occurred in the separate Tables I and II).
24. DECORANA was then run on the communities of the combined synoptic table, and once the communities were plotted on the DECORANA axes it was found that the DECORANA analysis supported the four major communities (Vegetation Types) derived by the classification (see Chapters 5 & 6). These communities were as follows: Vegetation Types 1 and 2 in Table I and Vegetation Types 3 and 4 in Table II, with Vegetation Types 1 and 3 corresponding to the "very different" original relevés 83 and 84. The DECORANA analysis (see Chapter 6) further indicated that in many respects the habitats of Vegetation Types 1 and 3 are very similar to one another and differ markedly from the habitats of Vegetation Types 2 and 4. It was therefore decided to combine Vegetation Types 1 and 3 into one phytosociological table (Table 5.1: see Chapter 5), with the remaining data in Tables I and II being retained as Tables 5.2 and 5.3 (see Chapter 5).

The numbering sequence of the Vegetation Types was then altered, with Vegetation Types 5.1 and 5.2 in Table 5.1 and Vegetation Types 5.3 and 5.4 respectively in Tables 5.2 and 5.3 (see Chapter 5).

25. DECORANA was also run on each of the detailed data sets of Tables 5.2 and 5.3 to determine whether the lowest levels of communities (Variants: see Chapter 5) could be identified. The Variants did not, however, form

discrete entities in the DECORANA plots, the constituent sub-sample relevés being widely dispersed.

26. Some of the individual communities in Tables 5.2 and 5.3 were not very well differentiated (see Chapter 5), in that they were identified by only one or a few diagnostic species, or else "species gradients" (Table 4.2) occurred. In an attempt to improve the classification it was decided to remove all species that occurred only once in these data sets. It has been stated that by virtue of the algorithm used by TWINSpan, infrequent species may be heavily weighted and thus greatly affect the classification derived by TWINSpan (Hill & Gauch 1980; Baruch 1984; van der Maarel et al. 1987). Since species with a single occurrence constitute ca 25% of the species in Tables 5.2 and 5.3, it was possible that their presence was exerting a considerable effect on the results. The data set for Table 5.3 was thus altered and TWINSpan was run on the new data set. It was found that the new TWINSpan classification was markedly similar to the previous TWINSpan classification, and for this reason this method was not pursued further.
27. The phytosociological tables were then finalized, retaining the Data Sets and Tables described in Step 24. A combined synoptic table was generated with the Vegetation Types in the revised sequence (Step 24), and synoptic tables for Vegetation Types 5.3 and 5.4 (detailed Tables 5.2 and 5.3) were created (see Chapter 5).

4.3.4 STATISTICAL ANALYSIS OF ENVIRONMENTAL AND HABITAT DATA

When considering the environmental and habitat data for a given community, the range and the mean value for each of the variables was determined, for those variables that were absolute values.

In many instances the sub-sample relevés within the communities were found to be very variable with respect to the different environmental or habitat factors (e.g. soil type and soil depth). For this reason the numbers of sub-sample relevés in a community having each of the different variables (e.g. Mispah or Arcadia soil forms) was determined and expressed as a percentage of the total, to allow for the comparison of the environmental and habitat data between communities.

The data were then analyzed to determine whether the observed differences in the variables of any two communities were statistically significant, using T-tests (in the case of absolute values) or Chi-Squared tests (in the case of class intervals) (Brown & Hollander 1977).

4.3.5 ANALYSIS OF THE SPECIES COMPOSITION OF THE VEGETATION

The species composition of the Amersfoort vegetation was compared with veld type data recorded by Acocks (1953, 1988) (see Chapter 8). When surveying the vegetation Acocks (1953) assigned to each species a "Relative Abundance" value, defined as "conservative estimates of the number of plants of each species to be expected per morgen in typical samples of the veld types".

The species composition data recorded by Acocks (1953, 1988) apply to the entire extent of each veld type. Since only a small area of the different veld types fall within the study area, proportionate, area-related relative abundance values for each species occurring within the study area were derived from Acocks' (1953, 1988) data.

Three veld types occur in the study area (see Figure 3.1), namely Veld Types 52, 54 and 57, respectively occupying ca 9%, 60% and 31% of the area. The relative abundance values assigned by Acocks (1953, 1988) to e.g. *Themeda triandra* in Veld Types 52, 54 and 57 were then respectively multiplied by factors of 9, 60 and 31, to derive proportionate estimates of the species' relative abundance. These three quotients were then summed, to give an approximate relative abundance value for the species within the study area. It was then possible to place the species into an order of decreasing relative abundance.

The cover-abundance values recorded for the different species during the present survey were then totalled, using the class midpoints of the Domin-Krajina scale (Westfall 1981). By this means, a total "relative abundance" value for each species was obtained, and the species could then likewise be placed into an order of decreasing relative abundance.

In order to be able to compare the species compositions of the major communities classified during this survey, similar "relative abundance" values were determined by summing the cover-abundance values recorded for each species in a given

community, and the species were also arranged into an order of decreasing relative abundance.

The species sequences in all of the above instances were then expressed as a percentage of the most abundant species in the data set or community, where that species was assigned a value of 100%. This was done to simplify the comparison of the data; the data are not intended to be directly comparable, but serve to indicate a sequence of the some of the most commonly occurring species in an order of decreasing abundance, relative to the most abundant species occurring in the given data set or community.

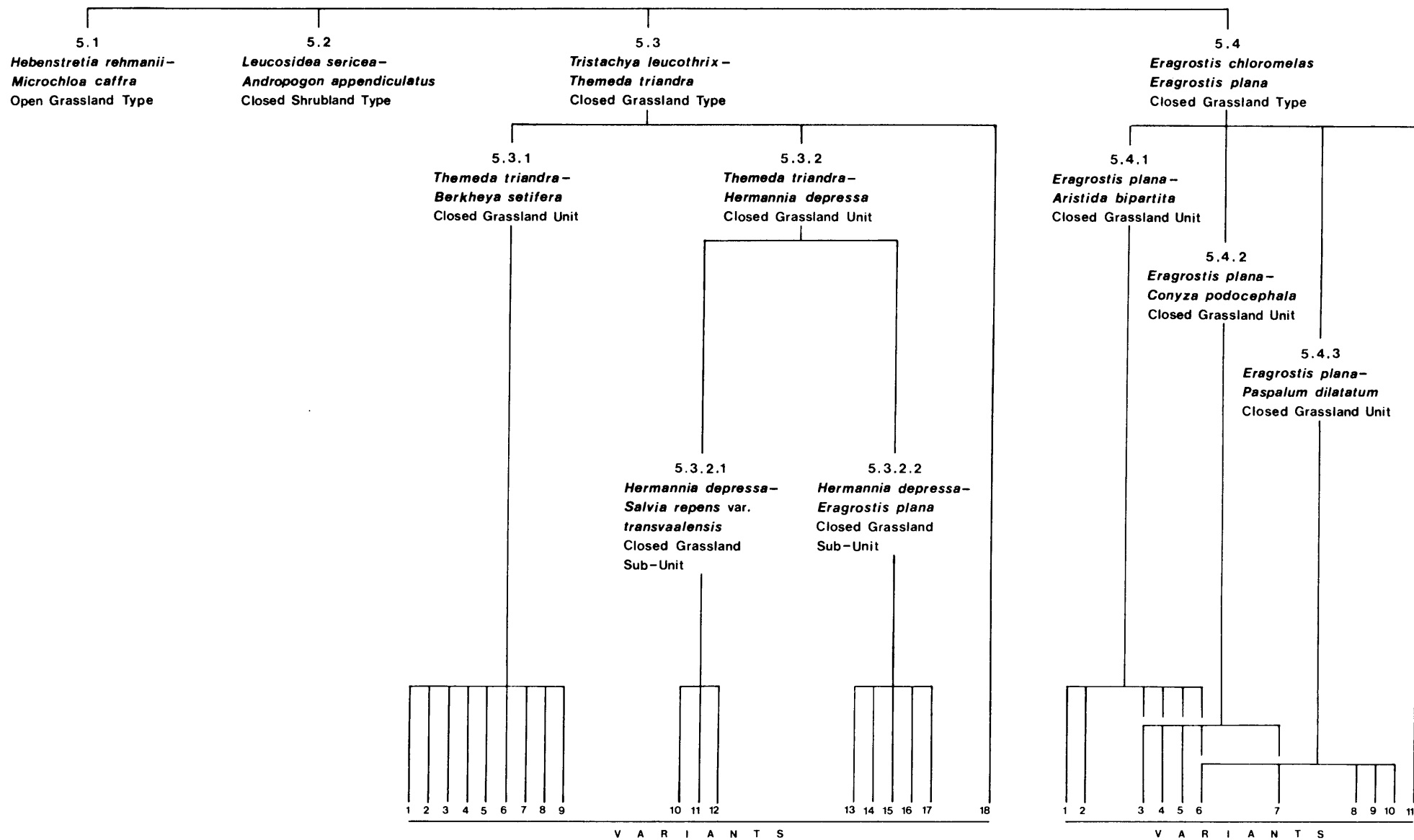


FIGURE 5.1 Dendrogram showing the hierarchical arrangement of the syntaxa of the Amersfoort vegetation in the south-eastern Transvaal.

CHAPTER 5

VEGETATION DESCRIPTION

Four Vegetation Types were identified in the classification and these have been further subdivided into Vegetation Units, Sub-Units and Variants (Figure 5.1). The terms "Type", "Unit", "Sub-Unit" and "Variant" are used to differentiate between the different levels of the hierarchically arranged syntaxa but they do not imply formal Braun-Blanquet (1932) nomenclature or ranking. Similarly, a "syntaxon" is defined as "A plant community of any rank" (Lincoln et al. 1982).

Some of the plants could not be completely identified and where these plants are referred to in the text or a phytosociological table the voucher number of the reference specimen is given in parentheses after the plant name. (These plants will be re-collected for complete identification).

Where a plant has been identified to the level of subspecies and variety or form, only the subspecies is mentioned, providing that only one variety or form of the given subspecies was recorded during the survey. The following species are thus abbreviated in the text and the phytosociological tables:

Dianthus mooiensis* subsp. *mooiensis* var. *dentatus

Herniaria erckertii* subsp. *erckertii* var. *erckertii

Limeum viscosum* subsp. *viscosum* var. *glomeratum

Nesaea sagittifolia* var. *ericiformis* forma *swaziensis

Distinction has not been made between the two subspecies of *Gazania krebsiana* that occur in the study area, i.e. *Gazania krebsiana* subsp. *arctotoides* and *Gazania krebsiana* subsp. *serrulata*.

Non-diagnostic species which occur in only one sub-sample relevé in Tables 5.1 to 5.5, or in only one syntaxon of the combined synoptic table (Table 5.6), are not reflected in these tables but are listed in Appendix 1. A complete list of all of the species recorded during this survey is given in Chapter 10.

In the description of the vegetation reference is made to species which are diagnostic for a given syntaxon. Distinction is made between the following types of diagnostic species (adapted from Westhoff & van der Maarel 1978):

An **exclusive** species occurs in only one syntaxon in the entire data set or study area.

A **selective** species occurs predominantly in one syntaxon but is not restricted to it. When occurring in other syntaxa such a species would constitute "noise" (see Section 4.3.3, Step 19).

A **preferential** species (which may be exclusive or selective) occurs with $\geq 50\%$ constancy in the Variants (or sub-sample relevés in the absence of Variants) of a syntaxon.

A **dominant** species has $\geq 30\%$ constancy of occurrence in the sub-sample relevés of a syntaxon, with $\geq 20\%$ cover-abundance values of ≥ 3 and a minimum of two cover-abundance values of ≥ 3 .

The syntaxa have been named according to their diagnostic species and further designated as e.g. "Open Grassland", which is derived from Edwards' (1983) system for vegetation classification.

In the descriptions of the syntaxa the preferential species are followed by a number in parentheses that indicates the percentage constancy with which a preferential species occurs in the Variants (or sub-sample relevés in the absence of Variants) of a syntaxon. Similarly, the dominant species are followed by two numbers in parentheses respectively indicating the percentage constancy with which a dominant species occurs in the sub-sample relevés of a syntaxon, and the percentage of sub-sample relevés in the syntaxon with cover-abundance values of ≥ 3 .

In the text reference is made to specific Species Groups in a given phytosociological table. For example, "Table 5.1:A & V" refers to Species Groups A and V of Table 5.1. It should be borne in mind that in the synoptic tables (Tables 5.4, 5.5 & 5.6) a percentage constancy code of 1 or 2 may be regarded as "noise" and therefore ignored (see Section 4.3.3, Step 19).

All syntaxa were found to occur over a wide range of habitat conditions. For this reason the habitat descriptions have been standardized and are of a generalized nature, intended to indicate the range of variability of some of the most important habitat factors occurring within each syntaxon. In describing the syntaxa reference is made to the range of e.g. soil depths in the constituent sub-sample relevés, followed by a number in parentheses which indicates the mean for the preceding range of values. All data referred to in the text are drawn from either the relevant phytosociological table or from Appendix 2.



FIGURE 5.2 The *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type is characterized by a high rock cover and a low maximum canopy cover.

The soils of the study area have been grouped into four types, namely Mispahs, vertic soils, freely drained soils and soils with restricted drainage. The first group comprises the Mispah Form only and the Arcadia and Rensburg Forms represent the vertic soils. The freely drained soils are represented by the Clovelly, Fernwood, Griffin and Hutton Forms, and the soils with restricted drainage are represented by the Avalon, Bainsvlei, Glencoe, Pinedene, Shortlands and Wasbank Forms.

5.1 THE *Hebenstretia rehmannii*-*Microchloa caffra* OPEN GRASSLAND TYPE

The *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type (Table 5.1:A) is represented by 5 sub-sample relevés and the type is sub-sample relevé 1. It has 13-23 (17) species per sub-sample relevé, with a maximum canopy cover of 10%.

HABITAT

This Vegetation Type occurs at high altitude (ca 1 875m above sea level (a.s.l.)) in the mountains to the east of the study area, and receives a mean annual rainfall of ca 759mm. It occurs on mudstone and sandstone in Land Type Ea25, on slopes of 2-16° (10°) with 7-99% (64%) rock cover. The soils are dark reddish brown, sandy Mispahs which are 0-120mm (39mm) deep, with a clay content in the A horizon of <10%.

FLORISTICS

The *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type (Figure 5.2 & Table 5.1:A) is characterized by ten preferential species, namely the grass *Rhynchelytrum nerviglume* (60%), the forbs *Eriospermum* sp. prob. *E. luteo-rubrum* (1460) (100%), *Anthericum fasciculatum* (80%), *Crassula lanceolata* subsp. *lanceolata* (80%), *Hebenstretia rehmannii* (80%), *Crassula setulosa* var. *setulosa* (60%), *Cyanotis speciosa* (60%) and *Gnidia* sp. cf. *G. polyantha* (1569) (60%), and the ferns *Cheilanthes eckloniana* (60%) and *Pellaea calomelanos* (60%).

Species which are exclusive to this Vegetation Type (Table 5.6:A) are the forbs *Commelina subulata*, *Crassula peploides*, *Crassula setulosa* var. *setulosa*, *Delosperma cooperi*, *Eriospermum* sp. prob. *E. luteo-rubrum* (1460), *Gnidia* sp. cf. *G. polyantha* (1459), *Hebenstretia rehmannii*, *Ifloga decumbens* and the fern *Pellaea calomelanos*. The ferns *Cheilanthes eckloniana* and *Cheilanthes quadripinnata* are selective species. Species such as *Felicia muricata* subsp.



FIGURE 5.3 The *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type occurs on steep slopes at high altitude. The visually dominant species are the shrub *Leonotis ocymifolia* var. *ocymifolia* (with the orange flowers) and the small trees *Leucosidea sericea* and *Myrsine africana*.

muricata and *Aristida diffusa* subsp. *burkei* (Table 5.1:C) are not diagnostic for this Vegetation Type since they occur as frequently in other syntaxa (Table 5.6:HH).

The dominant species (Table 5.1:C) are the grasses *Aristida junciformis* subsp. *junciformis* (60%, 40%) and *Microchloa caffra* (100%, 40%). Most of the species in the *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type (Table 5.1:A & C) have cover-abundance values in the range + to 2, reflecting the low maximum canopy cover of 10% for this Vegetation Type.

GENERAL

With additional samples this Vegetation Type may be divided into two entities. The first entity, comprising sub-sample relevés 2 and 4 (Table 5.1:A) represents vegetation that occurs on shallow slopes with moderately deep soils and a low rock cover (Appendix 2). The remainder of the sub-sample relevés represent vegetation which occurs on steeper slopes with very shallow soils and a high rock cover. This Vegetation Type is likely to be more widespread at high altitude in the mountainous regions in the study area, where the appropriate habitat occurs.

5.2 THE *Leucosidea sericea*-*Andropogon appendiculatus* CLOSED SHRUBLAND TYPE

The *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type (Table 5.1:B) is represented by 4 sub-sample relevés and the type is sub-sample relevé 8. It has 15-25 (20) species per sub-sample relevé and the vegetation reaches a height of 2m with a maximum canopy cover of 60%.

HABITAT

This Vegetation Type occurs at high altitude (ca 1 844m a.s.l.) on the western-facing slopes of the mountainous region in the east of the study area, and receives a mean annual rainfall of ca 759mm. It occurs on shale in Land Type Ea25, on slopes of 31-39° (36°) with 20-50% (35%) rock cover. The soils are brownish black, sandy Mispahs which are 120-170mm (143mm) deep, with a clay content in the A horizon of <10%.

FLORISTICS

The *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type (Figure 5.3 & Table 5.1:B) is characterized by seven preferential species, namely the



FIGURE 5.4 The *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type occurs on the western-facing slopes of the mountainous region in the Amersfoort area.

grass cf. *Sporobolus* sp. (1661) (100%), the ferns *Asplenium varians* subsp. *fimbriatum* (100%) and *Cheilanthes hirta* (100%), the forbs *Helichrysum nudifolium* (100%), *Helichrysum splendidum* (100%) and *Galium scabrelloides* (75%), and the shrub *Leonotis ocymifolia* var. *raineriana* (75%).

Species which are exclusive to this Vegetation Type (Table 5.6:B) are the grass *Brachypodium flexum*, the forbs *Agapanthus campanulatus*, *Galium scabrelloides*, *Helichrysum splendidum* and *Senecio affinis*, the shrub *Leonotis ocymifolia* var. *raineriana*, the small tree *Myrsine africana*, and the ferns *Asplenium varians* subsp. *fimbriatum* and *Cheilanthes hirta*. The selective species are *Helichrysum nudifolium*, *Leucosidea sericea* and cf. *Sporobolus* sp. (1661). Species such as *Oxalis obliquifolia* and *Pennisetum sphacelatum* (Table 5.1:C) are not diagnostic for this Vegetation Type since they occur as frequently in other syntaxa (Table 5.6:GG & HH).

The dominant species (Table 5.1:B & C) are the grass *Andropogon appendiculatus* (100%, 100%) and the forbs *Helichrysum splendidum* (100%, 75%) and *Indigofera frondosa* (100%, 75%). The visually dominant species are the shrub *Leonotis ocymifolia* var. *raineriana*, the small trees *Leucosidea sericea* and *Myrsine africana*, and the tall, robust grass *Pennisetum sphacelatum*.

GENERAL

Shrubland vegetation occurs at high altitude on the steep slopes of the mountainous regions of the study area (Figure 5.4). Additional samples will better typify and describe the extent of the *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type.

5.3 THE *Tristachya leucothrix*-*Themeda triandra* CLOSED GRASSLAND TYPE

The *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type (Table 5.2:A) is represented by 352 sub-sample relevés and has 7-38 (20) species per sub-sample relevé, with a maximum canopy cover of 12-96% (61%).

HABITAT

This Vegetation Type occurs predominantly in the high lands and mountainous regions in the south and east of the study area at altitudes of 1 524-2 111m a.s.l., and receives a mean annual rainfall of ca 737mm. It occurs predominantly



FIGURE 5.5 The *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type, in which *Themeda triandra* is conspicuously dominant.

on dolerite and shale, on slopes of 2-28° (4°) with 0-66% (4%) rock cover. The most commonly occurring soils are Mispahs and soils with restricted drainage (Avalon, Bainsvlei, Glencoe, Shortlands and Wasbank Forms).

FLORISTICS

The *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type (Figure 5.5 & Tables 5.4:A & 5.6:C) is characterized by the preferential grasses *Elionurus muticus* (100%), *Eragrostis racemosa* (89%), *Tristachya leucothrix* (83%) and *Brachiaria serrata* (67%). The preferential forbs are *Crabbea acaulis* (100%), *Rhynchosia totta* (94%), *Acalypha caperonioides* (67%), *Hibiscus aethiopicus* var. *ovatus* (56%) and *Indigofera frondosa* (56%). The selective species are the grass *Harpochloa falx* and the forb *Chaetacanthus setiger*.

The dominant grass species (Table 5.2:A & V) are *Eragrostis chloromelas* (69%, 40%), *Eragrostis plana* (61%, 46%), *Heteropogon contortus* (82%, 39%) and *Themeda triandra* (90%, 61%), and the dominant forb is *Acalypha caperonioides* (36%, 25%).

COMPONENTS OF THE VEGETATION TYPE

The *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type is divided into two Vegetation Units (Figure 5.1):

5.3.1 The *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit

5.3.2 The *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit

5.3.1 THE *Themeda triandra*-*Berkheya setifera* CLOSED GRASSLAND UNIT

The *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit (Table 5.2:B) is represented by 186 sub-sample relevés and has 11-38 (21) species per sub-sample relevé, with a maximum canopy cover of 20-96% (67%).

HABITAT

This Vegetation Unit occurs predominantly in the high lands and mountainous regions in the south and east of the study area at altitudes of 1 524-2 111m a.s.l., and receives a mean annual rainfall of ca 748mm. It occurs predominantly on shale and dolerite, on slopes of 2-23° (5°) with 0-65% (3%) rock cover. The most commonly occurring soils are Mispahs and soils with restricted drainage (Avalon, Bainsvlei and Shortlands Forms).

FLORISTICS

The *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit (Tables 5.4:B & 5.6:D) is characterized by the preferential forbs *Berkheya setifera* (88%), *Pelargonium luridum* (67%) and *Vernonia natalensis* (67%). *Tephrosia* sp. cf. *T. capensis* (1300) is a selective species.

The dominant species (Table 5.2:A & V) are the grasses *Eragrostis chloromelas* (63%, 26%), *Eragrostis plana* (61%, 28%), *Heteropogon contortus* (81%, 48%), *Themeda triandra* (91%, 60%) and *Tristachya leucothrix* (72%, 35%).

COMPONENTS OF THE VEGETATION UNIT

The *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit comprises nine Variants (Figure 5.1).

1. The *Berkheya setifera*-*Rhynchosia reptabunda* Closed Grassland Variant

The *Berkheya setifera*-*Rhynchosia reptabunda* Closed Grassland Variant (Table 5.2:C) is represented by 10 sub-sample relevés and the type is sub-sample relevé 249. It has 16-38 (24) species per sub-sample relevé, with a maximum canopy cover of 60-95% (78%).

This Variant occurs at altitudes of 1 768-1 890m a.s.l. on slopes of 2-17° (6°) with 0-15% (2%) rock cover. The soils are predominantly Mispahs (70%), with 30% soils with restricted drainage (Bainsvlei and Shortlands Forms).

The *Berkheya setifera*-*Rhynchosia reptabunda* Closed Grassland Variant (Tables 5.4:C & 5.6:E) is characterized by the preferential and selective forbs *Oxalis smithiana* (50%) and *Rhynchosia reptabunda* (50%), and the exclusive forbs *Aster bakeranus* and *Senecio pleistocephalus*. The dominant species (Table 5.2:A & V) are the grasses *Eragrostis chloromelas* (60%, 30%), *Heteropogon contortus* (80%, 20%), *Setaria nigrirostris* (70%, 40%), *Themeda triandra* (100%, 80%) and *Tristachya leucothrix* (60%, 40%), and the dominant forb is *Acalypha caperonioides* (80%, 30%).

2. The *Berkheya setifera*-*Hyparrhenia hirta* Closed Grassland Variant

The *Berkheya setifera*-*Hyparrhenia hirta* Closed Grassland Variant (Table 5.2:D) is represented by 18 sub-sample relevés and the type is sub-sample relevé 30. It

has 15-31 (22) species per sub-sample relevé, with a maximum canopy cover of 40-96% (72%).

This Variant occurs at altitudes of 1 676-1 951m a.s.l. on slopes of 2-8° (5°) with 0-50% (3%) rock cover. The soils are predominantly Mispahs (67%), with 17% freely drained soils (Hutton and Griffin Forms) and 16% soils with restricted drainage (Bainsvlei Form).

The *Berkheya setifera*-*Hyparrhenia hirta* Closed Grassland Variant (Tables 5.4:D & 5.6:F) is characterized by the selective species *Hyparrhenia hirta*. The dominant species (Table 5.2:A & V) are the grasses *Eragrostis chloromelas* (78%, 22%), *Heteropogon contortus* (83%, 67%) and *Themeda triandra* (94%, 83%), and the forb *Acalypha caperonioides* (94%, 50%).

3. The *Berkheya setifera*-*Euryops transvaalensis* subsp. *transvaalensis* Closed Grassland Variant

The *Berkheya setifera*-*Euryops transvaalensis* subsp. *transvaalensis* Closed Grassland Variant (Table 5.2:E) is represented by 19 sub-sample relevés and the type is sub-sample relevé 298. It has 13-29 (20) species per sub-sample relevé, with a maximum canopy cover of 50-90% (73%).

This Variant occurs at altitudes of 1 524-2 111m a.s.l. on slopes of 2-8° (3°) and it is rock-free. The most common soil types are those with restricted drainage (53%) (Avalon and Bainsvlei Forms), with 32% Mispahs and 15% vertic soils (Rensburg Form).

The *Berkheya setifera*-*Euryops transvaalensis* subsp. *transvaalensis* Closed Grassland Variant (Tables 5.4:E & 5.6:G) is characterized by the selective forb *Euryops transvaalensis* subsp. *transvaalensis* and the exclusive forb cf. *Argyrolobium* sp. (1358). Equally diagnostic is the absence of the species (Tables 5.4:S & 5.6:GG) *Aristida bipartita*, *Berkheya pinnatifida* subsp. *ingrata*, *Chaetacanthus burchellii*, *Eragrostis capensis* and *Solanum panduriforme*. The dominant species (Table 5.2:A & V) are the grasses *Heteropogon contortus* (95%, 37%), *Setaria nigrirostris* (79%, 26%), *Themeda triandra* (100%, 79%) and *Tristachya leucothrix* (95%, 63%).

4. The *Berkheya setifera*-*Harpochloa falx* Closed Grassland Variant

The *Berkheya setifera*-*Harpochloa falx* Closed Grassland Variant (Table 5.2) is represented by 8 sub-sample relevés and the type is sub-sample relevé 257. It has 12-33 (23) species per sub-sample relevé, with a maximum canopy cover of 60-90% (74%).

This Variant occurs at altitudes of 1 692-1 890m a.s.l. on slopes of 2-9° (4°) and it is rock-free. The soils are predominantly Mispahs (88%), with 12% soils with restricted drainage (Avalon Form).

The *Berkheya setifera*-*Harpochloa falx* Closed Grassland Variant is characterized by the absence of the species in Species Groups C-R and T (Table 5.4), since it has no diagnostic species of its own. The dominant species (Table 5.2:A & V) are the grasses *Harpochloa falx* (50%, 25%), *Heteropogon contortus* (88%, 50%), *Themeda triandra* (88%, 88%) and *Tristachya leucothrix* (88%, 63%), and the forb *Acalypha caperonioides* (100%, 38%).

5. The *Berkheya setifera*-*Digitaria tricholaenoides* Closed Grassland Variant

The *Berkheya setifera*-*Digitaria tricholaenoides* Closed Grassland Variant (Table 5.2:F) is represented by 36 sub-sample relevés and the type is sub-sample relevé 256. It has 14-32 (23) species per sub-sample relevé, with a maximum canopy cover of 35-90% (68%).

This Variant occurs at altitudes of 1 631-2 111m a.s.l. on slopes of 2-15° (4°) with 0-40% (3%) rock cover. The most common soil types are those with restricted drainage (54%) (Avalon, Bainsvlei and Shortlands Forms), with 25% Mispahs, 14% freely drained soils (Clovelly Form) and 7% vertic soils (Arcadia and Rensburg Forms).

The *Berkheya setifera*-*Digitaria tricholaenoides* Closed Grassland Variant (Tables 5.4:F & 5.6:H) is characterized by the preferential grass *Digitaria tricholaenoides* (55%). Other diagnostic species are the sedge *Cyperus esculentus*, the exclusive forbs *Gnidia kraussiana* var. *kraussiana*, *Gnidia* sp. cf. *G. gymnostachya* (1307) and *Helichrysum* sp. cf. *H. platypterum* (1645), and the exclusive grass *Monocymbium ceresiiforme*. Species which occur selectively in this Variant are the forbs *Gerbera piloselloides*, *Helichrysum oreophilum*,

Helichrysum pilosellum and *Pachystigma* sp. cf. *P. pygmaeum* (1396). The dominant species (Table 5.2:A & V) are the grasses *Eragrostis plana* (69%, 36%), *Heteropogon contortus* (86%, 61%), *Themeda triandra* (97%, 50%) and *Tristachya leucothrix* (83%, 61%).

6. The *Berkheya setifera*-*Lobelia flaccida* subsp. *flaccida* Closed Grassland Variant

The *Berkheya setifera*-*Lobelia flaccida* subsp. *flaccida* Closed Grassland Variant (Table 5.2:G) is represented by 27 sub-sample relevés and the type is sub-sample relevé 245. It has 13-33 (20) species per sub-sample relevé, with a maximum canopy cover of 45-90% (70%).

This Variant occurs at altitudes of 1 524-2 111m a.s.l. on slopes of 2-11° (4°) and it is rock-free. The most common soil types are those with restricted drainage (67%) (Avalon and Bainsvlei Forms), with 15% vertic soils (Arcadia and Rensburg Forms), 11% freely drained soils (Clovelly and Fernwood Forms) and 7% Mispahs.

The *Berkheya setifera*-*Lobelia flaccida* subsp. *flaccida* Closed Grassland Variant (Tables 5.4:G & 5.6:I) is characterized by the exclusive forbs *Argyrolobium* sp. (1651), *Dierama* sp. (953) and *Hypericum lalandii*. Other diagnostic species are the grasses *Eragrostis gummiflua* and *Eragrostis patentissima*, the sedge *Cyperus rigidifolius*, and the forbs *Gnidia* sp. cf. *G. nodiflora* (1526), *Lobelia flaccida* subsp. *flaccida* and *Monopsis decipiens*. The dominant species (Table 5.2:V) are the grasses *Eragrostis chloromelas* (56%, 22%), *Eragrostis plana* (85%, 67%), *Heteropogon contortus* (70%, 56%) and *Themeda triandra* (81%, 37%).

7. The *Berkheya setifera*-*Hermannia cristata* Closed Grassland Variant

The *Berkheya setifera*-*Hermannia cristata* Closed Grassland Variant (Table 5.2:H) is represented by 18 sub-sample relevés and the type is sub-sample relevé 50. It has 20-34 (24) species per sub-sample relevé, with a maximum canopy cover of 20-80% (55%).

This Variant occurs at altitudes of 1 660-1 859m a.s.l. on slopes of 2-15° (7°) and it is rock-free. The soils are predominantly Mispahs (70%), with 10% each of vertic soils (Rensburg Form), freely drained soils (Clovelly and Hutton Forms) and soils with restricted drainage (Avalon and Shortlands Forms).

The *Berkheya setifera*-*Hermannia cristata* Closed Grassland Variant (Tables 5.4:H & 5.6:J) is poorly characterized by the diagnostic forb *Hermannia cristata*, and the absence of the species in Species Groups C-G, I-R and T (Table 5.4) is of greater diagnostic value. The dominant species (Table 5.2:V) are the grasses *Eragrostis chloromelas* (80%, 35%), *Eragrostis plana* (80%, 20%), *Heteropogon contortus* (90%, 55%) and *Themeda triandra* (90%, 35%).

8. The *Berkheya setifera*-*Taraxacum hamatiforme* Closed Grassland Variant

The *Berkheya setifera*-*Taraxacum hamatiforme* Closed Grassland Variant (Table 5.2:I) is represented by 39 sub-sample relevés and the type is sub-sample relevé 326. It has 11-31 (20) species per sub-sample relevé, with a maximum canopy cover of 40-96% (61%).

This Variant occurs at altitudes of 1 676-1 996m a.s.l. on slopes of 2-23° (7°) with 0-65% (7%) rock cover. The soils are predominantly Mispahs (64%), with 16% freely drained soils (Fernwood, Griffin and Hutton Forms) and 10% each of vertic soils (Rensburg Form) and soils with restricted drainage (Bainsvlei Form).

The *Berkheya setifera*-*Taraxacum hamatiforme* Closed Grassland Variant (Tables 5.4:I & 5.6:K) is characterized by the selective forbs *Helichrysum melanacme*, *Indigofera* sp. cf. *I. stricta* (1669) and *Taraxacum hamatiforme*, and the selective grass *Fingerhuthia sesleriiformis*. Other diagnostic species are the forbs *Limeum pauciflorum* and *Rumex angiocarpus*, and the grass *Cynodon transvaalensis*. The dominant species (Table 5.2:A & V) are the grasses *Eragrostis chloromelas* (77%, 44%), *Eragrostis plana* (77%, 41%), *Heteropogon contortus* (69%, 33%), *Themeda triandra* (85%, 64%) and *Tristachya leucothrix* (87%, 28%).

9. The *Berkheya setifera*-*Eragrostis chloromelas* Closed Grassland Variant

The *Berkheya setifera*-*Eragrostis chloromelas* Closed Grassland Variant (Table 5.2) is represented by 9 sub-sample relevés and the type is sub-sample relevé 35. It has 16-35 (23) species per sub-sample relevé, with a maximum canopy cover of 40-90% (62%).

This Variant occurs at altitudes of 1 646-1 890m a.s.l. on slopes of 2-17° (6°) with 0-50% (2%) rock cover. The soils are predominantly Mispahs (90%), with 10% vertic soils (Rensburg Form).

The **Berkheya setifera-Eragrostis chloromelas** Closed Grassland Variant is characterized by the absence of the species in the Species Groups C-R and T (Table 5.4), since it has no diagnostic species of its own. The dominant species (Table 5.2:V) are the grasses **Eragrostis chloromelas** (100%, 55%), **Heteropogon contortus** (88%, 44%) and **Themeda triandra** (88%, 66%).

5.3.2 THE **Themeda triandra-Hermannia depressa** CLOSED GRASSLAND UNIT

The **Themeda triandra-Hermannia depressa** Closed Grassland Unit (Table 5.2:J) is represented by 153 sub-sample relevés and has 7-34 (18) species per sub-sample relevé, with a maximum canopy cover of 12-90% (55%).

HABITAT

This Vegetation Unit occurs throughout the study area at altitudes of 1 524-1 981m a.s.l., and receives a mean annual rainfall of ca 716mm. It occurs predominantly on dolerite and shale, on slopes of 2-28° (5°) with 0-45% (3%) rock cover. The most commonly occurring soils are Mispahs and vertic soils (Rensburg Form).

FLORISTICS

The **Themeda triandra-Hermannia depressa** Closed Grassland Unit (Tables 5.4:J & 5.6:L) is characterized by the preferential forb **Hermannia depressa** (100%).

The dominant species (Table 5.2:V) are the grasses **Eragrostis chloromelas** (77%, 32%), **Eragrostis plana** (63%, 31%) and **Themeda triandra** (89%, 54%).

COMPONENTS OF THE VEGETATION UNIT

The **Themeda triandra-Hermannia depressa** Closed Grassland Unit is divided into two Sub-Units (Figure 5.1):

5.3.2.1 The **Hermannia depressa-Eragrostis plana** Closed Grassland Sub-Unit

5.3.2.2 The **Hermannia depressa-Salvia repens** var. **transvaalensis** Closed Grassland Sub-Unit

5.3.2.1 The *Hermannia depressa*-*Eragrostis plana* Closed Grassland Sub-Unit

The *Hermannia depressa*-*Eragrostis plana* Closed Grassland Sub-Unit (Table 5.2) is represented by 85 sub-sample relevés and has 7-29 (16) species per sub-sample relevé, with a maximum canopy cover of 12-90% (56%).

HABITAT

This Vegetation Sub-Unit occurs throughout the study area at altitudes of 1 524-1 981m a.s.l., and receives a mean annual rainfall of ca 725mm. It occurs predominantly on dolerite and shale, on slopes of 2-24° (5°) with 0-45% (4%) rock cover. The most commonly occurring soils are Mispahs and soils with restricted drainage (Avalon, Bainsvlei and Shortlands Forms).

FLORISTICS

The *Hermannia depressa*-*Eragrostis plana* Closed Grassland Sub-Unit (Tables 5.4:M & 5.6:O) is characterized by the absence of the forbs *Oenothera tetraptera*, *Salvia repens* var. *transvaalensis* and *Sutera aurantiaca*, since it has no diagnostic species of its own.

The dominant species (Table 5.2:V) are the grasses *Eragrostis chloromelas* (82%, 38%), *Eragrostis plana* (62%, 24%), *Heteropogon contortus* (85%, 46%) and *Themeda triandra* (85%, 47%).

COMPONENTS OF THE VEGETATION SUB-UNIT

The *Hermannia depressa*-*Eragrostis plana* Closed Grassland Sub-Unit comprises three Variants (Figure 5.1).

10. The *Eragrostis plana*-*Heteropogon contortus* Closed Grassland Variant

The *Eragrostis plana*-*Heteropogon contortus* Closed Grassland Variant (Table 5.2) is represented by 21 sub-sample relevés and the type is sub-sample relevé 350. It has 7-28 (19) species per sub-sample relevé, with a maximum canopy cover of 16-75% (57%).

This Variant occurs at altitudes of 1 524-1 798m a.s.l. on slopes of 2-11° (6°) with 0-30% (4%) rock-cover. The soils are predominantly Mispahs (62%), with 24% soils with restricted drainage (Bainsvlei Form) and 14% vertic soils (Rensburg Form).

The **Eragrostis plana-Heteropogon contortus** Closed Grassland Variant is characterized by the absence of the species in Species Groups B-I, K-R and T (Table 5.4) since it has no diagnostic species of its own. The dominant species (Table 5.2:V) are the grasses **Heteropogon contortus** (86%, 57%) and **Themeda triandra** (100%, 81%).

11. The **Eragrostis plana-Psammotropha myriantha** Closed Grassland Variant

The **Eragrostis plana-Psammotropha myriantha** Closed Grassland Variant (Table 5.2:K) is represented by 37 sub-sample relevés and the type is sub-sample relevé 4. It has 8-28 (15) species per sub-sample relevé, with a maximum canopy cover of 12-90% (55%).

This Variant occurs at altitudes of 1 646-1 981m a.s.l. on slopes of 2-24° (6°) with 0-45% (7%) rock cover. The soils are predominantly Mispahs (60%), with 26% soils with restricted drainage (Avalon and Bainsvlei Forms) and 14% vertic soils (Rensburg Form).

The **Eragrostis plana-Psammotropha myriantha** Closed Grassland Variant (Tables 5.4:K & 5.6:M) is poorly characterized by the exclusive forb **Psammotropha myriantha** and the selective forb **Dianthus mooiensis** subsp. *mooiensis*. The absence of the species in Species Groups B-I, L-R and T (Table 5.4) is of greater diagnostic value. The dominant species (Table 5.2:V) is the grass **Heteropogon contortus** (89%, 54%).

12. The **Eragrostis plana-Verbena brasiliensis** Closed Grassland Variant

The **Eragrostis plana-Verbena brasiliensis** Closed Grassland Variant (Table 5.2:L) is represented by 27 sub-sample relevés and the type is sub-sample relevé 278. It has 12-29 (17) species per sub-sample relevé, with a maximum canopy cover of 20-70% (55%).

This Variant occurs at altitudes of 1 620-1 814m a.s.l. on slopes of 2-10° (4°) and it is rock-free. The soils are predominantly Mispahs (52%), with 30% soils with restricted drainage (Avalon, Bainsvlei and Shortlands Forms), 10% freely drained soils (Clovelly and Hutton Forms) and 8% vertic soils (Rensburg Form).

The **Eragrostis plana-Verbena brasiliensis** Closed Grassland Variant (Tables 5.4:L & 5.6:N) is poorly characterized by the diagnostic forb **Verbena brasiliensis**, and

the absence of the species in Species Groups B-I, K, M-R and T (Table 5.4) is of greater diagnostic value. The dominant species (Table 5.2:V) is the grass *Eragrostis chloromelas* (93%, 67%).

5.3.2.2 The *Hermannia depressa*-*Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit

The *Hermannia depressa*-*Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit (Table 5.2:M) is represented by 68 sub-sample relevés and has 11-34 (20) species per sub-sample relevé, with a maximum canopy cover of 16-90% (54%).

HABITAT

This Vegetation Sub-Unit occurs throughout the study area at altitudes of 1 620-1 838m a.s.l., and receives a mean annual rainfall of ca 728mm. It occurs predominantly on dolerite and shale, on slopes of 2-28° (6°) with 0-66% (3%) rock cover. The most commonly occurring soils are vertic soils (Arcadia and Rensburg Forms) and Mispahs.

FLORISTICS

The *Hermannia depressa*-*Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit (Tables 5.4:M & 5.6:O) is characterized by the preferential forbs *Salvia repens* var. *transvaalensis* (100%), *Oenothera tetraptera* (60%) and *Sutera aurantiaca* (60%).

The dominant species (Table 5.2:V) is the grass *Themeda triandra* (94%, 59%).

COMPONENTS OF THE VEGETATION

The *Hermannia depressa*-*Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit comprises five Variants (Figure 5.1).

13. The *Salvia repens* var. *transvaalensis*-*Berkheya radula* Closed Grassland Variant

The *Salvia repens* var. *transvaalensis*-*Berkheya radula* Closed Grassland Variant (Table 5.2:N) is represented by 14 sub-sample relevés and the type is sub-sample relevé 80. It has 11-29 (18) species per sub-sample relevé, with a maximum canopy cover of 30-79% (47%).

This Variant occurs at altitudes of 1 620-1 814m a.s.l. on slopes of 2-6° (3') with 0-25% (2%) rock cover. The soils are predominantly vertic (56%) (Rensburg Form), with 36% Mispahs and 8% soils with restricted drainage (Bainsvlei Form).

The *Salvia repens* var. *transvaalensis*-*Berkheya radula* Closed Grassland Variant (Tables 5.4:N & 5.6:P) is characterized by the exclusive forb *Polygala amatymbica* and the selective forbs *Berkheya radula* and *Nesaea sagittifolia* var. *sagittifolia*. The dominant species (Table 5.2:V) is the grass *Eragrostis plana* (79%, 50%).

14. The *Salvia repens* var. *transvaalensis*-*Lobelia angolensis* Closed Grassland Variant

The *Salvia repens* var. *transvaalensis*-*Lobelia angolensis* Closed Grassland Variant (Table 5.2:O) is represented by 19 sub-sample relevés and the type is sub-sample relevé 167. It has 13-34 (23) species per sub-sample relevé, with a maximum canopy cover of 16-80% (52%).

This Variant occurs at altitudes of 1 631-1 838m a.s.l. on slopes of 2-14° (6') with 0-12% (1%) rock cover. The soils are predominantly Mispahs (47%), with 32% vertic soils (Arcadia and Rensburg Forms) and 21% soils with restricted drainage (Avalon and Bainsvlei Forms).

The *Salvia repens* var. *transvaalensis*-*Lobelia angolensis* Closed Grassland Variant (Tables 5.4:O & 5.6:Q) is characterized by the diagnostic forbs *Chaetacanthus* sp. (1247) and *Lobelia angolensis*. The dominant species (Table 5.2:V) are the grasses *Heteropogon contortus* (79%, 53%) and *Themeda triandra* (90%, 63%).

15. The *Salvia repens* var. *transvaalensis*-*Rhus dentata* Closed Grassland Variant

The *Salvia repens* var. *transvaalensis*-*Rhus dentata* Closed Grassland Variant (Table 5.2:P) is represented by 12 sub-sample relevés and the type is sub-sample relevé 91. It has 15-28 (19) species per sub-sample relevé, with a maximum canopy cover of 70-90% (78%).

This Variant occurs at altitudes of 1 722-1 829m a.s.l. on slopes of 2-28° (11') with 0-30% (6%) rock cover. The soils are predominantly Mispahs (83%), with 9%

soils with restricted drainage (Bainsvlei Form) and 8% freely drained soils (Hutton Form).

The *Salvia repens* var. *transvaalensis*-*Rhus dentata* Closed Grassland Variant (Tables 5.4:P & 5.6:R) is characterized by the selective forb *Rhus dentata*. The dominant species (Table 5.2:V) are the grasses *Eragrostis plana* (92%, 75%) and *Heteropogon contortus* (92%, 67%).

16. The *Salvia repens* var. *transvaalensis*-*Striga bilabiata* Closed Grassland Variant

The *Salvia repens* var. *transvaalensis*-*Striga bilabiata* Closed Grassland Variant (Table 5.2:Q) is represented by 16 sub-sample relevés and the type is sub-sample relevé 141. It has 11-27 (14) species per sub-sample relevé, with a maximum canopy cover of 16-75% (44%).

This Variant occurs at altitudes of 1 640-1 798m a.s.l. on slopes of 2-13° (5°) with 0-25% (5%) rock cover. The soils are predominantly vertic (85%) (Rensburg Form), with 15% Mispahs.

The *Salvia repens* var. *transvaalensis*-*Striga bilabiata* Closed Grassland Variant (Tables 5.4:Q & 5.6:S) is characterized by the preferential and selective forb *Striga bilabiata* (56%). Equally diagnostic (Tables 5.4:U & 5.6:GG) is the absence of the grass *Microchloa caffra*, the sedge *Bulbostylis humilis* and the forb *Commelina africana* var. *africana* from this Variant. The dominant species (Table 5.2:V) are the grasses *Heteropogon contortus* (81%, 63%) and *Themeda triandra* (100%, 81%).

17. The *Salvia repens* var. *transvaalensis*-*Hermannia parviflora* Closed Grassland Variant

The *Salvia repens* var. *transvaalensis*-*Hermannia parviflora* Closed Grassland Variant (Table 5.2:R) is represented by 7 sub-sample relevés and the type is sub-sample relevé 3. It has 17-24 (21) species per sub-sample relevé, with a maximum canopy cover of 40-64% (56%).

This Variant occurs at altitudes of 1 620-1 680m a.s.l. on slopes of 2-4° (3°) and it is rock-free. The soils are predominantly vertic (86%) (Arcadia and Rensburg Forms), with 14% freely drained soils (Hutton Form).

The *Salvia repens* var. *transvaalensis*-*Hermannia parviflora* Closed Grassland Variant (Tables 5.4:R & 5.6:T) is characterized by the exclusive forb *Hermannia parviflora*. Equally diagnostic (Tables 5.4:U & 5.6:GG) is the absence of the grass *Microchloa caffra*, the sedge *Bulbostylis humilis* and the forb *Commelina africana* from this Variant. The dominant species (Table 5.2:V) is the grass *Themeda triandra* (100%, 100%).

18. The *Themeda triandra*-*Limeum viscosum* subsp. *viscosum* Closed Grassland Variant

The *Themeda triandra*-*Limeum viscosum* subsp. *viscosum* Closed Grassland Variant (Table 5.2:T) does not form part of either of the two Vegetation Units of the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type (Figure 5.1). It is represented by 13 sub-sample relevés and the type is sub-sample relevé 126. It has 12-26 (17) species per sub-sample relevé, with a maximum canopy cover of 30-80% (56%).

This Variant occurs at altitudes of 1 654-1 814m a.s.l. on slopes of 2-4° (3°) with 0-66% (6%) rock cover. The soils are predominantly Mispahs (62%), with 39% soils with restricted drainage (Glencoe and Wasbank Forms) and 8% vertic soils (Arcadia and Rensburg Forms). This Variant has 76% soils with a low ($\leq 15-20\%$) clay content in the A horizon. The other Variants of the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type have only 0-32% (16%) of the soils with a clay content in this range.

The *Themeda triandra*-*Limeum viscosum* subsp. *viscosum* Closed Grassland Variant (Tables 5.4:T & 5.6:U) is characterized by the preferential forb *Limeum viscosum* subsp. *viscosum* (69%). Other diagnostic species are the exclusive sedge *Scirpus burkei* and the exclusive forb *Gnidia nodiflora*, the selective sedge *Kyllinga erecta* and the selective forb *Tolpis capensis*.

Owing to the low cover-abundance values for the species in this Variant, there are no dominant species. However (Table 5.2:A & V), the grasses *Aristida junciformis* subsp. *junciformis*, *Elionurus muticus*, *Eragrostis racemosa*, *Heteropogon contortus*, *Themeda triandra* and *Tristachya leucothrix*, and the forb *Anthospermum pumilum* subsp. *rigidum* all have a high ($\geq 70\%$) frequency of occurrence in the sub-sample relevés of this Variant.



FIGURE 5.6 The *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type in which *Eragrostis plana* is conspicuously dominant.

5.4 THE *Eragrostis chloromelas*-*Eragrostis plana* CLOSED GRASSLAND TYPE

The *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (Table 5.3:A) is represented by 146 sub-sample relevés and has 3-29 (14) species per sub-sample relevé, with a maximum canopy cover of 16-95% (58%).

HABITAT

This Vegetation Type occurs predominantly in the high lands and mountainous regions in the south and east of the study area at altitudes of 1 620-1 996m a.s.l., and receives a mean annual rainfall of ca 744mm. It occurs predominantly on shale and dolerite, on slopes of 2-35° (5°) with 0-90% (4%) rock cover. The most commonly occurring soils are Mispahs, vertic soils (Arcadia and Rensburg Forms) and soils with restricted drainage (Avalon, Bainsvlei and Pinedene Forms).

FLORISTICS

The *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (Figure 5.6 & Table 5.6:C) is characterized by the absence or infrequent occurrence of the grasses *Brachiaria serrata*, *Elionurus muticus*, *Eragrostis racemosa*, *Harpochloa falx* and *Tristachya leucothrix*, and the forbs *Acalypha caperonioides*, *Chaetacanthus setiger*, *Crabbea acaulis*, *Hibiscus aethiopicus* var. *ovatus*, *Indigofera frondosa* and *Rhynchosia totta*. The species which characterize this grassland (Tables 5.5:A & 5.6:GG) are the preferential grasses *Eragrostis chloromelas* (100%), *Eragrostis plana* (100%) and *Themeda triandra* (66%), and the preferential forbs *Anthospermum pumilum* subsp. *rigidum* (66%), *Berkheya pinnatifida* subsp. *ingrata* (66%) and *Sonchus nanus* (55%).

The dominant species (Table 5.3:A) are the grasses *Eragrostis chloromelas* (67%, 35%) and *Eragrostis plana* (86%, 61%).

COMPONENTS OF THE VEGETATION TYPE

The *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type is divided into three Vegetation Units (Figure 5.1):

- 5.4.1 The *Eragrostis plana*-*Aristida bipartita* Closed Grassland Unit
- 5.4.2 The *Eragrostis plana*-*Conyza podocephala* Closed Grassland Unit
- 5.4.3 The *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit

The three Vegetation Units represent a gradient within the *Eragrostis chloromelas-Eragrostis plana* Closed Grassland Type, and some of the Variants are common to two or all three of the Vegetation Units (Figure 5.1). For this reason the Vegetation Units will be described first, followed by the Variants. A Variant is named according to the Vegetation Unit immediately preceding it in Table 5.5.

5.4.1 THE *Eragrostis plana-Aristida bipartita* CLOSED GRASSLAND UNIT

The *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (Table 5.3:B) is represented by 103 sub-sample relevés and has 3-29 (14) species per sub-sample relevé, with a maximum canopy cover of 16-95% (56%).

HABITAT

This Vegetation Unit occurs predominantly in the high lands and mountainous regions in the south and east of the study area at altitudes of 1 620-1 996m a.s.l., and receives a mean annual rainfall of ca 742mm. It occurs predominantly on dolerite and shale, on slopes of 2-35° (6°) with 0-90% (5%) rock cover. The most commonly occurring soils are Mispahs, soils with restricted drainage (Avalon, Bainsvlei and Pinedene Forms) and vertic soils (Arcadia and Rensburg Forms).

FLORISTICS

The *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (Tables 5.5:B & 5.6:GG) is characterized by the preferential grasses *Aristida bipartita* (83%), *Aristida congesta* subsp. *congesta* (67%) and *Heteropogon contortus* (50%), and the preferential forbs *Chamaesyce prostrata* (83%) and *Solanum panduriforme* (50%).

The dominant species (Table 5.3:A) are the grasses *Eragrostis chloromelas* (80%, 40%) and *Eragrostis plana* (83%, 52%).

COMPONENTS OF THE VEGETATION UNIT

The *Eragrostis plana-Aristida bipartita* Closed Grassland Unit comprises six Variants (Figure 5.1).

5.4.2 THE *Eragrostis plana*-*Conyza podocephala* CLOSED GRASSLAND UNIT

The *Eragrostis plana*-*Conyza podocephala* Closed Grassland Unit (Table 5.3:E) is represented by 100 sub-sample relevés and has 3-29 (14) species per sub-sample relevé, with a maximum canopy cover of 16-95% (58%).

HABITAT

This Vegetation Unit occurs predominantly in the high lands and mountainous regions in the south and east of the study area at altitudes of 1 620-1 996m a.s.l., and receives a mean annual rainfall of ca 742mm. It occurs predominantly on shale and dolerite, on slopes of 2-35° (5°) with 0-60% (2%) rock cover. The most commonly occurring soils are Mispahs, soils with restricted drainage (Avalon, Bainsvlei and Pinedene Forms) and vertic soils (Arcadia and Rensburg Forms).

FLORISTICS

The *Eragrostis plana*-*Conyza podocephala* Closed Grassland Unit (Tables 5.5:E & 5.6:O & GG) is characterized by the preferential grass *Brachiaria eruciformis* (80%) and the preferential forbs *Conyza podocephala* (100%), *Oenothera tetraptera* (80%) and *Helichrysum rugulosum* (60%).

The dominant species (Table 5.3:A) are the grasses *Eragrostis chloromelas* (76%, 39%) and *Eragrostis plana* (89%, 63%).

COMPONENTS OF THE VEGETATION UNIT

The *Eragrostis plana*-*Conyza podocephala* Closed Grassland Unit comprises five Variants (Figure 5.1).

5.4.3 THE *Eragrostis plana*-*Paspalum dilatatum* CLOSED GRASSLAND UNIT

The *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit (Table 5.3:I) is represented by 49 sub-sample relevés and has 4-22 (14) species per sub-sample relevé, with a maximum canopy cover of 40-95% (62%).

HABITAT

This Vegetation Unit occurs throughout the study area at altitudes of 1 620-1 829m a.s.l., and receives a mean annual rainfall of ca 745mm. It occurs predominantly on shale and dolerite, on slopes of 2-11° (4°) with 0-50% (1%) rock

cover. The most commonly occurring soils are vertic soils (Arcadia and Rensburg Forms) and soils with restricted drainage (Avalon, Bainsvlei and Pinedene Forms).

FLORISTICS

The *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit (Tables 5.5:I & 5.6:AA) is characterized by two selective and preferential species, the grass *Paspalum dilatatum* (100%) and the forb *Oenothera rosea* (60%).

The dominant species (Table 5.3:A) is the grass *Eragrostis plana* (98%, 80%).

COMPONENTS OF THE VEGETATION UNIT

The *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit comprises five Variants (Figure 5.1).

1. The *Aristida bipartita*-*Tragus racemosus* Closed Grassland Variant

The *Aristida bipartita*-*Tragus racemosus* Closed Grassland Variant (Table 5.3:C) is unique to the *Eragrostis plana*-*Aristida bipartita* Closed Grassland Unit (Figure 5.1). It is represented by 7 sub-sample relevés and the type is sub-sample relevé 118. It has 8-19 (13) species per sub-sample relevé, with a maximum canopy cover of 30-70% (51%).

This Variant occurs at altitudes of 1 646-1 722m a.s.l. on slopes of 2-9° (3°) with 0-75% (15%) rock cover. The soils are all Mispahs.

The *Aristida bipartita*-*Tragus racemosus* Closed Grassland Variant (Tables 5.5:C & 5.6:V) is characterized by the diagnostic forbs *Crassula lanceolata* subsp. *transvaalensis* and *Monsonia angustifolia*, and two selective species, the grass *Tragus racemosus* and the forb *Senecio inaequidens*. Owing to the low cover-abundance values for the species in this Variant, there are no dominant species. However (Table 5.3:A & O), the grasses *Eragrostis chloromelas*, *Microchloa caffra* and *Setaria flabellata* subsp. *natalensis*, and the sedge *Bulbostylis humilis*, all have a high ($\geq 70\%$) frequency of occurrence in the sub-sample relevés of this Variant.

2. The *Aristida bipartita*-*Hermannia geniculata* Closed Grassland Variant

The *Aristida bipartita*-*Hermannia geniculata* Closed Grassland Variant (Table 5.3:D) is unique to the *Eragrostis plana*-*Aristida bipartita* Closed Grassland Unit

(Figure 5.1). It is represented by 6 sub-sample relevés and the type is sub-sample relevé 139. It has 12-18 (15) species per sub-sample relevé, with a maximum canopy cover of 50-60% (55%).

This Variant occurs at altitudes of 1 798-1 859m a.s.l. on slopes of 5-17° (10°) with 0-90% (28%) rock cover. The soils are all Mispahs.

The *Aristida bipartita*-*Hermannia geniculata* Closed Grassland Variant (Tables 5.5:D & 5.6:K & W) is characterized by the selective and preferential forbs *Hermannia geniculata* (67%) and *Limeum pauciflorum* (67%), and the selective forb *Monsonia brevirostrata*. The dominant species (Table 5.3:A, B & O) are the grasses *Aristida congesta* subsp. *congesta* (100%, 83%), *Aristida diffusa* subsp. *burkei* (50%, 33%), *Eragrostis chloromelas* (50%, 33%), *Eragrostis curvula* (50%, 50%) and *Heteropogon contortus* (67%, 33%).

3. The *Conyza podocephala*-*Hermannia depressa* Closed Grassland Variant

The *Conyza podocephala*-*Hermannia depressa* Closed Grassland Variant (Table 5.3:F) is common to both the *Eragrostis plana*-*Aristida bipartita* and the *Eragrostis plana*-*Conyza podocephala* Closed Grassland Units (Figure 5.1). It is represented by 44 sub-sample relevés and the type is sub-sample relevé 130. It has 5-29 (15) species per sub-sample relevé, with a maximum canopy cover of 16-90% (57%).

This Variant occurs at altitudes of 1 660-1 996m a.s.l. on slopes of 2-35° (7°) with 0-60% (5%) rock cover. Mispahs are the most common soil form (58%), with 20% freely drained soils (Clovelly and Hutton Forms), 16% soils with restricted drainage (Avalon and Bainsvlei Forms) and 6% vertic soils (Arcadia and Rensburg Forms).

The *Conyza podocephala*-*Hermannia depressa* Closed Grassland Variant (Tables 5.5:F & 5.6:C, D, L & X) is characterized by the exclusive forbs *Argyrolobium* sp. cf. *A. pauciflorum* (1589), *Berkheya robusta*, *Cineraria aspera*, *Echium plantagineum* and *Helichrysum* sp. (1351). The selective species are the forbs *Chenopodium schraderianum*, *Cucumis myriocarpus*, *Plantago virginica* and *Sutera neglecta*, and the shrub *Diospyros lycioides* subsp. *guerkei*. Other diagnostic species are the grass *Tristachya leucothrix* and the forbs *Alternanthera pungens*, *Hermannia coccocarpa*, *Hermannia cordata*, *Hermannia depressa*, *Herniaria erckertii* subsp. *erckertii* and *Vernonia natalensis*. The dominant species (Table 5.3:A & E) are

the grasses *Eragrostis chloromelas* (86%, 57%) and *Eragrostis plana* (91%, 59%), and the forb *Helichrysum rugulosum* (77%, 23%).

4. The *Conyza podocephala*-*Euphorbia striata* Closed Grassland Variant

The *Conyza podocephala*-*Euphorbia striata* Closed Grassland Variant (Table 5.3:G) is common to both the *Eragrostis plana*-*Aristida bipartita* and the *Eragrostis plana*-*Conyza podocephala* Closed Grassland Units (Figure 5.1). It is represented by 24 sub-sample relevés and the type is sub-sample relevé 57. It has 3-20 (12) species per sub-sample relevé, with a maximum canopy cover of 35-95% (56%).

This Variant occurs at altitudes of 1 684-1 814m a.s.l. on slopes of 2-5° (3°) and it is rock-free. The most commonly occurring soils are those with restricted drainage (50%) (Avalon, Bainsvlei and Pinedene Forms), with 26% freely drained soils (Clovelly, Fernwood and Griffin Forms), 20% vertic soils (Rensburg Form) and 4% Mispahs.

The *Conyza podocephala*-*Euphorbia striata* Closed Grassland Variant (Tables 5.5:G & 5.6:I & Y) is characterized by the exclusive forb *Conyza obscura* and the selective forb *Helichrysum callicomum*. Other diagnostic species are the grasses *Eragrostis gummiflua*, *Eragrostis patentissima* and *Trichoneura grandiglumis*, and the forbs *Euphorbia striata*, *Helichrysum caespititium*, *Kohautia* sp. (1295) and *Rhynchosia adenodes*. The dominant species (Table 5.3:A & O) are the grasses *Eragrostis chloromelas* (92%, 38%), *Eragrostis plana* (75%, 46%) and *Hyparrhenia dregeana* (71%, 54%).

5. The *Conyza podocephala*-*Cymbopogon excavatus* Closed Grassland Variant

The *Conyza podocephala*-*Cymbopogon excavatus* Closed Grassland Variant (Table 5.3:H) is common to both the *Eragrostis plana*-*Aristida bipartita* and the *Eragrostis plana*-*Conyza podocephala* Closed Grassland Units (Figure 5.1). It is represented by 11 sub-sample relevés and the type is sub-sample relevé 25. It has 6-26 (13) species per sub-sample relevé, with a maximum canopy cover of 50-90% (58%).

This Variant occurs at altitudes of 1 630-1 760m a.s.l. on slopes of 2-9° (4°) and it is rock-free. The soils are predominantly vertic soils (72%) (Arcadia and Rensburg Forms), with 18% Mispahs and 10% freely drained soils (Hutton Form).

The *Conyza podocephala*-*Cymbopogon excavatus* Closed Grassland Variant (Tables 5.5:H & 5.6:Z) is characterized by the exclusive forb *Raphionacme* sp. (1013) and two selective species, the grass *Eragrostis micrantha* and the forb *Convolvulus sagittatus* subsp. *sagittatus* var. *hirtellus*. Other diagnostic species are the grasses *Cymbopogon excavatus* and *Diheteropogon amplexans*. The dominant species (Table 5.3: A, B, E & O) are the grasses *Aristida bipartita* (100%, 45%), *Brachiaria eruciformis* (82%, 27%), *Eragrostis plana* (91%, 73%) and *Hyparrhenia dregeana* (36%, 27%), and the forbs *Berkheya pinnatifida* subsp. *ingrata* (73%, 27%) and *Solanum panduriforme* (64%, 36%).

6. The *Paspalum dilatatum*-*Senecio erubescens* var. *crepidifolius* Closed Grassland Variant

The *Paspalum dilatatum*-*Senecio erubescens* var. *crepidifolius* Closed Grassland Variant (Table 5.3:J) is common to all three of the Vegetation Units comprising the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (Figure 5.1). It is represented by 11 sub-sample relevés and the type is sub-sample relevé 127. It has 12-21 (16) species per sub-sample relevé, with a maximum canopy cover of 40-70% (51%).

This Variant occurs at altitudes of 1 620-1 776m a.s.l. on slopes of 2-11° (4°) and it is rock-free. The soils are predominantly vertic soils (64%) (Rensburg Form), with 18% Mispahs, 10% freely drained soils (Hutton Form) and 8% soils with restricted drainage (Avalon Form).

The *Paspalum dilatatum*-*Senecio erubescens* var. *crepidifolius* Closed Grassland Variant (Tables 5.5:J & 5.6:BB) is characterized by the preferential forb *Senecio erubescens* var. *crepidifolius* (55%) and the selective forb *Medicago laciniata*. The other diagnostic species are the forbs *Hermannia* sp. (806) and *Scabiosa columbaria*, and the grass *Setaria pallide-fusca*. The dominant species (Table 5.3:A & E) are the grasses *Brachiaria eruciformis* (73%, 27%), *Eragrostis plana* (100%, 73%) and *Themeda triandra* (64%, 36%).

7. The *Paspalum dilatatum*-*Berkheya speciosa* subsp. *lanceolata* Closed Grassland Variant

The *Paspalum dilatatum*-*Berkheya speciosa* subsp. *lanceolata* Closed Grassland Variant (Table 5.3:K) is common to both the *Eragrostis plana*-*Conyza podocephala* and the *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Units (Figure 5.1).

It is represented by 10 sub-sample relevés and the type is sub-sample relevé 67. It has 5-21 (12) species per sub-sample relevé, with a maximum canopy cover of 50-95% (72%).

This Variant occurs at altitudes of 1 676-1 798m a.s.l. on slopes of 2-14° (4°) and it is rock-free. The most commonly occurring soils are those with restricted drainage (60%) (Avalon, Bainsvlei and Pinedene Forms), with 20% each of vertic soils (Rensburg Form) and Mispahs.

The *Paspalum dilatatum*-*Berkheya speciosa* subsp. *lanceolata* Closed Grassland Variant (Tables 5.5:K & 5.6:CC) is characterized by the exclusive forb *Bidens formosa* and the selective forb *Berkheya speciosa* subsp. *lanceolata*. The dominant species (Table 5.3:A & O) are the grasses *Eragrostis chloromelas* (40%, 20%), *Eragrostis plana* (100%, 100%), *Setaria flabellata* subsp. *natalensis* (70%, 30%) and *Themeda triandra* (30%, 20%).

8. The *Paspalum dilatatum*-*Arundinella nepalensis* Closed Grassland Variant

The *Paspalum dilatatum*-*Arundinella nepalensis* Closed Grassland Variant (Table 5.3:L) is unique to the *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit (Figure 5.1). It is represented by 15 sub-sample relevés and the type is sub-sample relevé 38. It has 6-20 (13) species per sub-sample relevé, with a maximum canopy cover of 45-80% (66%).

This Variant occurs at altitudes of 1 646-1 829m a.s.l. on slopes of 2-9° (4°) with 0-50% (3%) rock cover. Vertic soils (Arcadia and Rensburg Forms) predominate (68%), with 20% soils with restricted drainage (Avalon and Bainsvlei Forms) and 12% Mispahs.

The *Paspalum dilatatum*-*Arundinella nepalensis* Closed Grassland Variant (Tables 5.5:L & 5.6:I, Q & DD) is characterized by the preferential and selective grass *Arundinella nepalensis* (67%), the exclusive forbs *Alchemilla kiwuensis* and *Senecio serratuloides* var. *gracilis*, and the selective forbs *Lobelia* sp. (1662) and *Pseudognaphalium luteo-album*. Other diagnostic species are the forbs *Lobelia angolensis*, *Monopsis decipiens* and *Monopsis scabra*, and the sedge *Schoenoxiphium sparteum*. The dominant species (Table 5.3:A, L & O) are the grasses *Andropogon appendiculatus* (33%, 26%), *Arundinella nepalensis* (67%, 53%), *Eragrostis curvula* (53%, 26%) and *Eragrostis plana* (93%, 80%).

9. The *Paspalum dilatatum*-*Hyparrhenia anamesa* Closed Grassland Variant

The *Paspalum dilatatum*-*Hyparrhenia anamesa* Closed Grassland Variant (Table 5.3) is unique to the *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit (Figure 5.1). It is represented by 4 sub-sample relevés and the type is sub-sample relevé 61. It has 14-19 (16) species per sub-sample relevé, with a maximum canopy cover of 60%.

This Variant occurs at altitudes of 1 684-1 737m a.s.l. on slopes of 3-10° (6°) and it is rock-free. Vertic soils (Rensburg Form) are the most common (50%), with 25% each of Mispahs and soils with restricted drainage (Bainsvlei Form).

The *Paspalum dilatatum*-*Hyparrhenia anamesa* Closed Grassland Variant is characterized by the absence of the species in Species Groups B-H and J-N (Table 5.5), since it has no diagnostic species of its own. The dominant species (Table 5.3:A & O) are the grasses *Eragrostis plana* (100%, 75%) and *Hyparrhenia anamesa* (75%, 75%), and the sedge *Mariscus congestus* (75%, 50%).

10. The *Paspalum dilatatum*-*Eleusine coracana* subsp. *africana* Closed Grassland Variant

The *Paspalum dilatatum*-*Eleusine coracana* subsp. *africana* Closed Grassland Variant (Table 5.3:M) is unique to the *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit (Figure 5.1). It is represented by 9 sub-sample relevés and the type is sub-sample relevé 92. It has 5-22 (13) species per sub-sample relevé, with a maximum canopy cover of 60%.

This Variant occurs at altitudes of 1 722-1 783m a.s.l. on slopes of 2-6° (3°) and it is rock-free. Soils with restricted drainage (Avalon and Bainsvlei Forms) predominate (68%), with 32% freely drained soils (Clovelly Form).

The *Paspalum dilatatum*-*Eleusine coracana* subsp. *africana* Closed Grassland Variant (Tables 5.5:M & 5.6:EE) is characterized by the exclusive, preferential grass *Eleusine coracana* subsp. *africana* (67%), and two other exclusive species, the grass *Eleusine multiflora* and the forb *Sutera* sp. (1501). The grass *Eragrostis tef* and the forb *Brayulinea densa* are both selective species. The dominant species (Table 5.3:A & O) are the grasses *Cynodon hirsutus* (55%, 44%) and *Eragrostis plana* (100%, 67%).

11. The *Eragrostis plana*-*Nidorella anomala* Closed Grassland Variant

The *Eragrostis plana*-*Nidorella anomala* Closed Grassland Variant (Table 5.3:N) does not form part of the three Vegetation Units of the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (Figure 5.1). It is represented by 5 sub-sample relevés and the type is sub-sample relevé 71. It has 4-17 (11) species per sub-sample relevé, with a maximum canopy cover of 50-60% (54%).

This Variant occurs at altitudes of 1 684-1 798m a.s.l. on slopes of 2-7° (4°) and it is rock-free. Soils with restricted drainage (Avalon and Bainsvlei Forms) are the most common (80%), with 20% freely drained soils (Clovelly Form). All of the soils in this Grassland Variant have a high (35-55%) clay content in the A horizon. The other Variants of the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type have only from 0-60% (34%) of the soils with a clay content of ≥ 35 -55%.

The *Eragrostis plana*-*Nidorella anomala* Closed Grassland Variant (Tables 5.5:N & 5.6:FF) is characterized by the diagnostic forb *Hypericum aethiopicum* subsp. *sonderi*, the preferential forb *Nidorella anomala* (60%) and the selective forb *Plantago myosuroides*. The dominant species (Table 5.3:A & O) are the grasses *Eragrostis chloromelas* (60%, 40%), *Eragrostis plana* (80%, 80%) and *Hyparrhenia dregeana* (100%, 100%).

CHAPTER 6

ORDINATION: FLORISTIC AND HABITAT CORRELATION

The data were ordinated (see Section 4.3.2) to determine whether DECORANA detected any discontinuities in the data, and whether such discontinuities supported the results of the classification. A further objective was to correlate the ordination with environmental (habitat) factors to ascertain whether the sequence of the syntaxa along the DECORANA axes reflected any environmental gradients which might be responsible for the differentiation of the individual syntaxa. Floristic gradients were also determined so that the environmental gradients could be related to species distributions.

An eigenvalue is calculated for each of the axes generated by the ordination. This value indicates the amount of the variation in the data set that is reflected by a given axis (e.g. an eigenvalue of 0,721 represents 72,1% of the variation) (Hill 1979a; Bloem 1988). Any axis that has an eigenvalue that is considerably lower than the highest eigenvalue recorded in the ordination will probably be of little significance (Hill 1979a) in terms of reflecting environmental gradients.

The DECORANA output is interpreted by constructing two-dimensional diagrams using different combinations of the DECORANA axes. The units of each axis are "units of ordination-length" (Hill 1979a), measured in standard deviations (sd), and the position of a syntaxon is plotted from its standard deviation values for any two axes. In the ordination diagram similar syntaxa (with respect to one or more floristic and/or environmental factors) are situated close to one another, with dissimilar syntaxa at some distance from one another.

The axes of the ordination directly reflect beta diversity when syntaxa or sub-sample relevés and species are ordinated (Hill 1979a; Bloem 1988). Beta diversity is a measure of "the extent of change" or the "degree of difference" in the species composition of a coenocline (Whittaker 1972, 1977), which is defined as "a sequence of natural communities associated with an environmental gradient" (Allaby 1977). An axis length (or "gradient length": Hill 1979a) of 4,0sd corresponds to the distance within which the bell-shaped distribution curve, of binomial or Gaussian form (Whittaker 1972), of a species is expressed (Hill &

TABLE 6.1 The eigenvalues and gradient lengths of the first four axes of the DECORANA ordination of the data for the Amersfoort vegetation.

AXIS	EIGENVALUE	GRADIENT LENGTH (sd)
1	0,608	4,821
2	0,306	3,100
3	0,180	1,918
4	0,136	1,911

Gauch 1980). Thus if two syntaxa ("communities") or sub-sample relevés are separated by 4,0sd or more in an ordination, they will have no, or few, species in common, and may thus be said to have a high beta diversity.

Where a coenocline has a high beta diversity, the species occurring along the gradient tend (by virtue of increasing competition resulting from an increase in the number of species occurring along the gradient) to have narrower distributions along the gradient, i.e. the range of environmental conditions in which a species occurs becomes restricted (Whittaker 1972).

Three data sets were ordinated - the entire data set for the Amersfoort vegetation and the data sets for each of the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types. In all instances the ordinations were correlated with the environmental data by superimposing the actual values of the different environmental variables on the positions of the syntaxa in the ordination diagrams, so making it possible to determine whether any gradients were present. The term "gradient" is used with the qualification that it represents a trend rather than a direct or an absolute gradient, as there are deviations from the established patterns. Because of the discrepancies in the gradient data, all data were subjected to statistical analysis (see Chapter 7) to determine the validity of the conclusions drawn based on the interpretation of the ordination diagrams.

6.1 THE AMERSFOORT VEGETATION

The data for the four Vegetation Types (see Table 5.6) were ordinated. Axes 1 and 2 respectively represent 60,8% and 30,6% of the variation of the data (Table 6.1), and together these two axes represent a sufficiently high percentage of the variation to adequately reflect the structure of the data (Figure 6.1).

Axis 1 has a gradient length greater than 4,0sd (Table 6.1) and thus reflects a high beta diversity. This is as a result of the completely different species compositions of the *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types (see Table 5.6), which are situated at the two extremes of the axis (Figure 6.1).

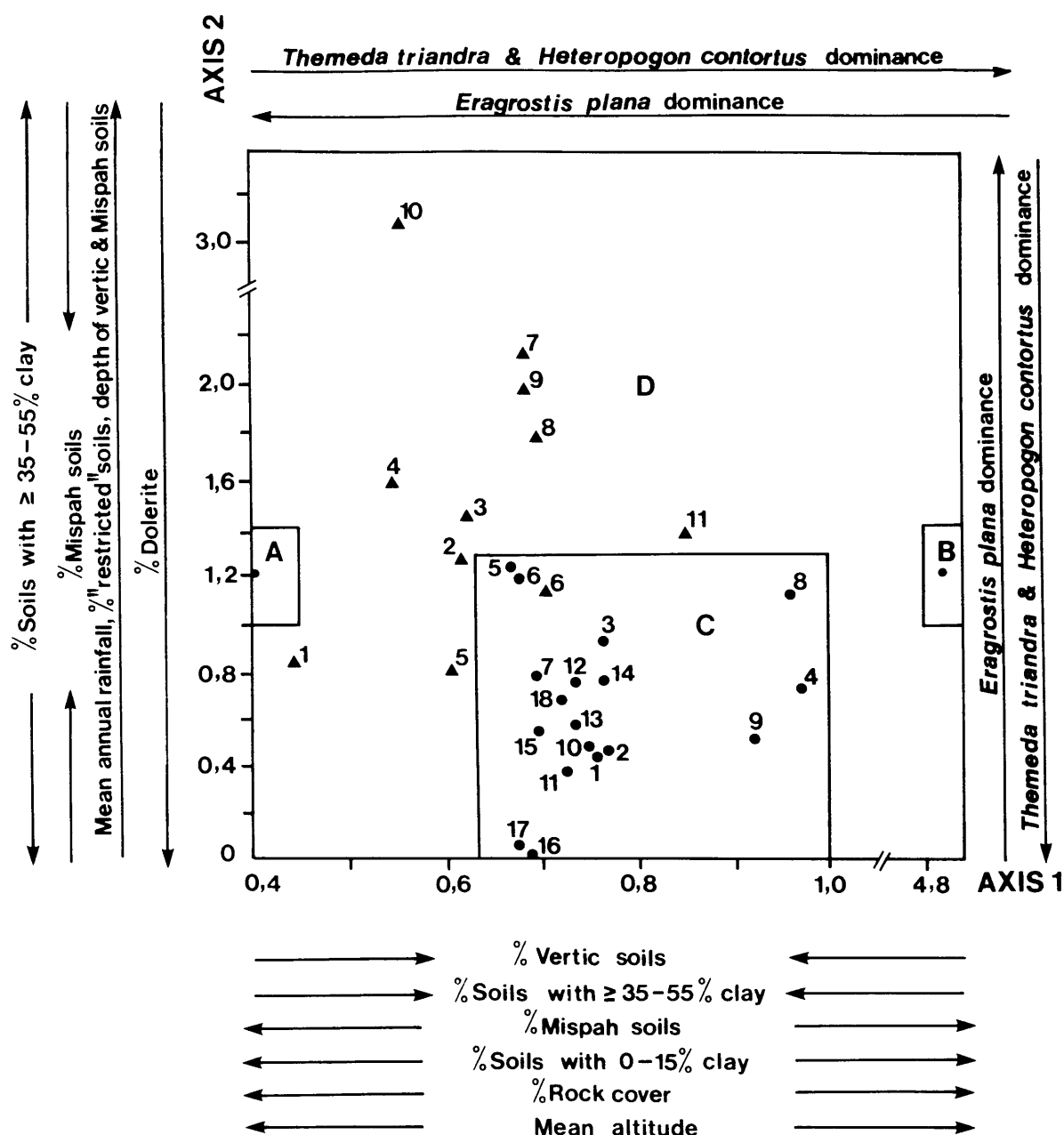


FIGURE 6.1 DECORANA ordination of the Amersfoort vegetation. Axes 1 & 2 represent the main environmental gradients as shown, where the direction of an arrow indicates the direction in which the value of an environmental variable increases. "Restricted" soils are soils with restricted drainage. (Axes measured in sd units).

Axis 2 has a gradient length of less than 4,0sd (Table 6.1) and thus reflects a low beta diversity. This axis does not reflect the difference in the species compositions of the *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types (both Vegetation Types have a value of ca 1,20sd for this axis) but has been constructed in response to the species compositions of the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types (Figure 6.1). The low beta diversity reflected by this axis indicates that there are many species common to both of these Vegetation Types. Nevertheless, the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types are clearly distinguishable by an arbitrarily drawn line (Figure 6.1), although the inclusion of the *Paspalum dilatatum*-*Senecio erubescens* var. *crepidifolius* Variant (Variant ▲6 in Figure 6.1) of the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Type in the *Tristachya leucothrix*-*Themeda triandra* Vegetation Type is anomalous.

ENVIRONMENTAL AND FLORISTIC CORRELATION

Two types of gradient are represented by axis 1. There is an environmental gradient that distinguishes the singularity of the habitats of the *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types, hence their positioning at the two extremes of this axis (Figure 6.1). However, in many respects the habitats of these two Vegetation Types are more similar to one another than they are to the habitats of the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types. The environmental gradients thus resemble a normal distribution curve, with the gradients beginning at the two extremes of the axis and either increasing or decreasing towards the center of the axis.

Axis 1 also represents a floristic gradient operative within the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types only. This gradient begins at one extreme of the axis and either decreases or increases towards the other extreme (Figure 6.1).

Six environmental gradients are represented by axis 1 (Figure 6.1). From both extremes towards the center of the axis there is an increase in the percentage of vertic soils, a decrease in the percentage of Mispah soils and correspondingly there is an increase in the percentage of soils with a high (≥ 35 -55%) clay content and a decrease in the percentage of soils with a low (0-15%) clay content

in the A horizon. There is also a decrease in the mean percentage of rock cover and the mean altitude.

The floristic gradient represented by axis 1 reflects a change in the dominant grass species and the percentage constancy with which these species occur (see Chapter 5) in the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types (Figure 6.1). From left to right on the axis there is a change in dominance from *Eragrostis plana* to *Themeda triandra* and *Heteropogon contortus*, and a corresponding decrease in the percentage constancy of occurrence of *Eragrostis plana* with an increase in the percentage constancy of occurrence of *Themeda triandra* and *Heteropogon contortus*. There is also an increase in the mean number of species per sub-sample relevé from left to right.

Axis 2 represents seven environmental gradients (Figure 6.1). From the top to the bottom of the axis there is a decrease in the mean annual rainfall, the percentage of soils with restricted drainage and the mean depths of both vertic and Mispah soils, with an increase in the percentage of dolerite. From both extremes towards the center of the axis there is an increase in the percentage of Mispah soils and a decrease in the percentage of soils with a high (≥ 35 -55%) clay content in the A horizon.

The floristic gradient represented by axis 2 is similar to that of axis 1. At the top of the axis *Eragrostis plana* is dominant and has a high percentage constancy of occurrence, whilst at the bottom of the axis *Themeda triandra* and *Heteropogon contortus* are the dominant species with a high percentage constancy of occurrence. There is also an increase in the mean number of species per sub-sample relevé from the top to the bottom of the axis.

Axis 1 detects the specific habitats of the *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types, but does not establish what differentiates between them. The environmental gradients determined for axis 1 reveal that both of these Vegetation Types have a low percentage of vertic soils and soils with a high (≥ 35 -55%) clay content in the A horizon. They occur at high altitude and have a high percentage of Mispah soils and soils with a low (0-15%) clay content in the A horizon, and they have a high mean percentage rock cover.

There is a considerable overlap of the Variants of the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types on axis 1, which makes it difficult to establish what differentiates between them in terms of habitat. There is less overlap of the Variants on axis 2 and it is therefore possible to state that the *Tristachya leucothrix*-*Themeda triandra* Vegetation Type has more dolerite, and that the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Type has the higher mean annual rainfall, more soils with restricted drainage and deeper Mispah and vertic soils. The statistical analysis of these data (see Chapter 7) does not, however, detect a statistically significant difference in the amount of dolerite nor in the depths of the Mispah soils in these two Vegetation Types.

The floristic gradients that were established indicate the change in the dominant grass species from *Eragrostis plana* in the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Type to *Themeda triandra* and *Heteropogon contortus* in the *Tristachya leucothrix*-*Themeda triandra* Vegetation Type, with the latter Vegetation Type having the higher mean number of species per sub-sample relevé.

The inclusion of the *Paspalum dilatatum*-*Senecio erubescens* var. *crepidifolius* Variant (Variant ▲6 in Figure 6.1) of the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Type within the *Tristachya leucothrix*-*Themeda triandra* Vegetation Type in the ordination diagram is not determined by the floristic gradients, since *Eragrostis plana* occurs with 100% constancy in this Variant. In terms of habitat conditions, this Variant falls approximately in the center of both axes, where the group of centrally placed Variants all have similar values for the different environmental variables involved. The positioning of the *Paspalum dilatatum*-*Senecio erubescens* var. *crepidifolius* Variant may thus be arbitrary and it may as easily have been placed within the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Type in the ordination diagram. It is also possible that environmental gradients other than those investigated during this survey are the primary gradients on axes 1 and 2, and that it is in response to these gradients that the *Paspalum dilatatum*-*Senecio erubescens* var. *crepidifolius* Variant is placed amongst the Variants of the *Tristachya leucothrix*-*Themeda triandra* Vegetation Type.

TABLE 6.3 The eigenvalues and gradient lengths of the first four axes of the DECORANA ordination of the data for the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type

AXIS	EIGENVALUE	GRADIENT LENGTH (sd)
1	0,384	2,945
2	0,234	2,227
3	0,152	2,232
4	0,020	1,568

6.2 THE *Tristachya leucothrix*-*Themeda triandra* CLOSED GRASSLAND TYPE

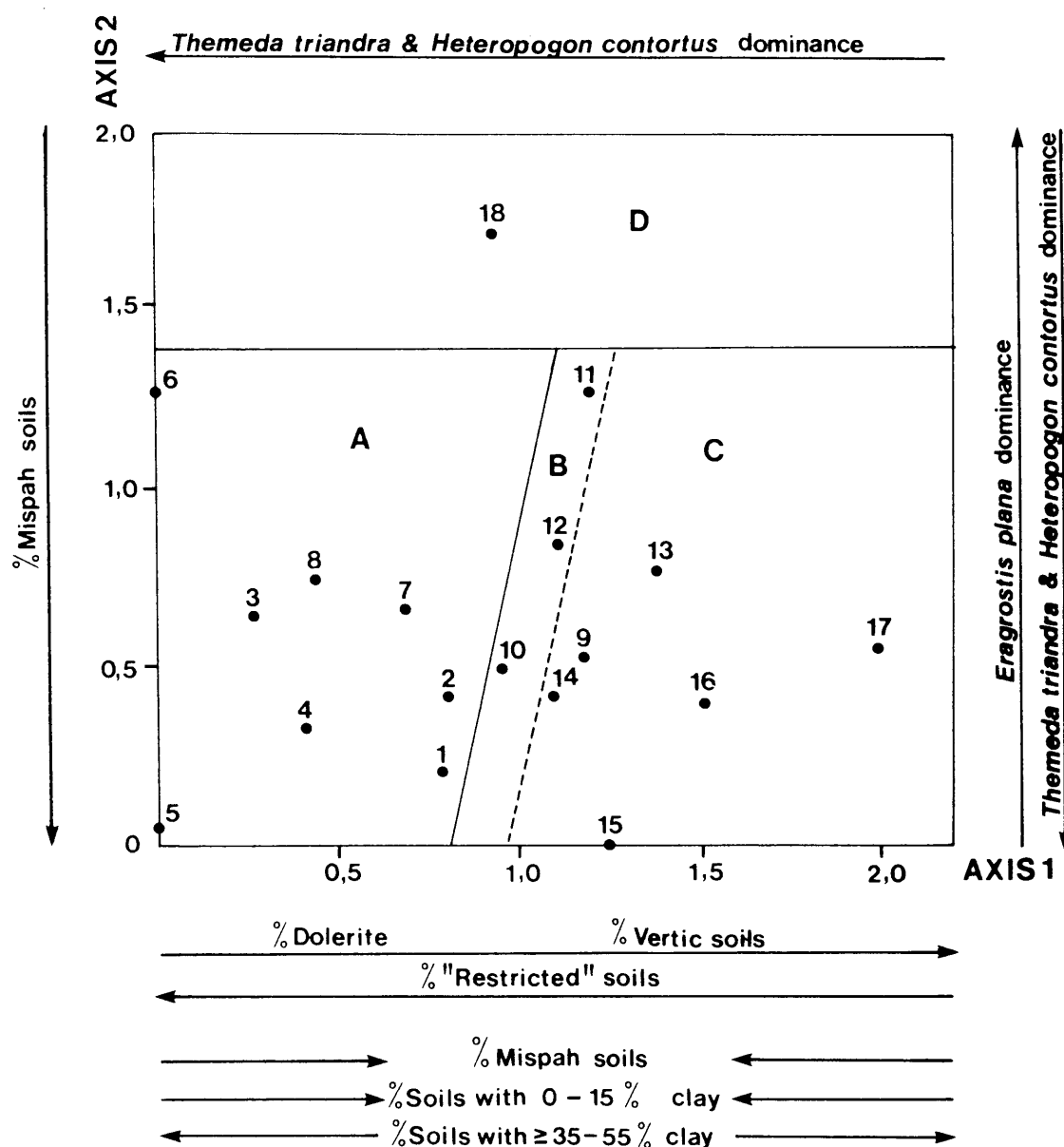
The data for the 18 Variants of the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type (see Table 5.6) were ordinated. Axes 1 and 2 respectively represent 24,0% and 16,7% of the variation of the data (Table 6.2), and although these two axes together represent less than 50% of the variation of the data, the structure of the data is reflected, permitting the delineation of the groupings determined by the classification (Figure 6.2).

Axes 1 and 2 both have gradient lengths of less than 4,0sd (Table 6.2), indicating a low beta diversity. There are therefore a large number of species common to all of the Variants of this Vegetation Type. Nevertheless, the ordination confirmed the division of this Vegetation Type into the *Themeda triandra*-*Berkheya setifera* and the *Themeda triandra*-*Hermannia depressa* Vegetation Units, as well as the division of the latter Vegetation Unit into the *Hermannia depressa*-*Eragrostis plana* and the *Hermannia depressa*-*Salvia repens* var. *transvaalensis* Vegetation Sub-Units (Figure 6.2), although the inclusion of the *Berkheya setifera*-*Eragrostis chloromelas* Variant (Variant 9 in Figure 6.2) of the *Themeda triandra*-*Berkheya setifera* Vegetation Unit in the *Themeda triandra*-*Hermannia depressa* Vegetation Unit is anomalous. The DECORANA ordination also confirms the exclusion of the *Themeda triandra*-*Limeum viscosum* subsp. *viscosum* Closed Grassland Variant (Variant 18 in Figure 6.2) from the Vegetation Units of the classification (see Chapter 5).

ENVIRONMENTAL AND FLORISTIC CORRELATION

Axis 1 reflects the greatest variation in the data (Table 6.2) and represents six environmental gradients which may contribute to the differentiation of the different syntaxa (Figure 6.2). From left to right on axis 1 there is an increase in the percentage of dolerite and vertic soils, and a decrease in the percentage of soils with restricted drainage. From the two extremes of the axis towards the center there is an increase in the percentage of Mispah soils and the percentage of soils with a low (0-15%) clay content, and a corresponding decrease in the percentage of soils with a high (≥ 35 -55%) clay content in the A horizon.

The floristic gradient represented by axis 1 reflects a decrease in the percentage constancy of occurrence and the frequency of dominance of *Themeda triandra* and *Heteropogon contortus* from left to right, with a corresponding decrease in



- A The *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit
- B+C The *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit
- B The *Hermannia depressa*-*Eragrostis plana* Closed Grassland Sub-Unit
- C The *Hermannia depressa*-*Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit
- D The *Themeda triandra*-*Limeum viscosum* subsp. *viscosum* Closed Grassland Variant

FIGURE 6.2 DECORANA ordination of the Variants (1-18) of the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type. Axes 1 & 2 represent the main environmental gradients as shown, where the direction of an arrow indicates the direction in which the value of an environmental variable increases. "Restricted" soils are soils with restricted drainage. (Axes measured in sd units).

the mean percentage maximum canopy cover and the mean number of species per sub-sample relevé.

Axis 2 reflects one environmental gradient, namely an increase in the percentage of Mispah soils from the top to the bottom of the axis (Figure 6.2). Floristically, from the top to the bottom of the axis there is a change in the frequency of dominance from *Eragrostis plana* to *Themeda triandra* and *Heteropogon contortus* (Figure 6.2), with an increase in the mean percentage maximum canopy cover and the mean number of species per sub-sample relevé.

The ordination of the data on axis 1 reveals that the *Themeda triandra-Berkheya setifera* Closed Grassland Unit has a higher percentage of soils with restricted drainage whilst the *Themeda triandra-Hermannia depressa* Closed Grassland Unit has more dolerite and a higher percentage of vertic soils. Furthermore, the *Hermannia depressa-Eragrostis plana* Closed Grassland Sub-Unit has the highest percentage of Mispah soils and soils with a low (0-15%) clay content, with few soils with a high ($\geq 35-55\%$) clay content in the A horizon, as compared to the *Themeda triandra-Berkheya setifera* Closed Grassland Unit and the *Hermannia depressa-Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit.

Axis 2 is the axis chiefly responsible for the position of the *Themeda triandra-Limeum viscosum* subsp. *viscosum* Closed Grassland Variant, which is situated at some distance from the other Variants in the ordination diagram (Figure 6.2). This confirms the finding of the classification that this Variant differs in some respect from all of the other Variants of the *Tristachya leucothrix-Themeda triandra* Closed Grassland Type. The environmental gradient represented by axis 2 reveals that the *Themeda triandra-Limeum viscosum* subsp. *viscosum* Closed Grassland Variant has a low percentage of Mispah soils, but the primary distinguishing characteristic of this Variant, namely a high percentage of soils with 0-15% clay in the A horizon (see Chapter 5), is not revealed by this axis.

In the ordination diagram the *Berkheya setifera-Eragrostis chloromelas* Variant (Variant 9 in Figure 6.2) of the *Themeda triandra-Berkheya setifera* Closed Grassland Unit falls within the *Themeda triandra-Hermannia depressa* Closed Grassland Unit. This may be because this Variant falls approximately in the center of both axes, amongst a group of Variants that have similar values for the different environmental factors, which may have resulted in a somewhat arbitrary positioning of this Variant by DECORANA. Alternatively, its position may have been determined by the fact that both this Variant and the *Eragrostis plana-*

TABLE 6.3 The eigenvalues and gradient lengths of the first four axes of the DECORANA ordination of the data for the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type

AXIS	EIGENVALUE	GRADIENT LENGTH (sd)
1	0,384	2,945
2	0,234	2,227
3	0,152	2,232
4	0,020	1,568

Heteropogon contortus Variant (Variants 9 and 10 in Figure 6.2) are without diagnostic species (see Table 5.6), and may represent syntaxa that are ecotonal between the two Vegetation Units. A further possibility is that the *Berkheya setifera-Eragrostis chloromelas* Variant was placed in the *Themeda triandra-Hermannia depressa* Closed Grassland Unit in response to environmental gradients other than those measured during this survey.

6.3 THE *Eragrostis chloromelas-Eragrostis plana* CLOSED GRASSLAND TYPE

The data for the 11 Variants of the *Eragrostis chloromelas-Eragrostis plana* Closed Grassland Type (see Table 5.6) were ordinated. Axes 1, 2 and 3 respectively represent 38,4%, 23,4% and 15,2% of the variation of the data (Table 6.3), and axis 1 together with either axis 2 (Figure 6.3) or axis 3 (Figure 6.4) represents a sufficiently high percentage of the variation to adequately reflect the structure of the data.

Axes 1, 2 and 3 all have gradient lengths of less than 4,0sd (Table 6.3), indicating a low beta diversity. There are therefore a large number of species common to all of the Variants of this Vegetation Type. Nevertheless, the ordination supports the classification (see Chapter 5) in that it also detects a gradient from the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit to the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit, with Variants 3 to 7 forming a region of overlap between the two extremes (Figures 6.3 & 6.4). The DECORANA ordination also confirms the exclusion of the *Eragrostis plana-Nidorella anomala* Closed Grassland Variant (Variant 11 in Figures 6.3 & 6.4) from the Vegetation Units of the classification (see Chapter 5).

ENVIRONMENTAL AND FLORISTIC CORRELATION

Axis 1 reflects the greatest variation in the data (Table 6.3) and represents three environmental gradients which may contribute to the differentiation of the different syntaxa (Figures 6.3 & 6.4). From left to right on axis 1 there is an increase in the percentage of Mispah soils and a decrease in the percentage of restricted soils and soils with a high ($\geq 35-55\%$) clay content in the A horizon.

Axis 2 represents three environmental gradients (Figure 6.3). From the top to the bottom of the axis there is an increase in the percentage of vertic soils and a decrease in the percentage of soils with restricted drainage. From the two

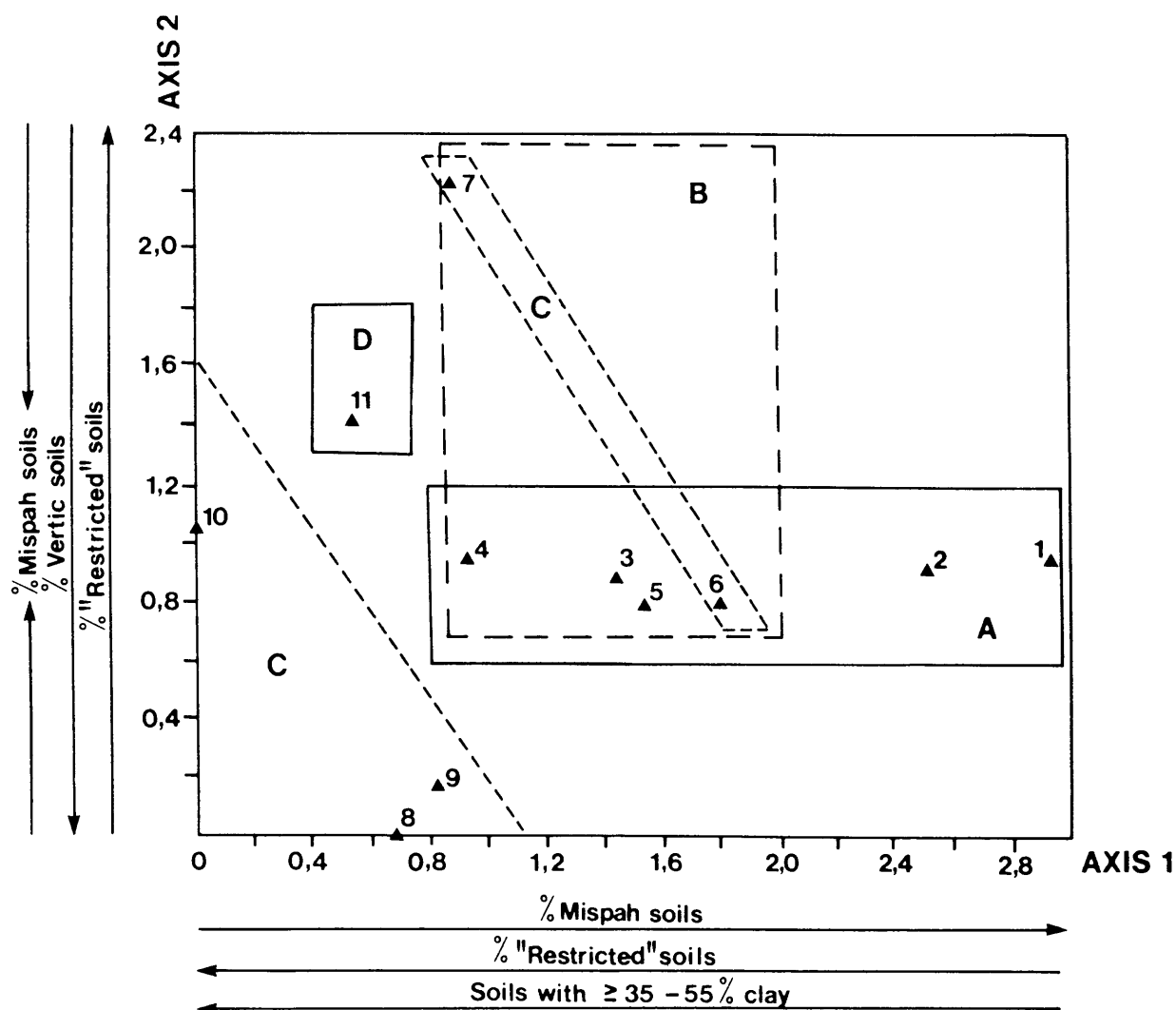


FIGURE 6.3 DECORANA ordination of the Variants (1-11) of the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type. Axes 1 and 2 represent the main environmental gradients as shown, where the direction of an arrow indicates the direction in which the value of an environmental variable increases. "Restricted" soils are soils with restricted drainage. (Axes measured in sd units).

extremes of the axis towards the center there is an increase in the percentage of Mispah soils.

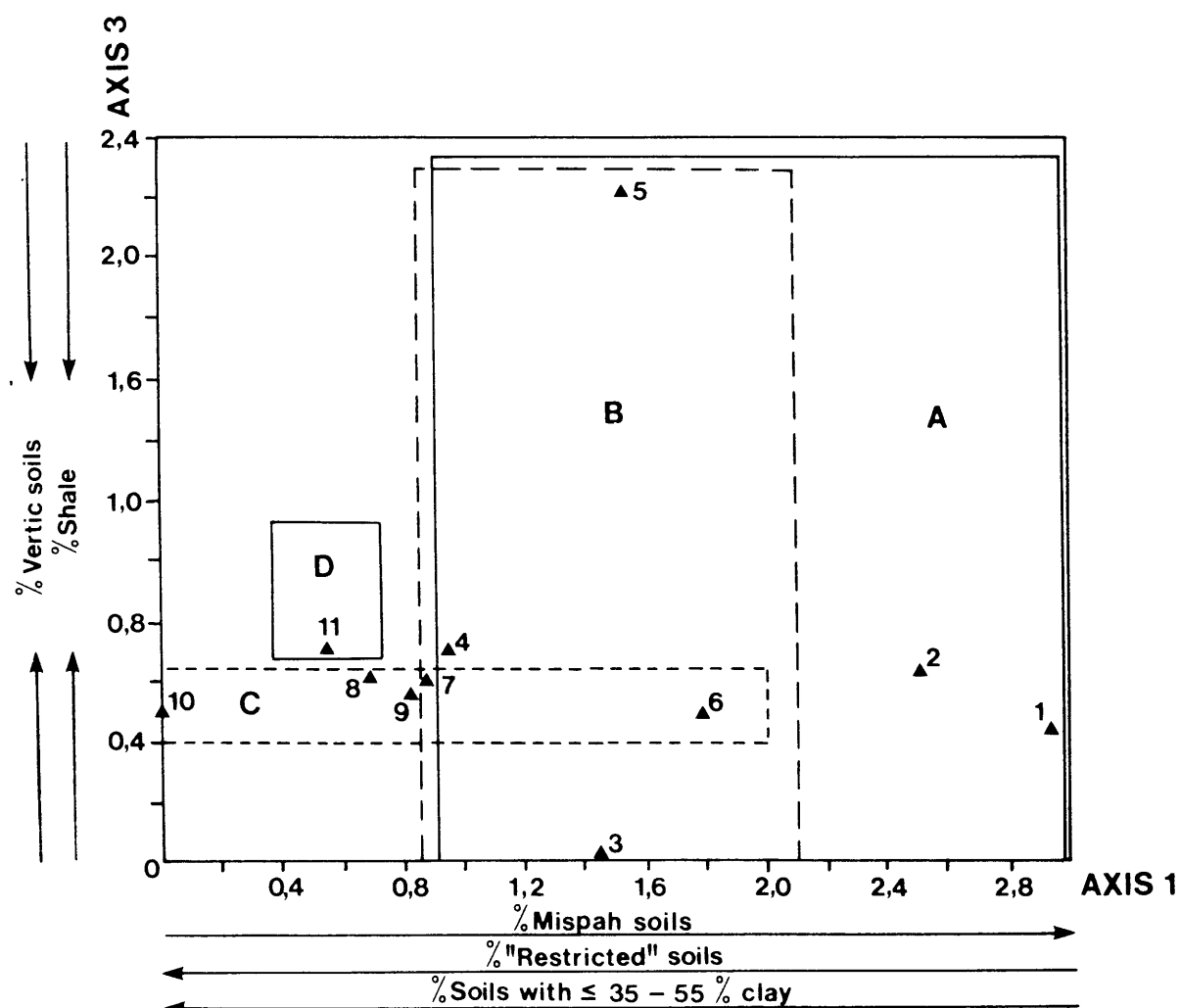
Two environmental gradients are represented by axis 3 (Figure 6.4). From both extremes towards the center of the axis there is an increase in the percentage of shale and the percentage of vertic soils.

No floristic gradients are represented by the three DECORANA axes in Figures 6.3 and 6.4, since *Eragrostis chloromelas* and *Eragrostis plana* are the most commonly dominant species of the Vegetation Type, being dominant in most of the constituent Variants.

The ordination of the data on axis 1 reveals that the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit has the highest percentage of Mispah soils and that the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit has the highest percentage of soils with restricted drainage and soils with a high ($\geq 35-55\%$) clay content in the A horizon, although the latter correlation is not confirmed by the statistical analysis of the data (see Chapter 7). There is considerable overlap of the Variants comprising the three Vegetation Units on axes 2 and 3, which makes it difficult to establish what differentiates between them in terms of habitat, despite the fact that environmental gradients are represented by these axes.

In Figure 6.3 there is a distinct discontinuity within the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit, with Variants 6 and 7 separated from the remaining Variants of the Vegetation Unit, although the integrity of the Vegetation Unit is confirmed in Figure 6.4. The reason for the discontinuity in Figure 6.3 is unknown, since Variants 6 and 7 do not differ markedly from the remaining Variants of this Vegetation Unit with respect to either floristic (see Table 5.6) or environmental factors. It is possible that the discontinuity is in response to environmental gradients not measured during this survey, which run diagonally between axes 1 and 2.

In both ordination diagrams (Figures 6.3 & 6.4) the exclusion of the *Eragrostis plana-Nidorella anomala* Closed Grassland Variant (Variant 11) from the Vegetation Units of the *Eragrostis chloromelas-Eragrostis plana* Closed Grassland Type is confirmed. The *Eragrostis plana-Nidorella anomala* Closed Grassland Variant is centrally situated on both axes 2 and 3, and the reason for its exclusion from the three Vegetation Units is not apparent. Axis 1 reveals that the *Eragrostis*



- A The *Eragrostis plana*-*Aristida bipartita* Closed Grassland Unit
- B The *Eragrostis plana*-*Conyza podocephala* Closed Grassland Unit
- C The *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit
- D The *Eragrostis plana*-*Nidorella anomala* Closed Grassland Variant

FIGURE 6.4 DECORANA ordination of the Variants (1-11) of the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type. Axes 1 and 3 represent the main environmental gradients as shown, where the direction of an arrow indicates the direction in which the value of an environmental variable increases. "Restricted" soils are soils with restricted drainage. (Axes measured in sd units).

plana-Nidorella anomala Closed Grassland Variant has a high percentage of restricted soils and soils with a high ($\geq 35-55\%$) clay content in the A horizon, and a low percentage of Mispah soils. However, the primary distinguishing characteristic of this Variant, namely that it has the highest percentage of soils with a high ($\geq 35-55\%$) clay content in the A horizon in the Vegetation Type (see Chapter 5), is not readily discernable.

CHAPTER 7

STATISTICAL ANALYSIS AND HABITAT DESCRIPTION

The classification of the Amersfoort vegetation identified four floristically distinct Vegetation Types (see Chapter 5), of which only the *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types occur in specific habitats.

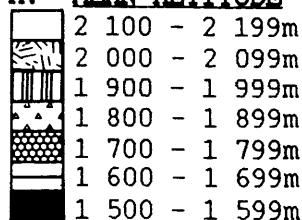
It is not possible to differentiate between the habitats of most of the Variants of the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types (see Figure 5.1), since few of the Variants display any specific habitat features (see Chapter 5). The two exceptions are the *Themeda triandra*-*Limeum viscosum* subsp. *viscosum* Closed Grassland Variant (of the *Tristachya leucothrix*-*Themeda triandra* Vegetation Type) and the *Eragrostis plana*-*Nidorella anomala* Closed Grassland Variant (of the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Type), both of which differ from the remaining Variants with respect to the clay content in the A horizon of the soil (see Chapter 5).

In order to determine whether there were any significant differences in the habitat features of the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types, the following syntaxa were compared (see Figure 5.1) and their habitat data were subjected to statistical analysis (see Section 4.3.4):

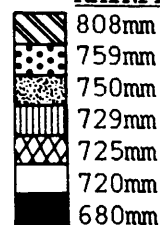
- 7.1 The *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type and the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type
- 7.2 The *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit and the *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit
- 7.3 The *Hermannia depressa*-*Eragrostis plana* Closed Grassland Sub-Unit and the *Hermannia depressa*-*Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit
- 7.4 The *Eragrostis plana*-*Aristida bipartita* Closed Grassland Unit, the *Eragrostis plana*-*Conyza podocephala* Closed Grassland Unit and the *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit

LEGEND

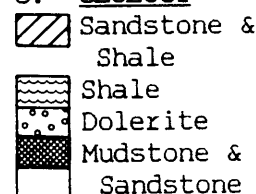
A. MEAN ALTITUDE



B. MEAN ANNUAL RAINFALL



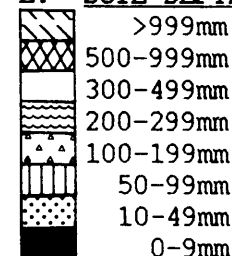
C. GEOLOGY



D. SOIL TYPES

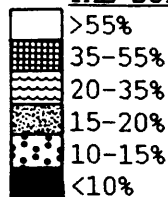


E. SOIL DEPTHS

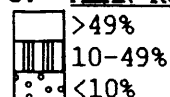


- E1. Mispah soils
E2. Vertic soils
E3. Soils with restricted drainage
E4. Freely drained soils

F. CLAY CONTENT IN THE A HORIZON OF THE SOIL



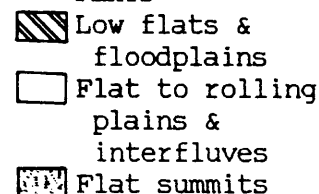
G. MEAN ROCK COVER



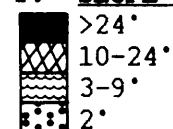
H. GEOMORPHOLOGY SLOPES



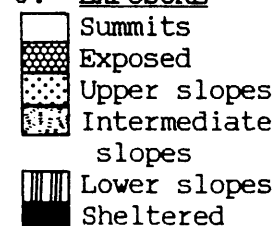
FLATS



I. SLOPE MAGNITUDE



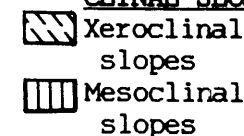
J. EXPOSURE



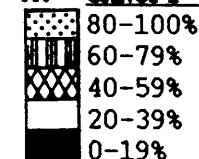
K. ASPECT



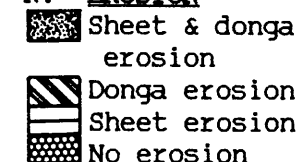
L. MESO- & XEROCLINAL SLOPES



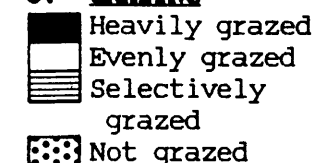
M. CANOPY COVER



N. EROSION



O. GRAZING



P. FIRE



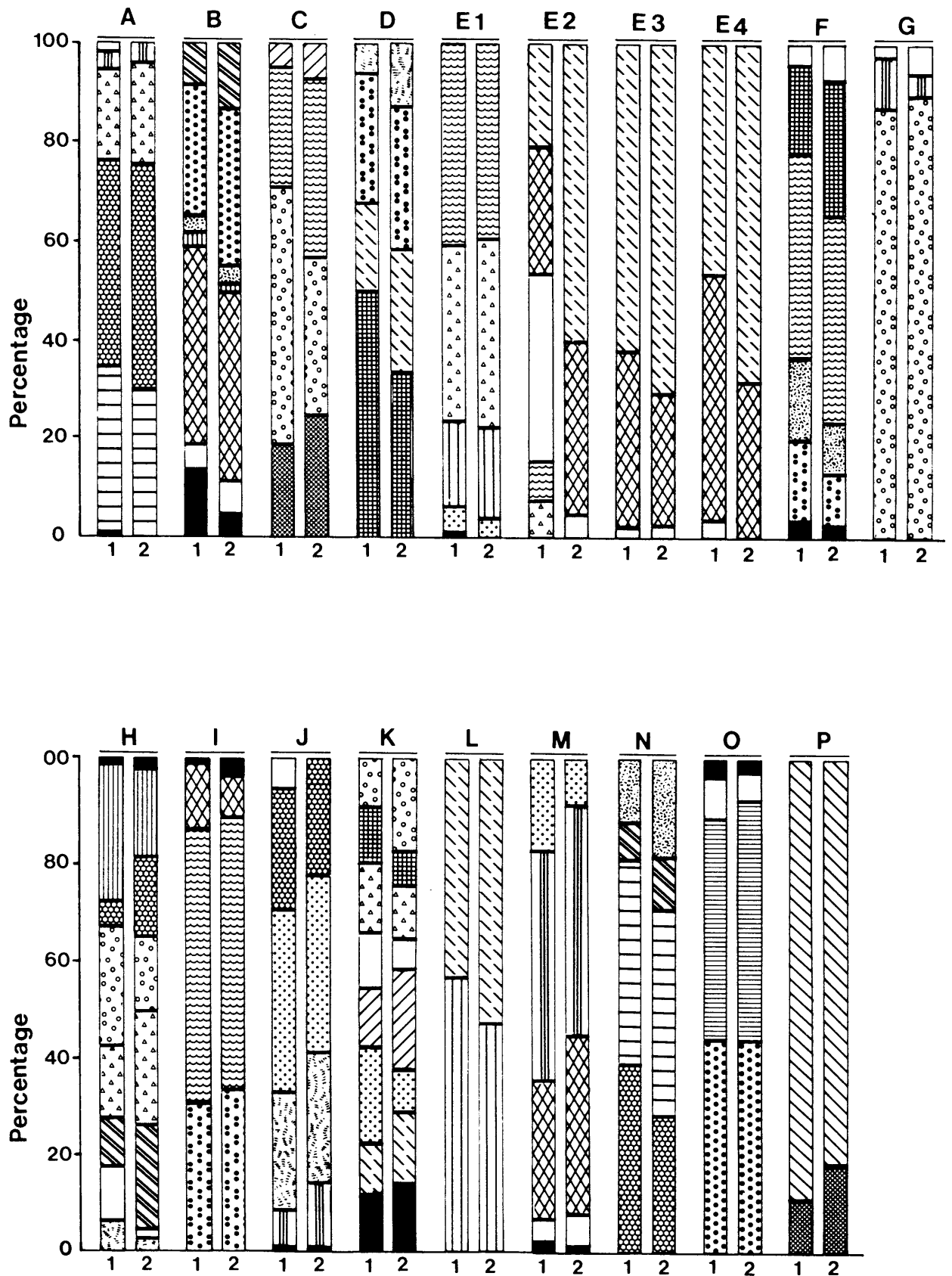


FIGURE 7.1 Comparison of the habitat data for the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type (1) and the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (2).

The results of the statistical analyses are given in Appendix 3 and in the text, e.g. "Appendix 3:1" refers to Table 1 in Appendix 3. In the text reference is made only to the statistically significant differences between syntaxa, where a level of significance of $\geq 95\%$ is considered to be of ecological importance.

7.1 COMPARISON OF THE HABITATS OF THE *Tristachya leucothrix*-*Themeda triandra* CLOSED GRASSLAND TYPE AND THE *Eragrostis chloromelas*-*Eragrostis plana* CLOSED GRASSLAND TYPE

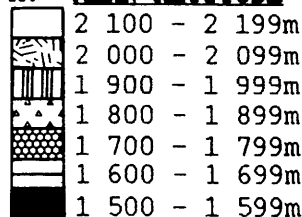
The *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type (Figure 7.1:B) receives predominantly low ($\leq 729\text{mm}$) rainfall whilst the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type receives approximately equal quantities of low and high ($\geq 750\text{mm}$) rainfall, and has the higher mean annual rainfall (Appendix 3:1).

The primary difference in the geomorphology of these two Vegetation Types (Figure 7.1:H) is that the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type has a greater percentage of low flats and floodplains, and debris slopes, and fewer midslopes than the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type. In both Vegetation Types (Figure 7.1:I) slopes of $\geq 10^\circ$ are of infrequent occurrence, comprising only ca 12% of the total. Nevertheless, where the slope of the land is $\geq 10^\circ$, the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type has a greater mean slope magnitude (Appendix 3:1) by virtue of its having a higher percentage of slopes of $\geq 25^\circ$. The aspect of the slopes is very variable in both Vegetation Types (Figure 7.1:K) but the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type (Figure 7.1:L) has a higher percentage of meso-clinal slopes.

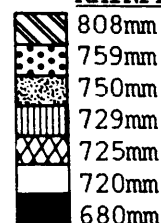
The *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type (Figure 7.1:D) has more Mispah soils whilst the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type has more vertic soils, and these are deeper (Figure 7.1:E2) than the vertic soils of the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type. The clay content in the A horizon of the soils in both Vegetation Types (Figure 7.1:F) is predominantly $\geq 15\text{--}20\%$, but the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland has a higher percentage of soils with a clay content of $\geq 35\text{--}55\%$, as a result of the higher percentage of vertic soils in this Vegetation Type (Figure 7.1:D).

LEGEND

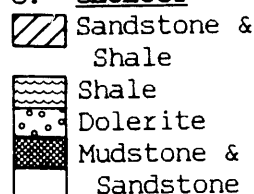
A. MEAN ALTITUDE



B. MEAN ANNUAL RAINFALL



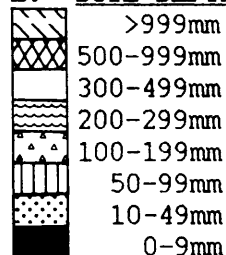
C. GEOLOGY



D. SOIL TYPES

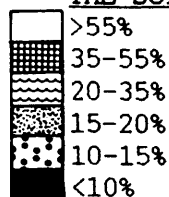


E. SOIL DEPTHS

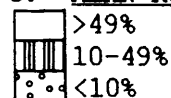


- E1. Mispah soils
- E2. Vertic soils
- E3. Soils with restricted drainage
- E4. Freely drained soils

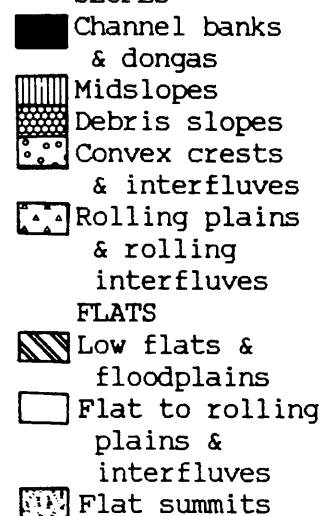
F. CLAY CONTENT IN THE A HORIZON OF THE SOIL



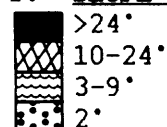
G. MEAN ROCK COVER



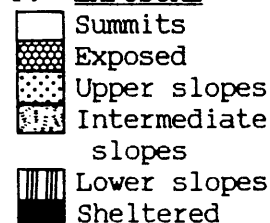
H. GEOMORPHOLOGY SLOPES



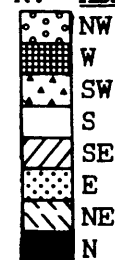
I. SLOPE MAGNITUDE



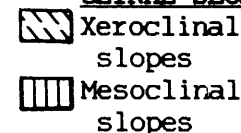
J. EXPOSURE



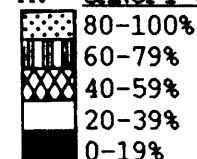
K. ASPECT



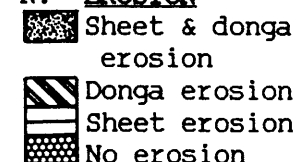
L. MESO- & XEROCLINAL SLOPES



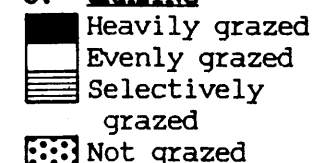
M. CANOPY COVER



N. EROSION



O. GRAZING



P. FIRE



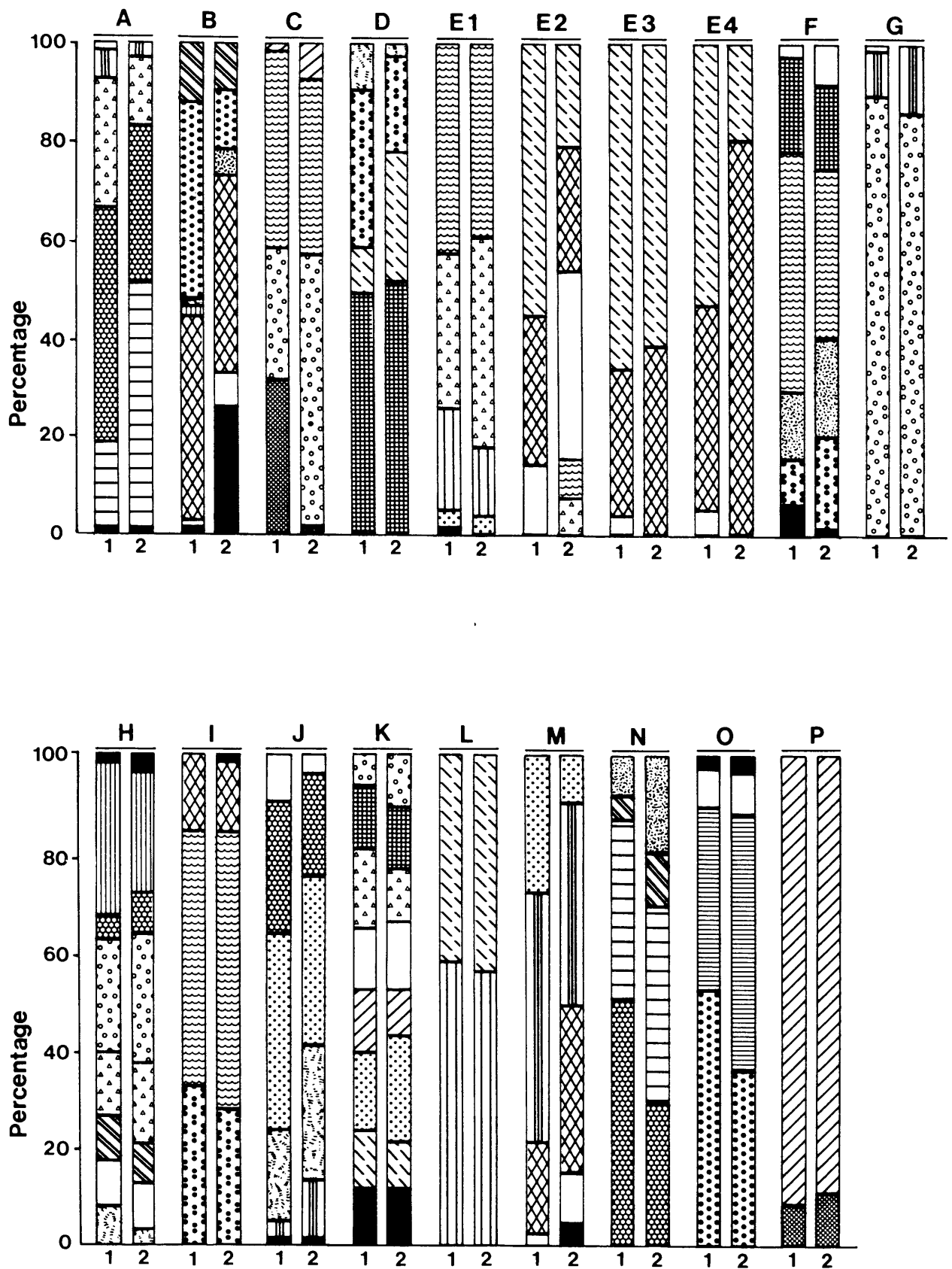


FIGURE 7.2 Comparison of the habitat data for the *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit (1) and the *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit (2).

Where the rock cover is $\geq 10\%$ (Figure 7.1:G) the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type has a higher mean percentage of rock cover (Appendix 3:1). This is correlated with the higher percentage of steep slopes and debris slopes in this Vegetation Type, since a rock cover of $\geq 10\%$ most frequently occurs on slopes of $\geq 10^\circ$ (Appendix 2).

The *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (Figure 7.1:N) has a lower percentage of land that has not been eroded and a higher percentage of land that has been badly eroded (i.e. donga erosion plus donga and sheet erosion) than the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type.

7.2 COMPARISON OF THE HABITATS OF THE *Themeda triandra*-*Berkheya setifera* CLOSED GRASSLAND UNIT AND THE *Themeda triandra*-*Hermannia depressa* CLOSED GRASSLAND UNIT

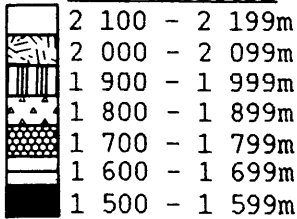
Both the *Themeda triandra*-*Berkheya setifera* and the *Themeda triandra*-*Hermannia depressa* Closed Grassland Units (Figure 7.2:A) occur predominantly at low ($< 1\ 800\text{m}$) altitude, but the former has more sub-sample relevés at high ($\geq 1\ 800\text{m}$) altitude and has the higher mean altitude (Appendix 3:3). The *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit (Figure 7.2:B) receives predominantly low ($\leq 729\text{mm}$) rainfall whilst the *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit receives approximately equal quantities of low and high ($\geq 750\text{mm}$) rainfall, and has the higher mean annual rainfall (Appendix 3:3).

The primary difference in the geomorphology of these two Vegetation Units (Figure 7.2:H) is that the *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit has a higher percentage of midslopes and fewer debris slopes than the *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit. The *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit (Figure 7.2:J) has more sub-sample relevés in exposed positions (from intermediate slopes to the summits) in the landscape.

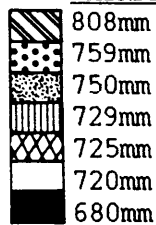
The *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit (Figure 7.2:C) occurs predominantly on dolerite and shale, while the *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit has less dolerite and significantly more mudstone and sandstone than occurs in the former Vegetation Unit. Both Closed Grassland Units (Figure 7.2:D) have ca 50% Mispah soils; thereafter soils with restricted drainage are the most common in the *Themeda triandra*-*Berkheya setifera* Closed

LEGEND

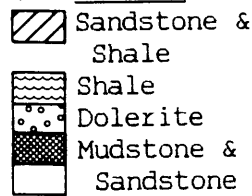
A. MEAN ALTITUDE



B. MEAN ANNUAL RAINFALL



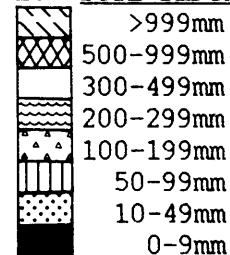
C. GEOLOGY



D. SOIL TYPES

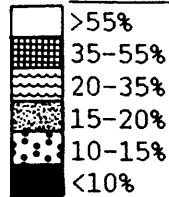


E. SOIL DEPTHS

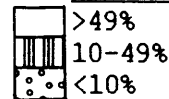


- E1. Mispah soils
- E2. Vertic soils
- E3. Soils with restricted drainage
- E4. Freely drained soils

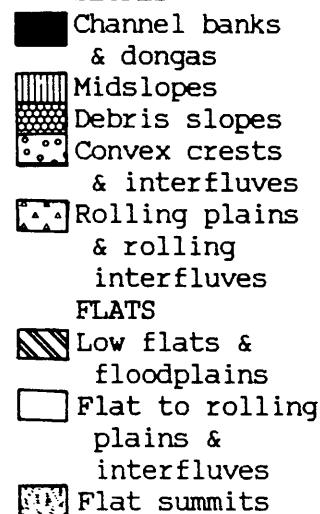
F. CLAY CONTENT IN THE A HORIZON OF THE SOIL



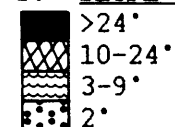
G. MEAN ROCK COVER



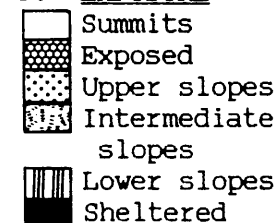
H. GEOMORPHOLOGY SLOPES



I. SLOPE MAGNITUDE



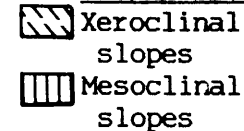
J. EXPOSURE



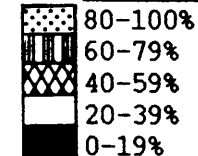
K. ASPECT



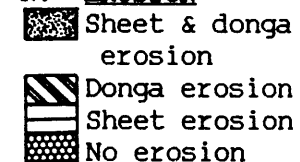
L. MESO- & XEROCLINAL SLOPES



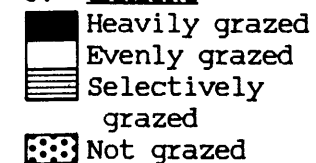
M. CANOPY COVER



N. EROSION



O. GRAZING



P. FIRE



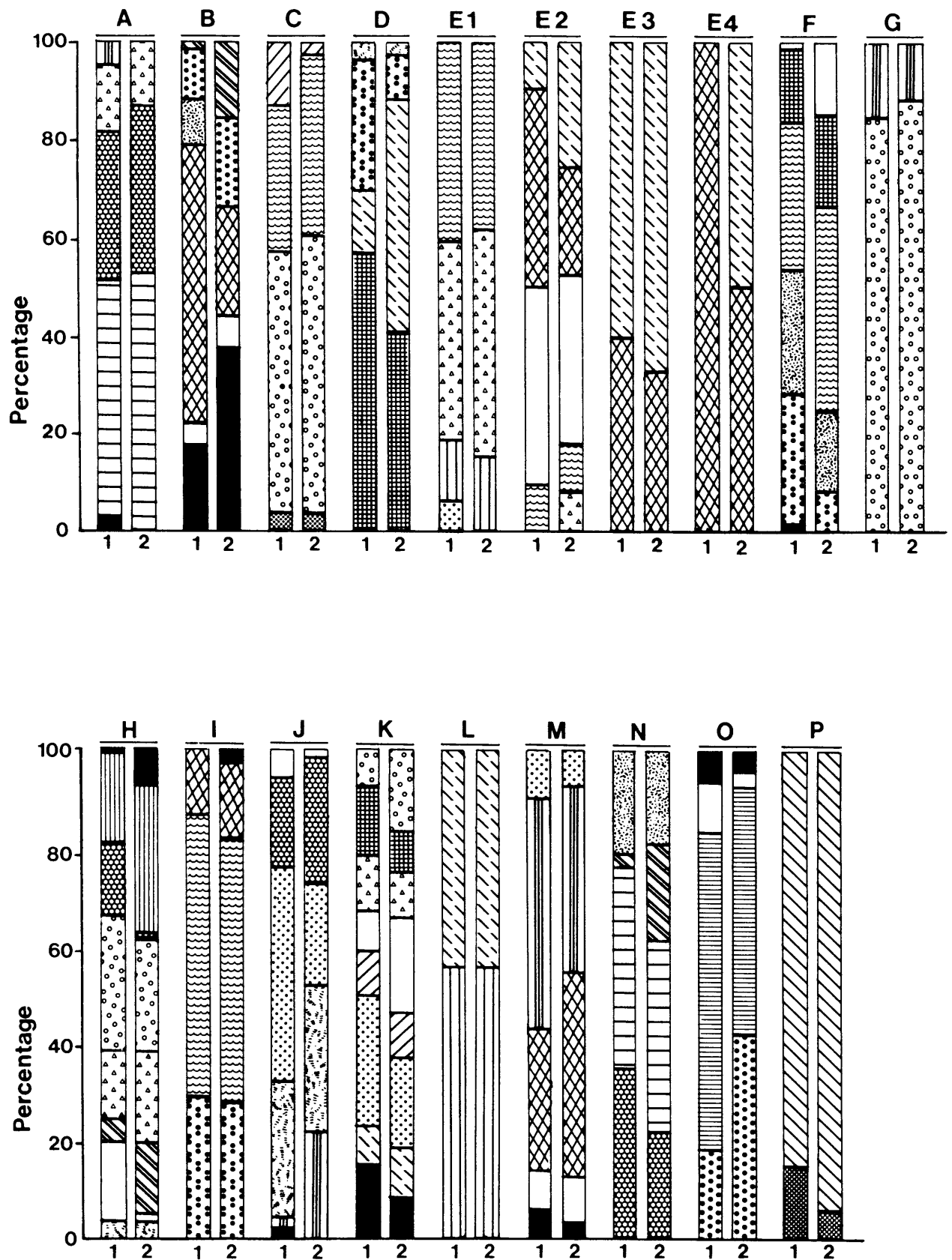


FIGURE 7.3 Comparison of the habitat data for the *Hermannia depressa*-*Eragrostis plana* Closed Grassland Sub-Unit (1) and the *Hermannia depressa*-*Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit (2).

Grassland Unit, while vertic soils are the most common in the *Themeda triandra-Hermannia depressa* Closed Grassland Unit.

The vertic soils in the *Themeda triandra-Berkheya setifera* Closed Grassland Unit (Figure 7.2:E2) are deeper than those in the *Themeda triandra-Hermannia depressa* Closed Grassland Unit, but the *Themeda triandra-Hermannia depressa* Closed Grassland Unit (Figure 7.2:F) has more soils with a high ($\geq 35-55\%$) clay content in the A horizon, as a result of the higher percentage of vertic soils in this Vegetation Unit (Figure 7.2:D).

The *Themeda triandra-Berkheya setifera* Closed Grassland Unit (Figure 7.2:M) has a higher mean percentage maximum canopy cover (Appendix 3:3) and it is predominantly not utilized (Figure 7.2:O), whereas the *Themeda triandra-Hermannia depressa* Closed Grassland Unit is predominantly selectively grazed. The *Themeda triandra-Berkheya setifera* Closed Grassland Unit (Figure 7.2:N) has a higher percentage of land that has not been eroded and a lower percentage of land that has been badly eroded (donga plus donga and sheet erosion) than the *Themeda triandra-Hermannia depressa* Closed Grassland Unit.

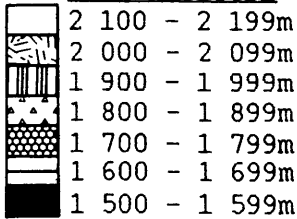
7.3 COMPARISON OF THE HABITATS OF THE *Hermannia depressa*-*Eragrostis plana* CLOSED GRASSLAND SUB-UNIT AND THE *Hermannia depressa*-*Salvia repens* var. *transvaalensis* CLOSED GRASSLAND SUB-UNIT

The *Hermannia depressa-Eragrostis plana* and the *Hermannia depressa-Salvia repens* var. *transvaalensis* Closed Grassland Sub-Units (Figure 7.3:H) differ with respect to their geomorphology in that the flat planes of the former are predominantly flat to rolling plains and interfluves, and those of the latter are predominantly low flats and floodplains. With respect to the sloped planes, the *Hermannia depressa-Eragrostis plana* Closed Grassland Sub-Unit has a higher percentage of debris slopes whilst the *Hermannia depressa-Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit has a higher percentage of midslopes and channel banks and dongas. The *Hermannia depressa-Eragrostis plana* Closed Grassland Sub-Unit (Figure 7.3:J) has more sub-sample relevés in exposed positions (from intermediate slopes to the summits) in the landscape.

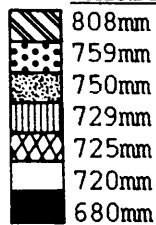
The *Hermannia depressa-Eragrostis plana* Closed Grassland Sub-Unit (Figure 7.3:D) occurs predominantly on Mispah soils and soils with restricted drainage, whereas

LEGEND

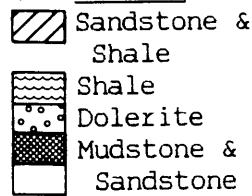
A. MEAN ALTITUDE



B. MEAN ANNUAL RAINFALL



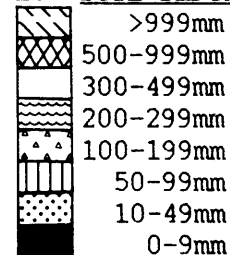
C. GEOLOGY



D. SOIL TYPES

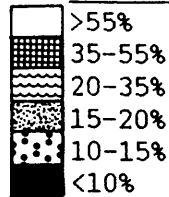


E. SOIL DEPTHS

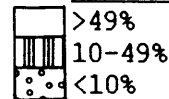


- E1. Mispah soils
E2. Vertic soils
E3. Soils with restricted drainage
E4. Freely drained soils

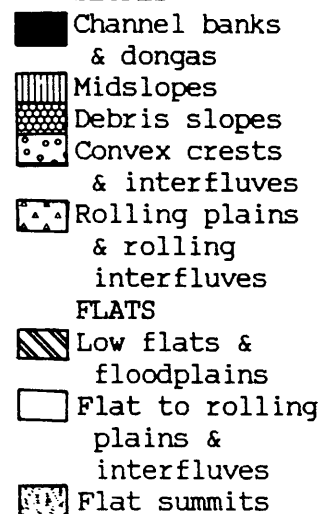
F. CLAY CONTENT IN THE A HORIZON OF THE SOIL



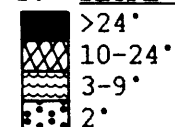
G. MEAN ROCK COVER



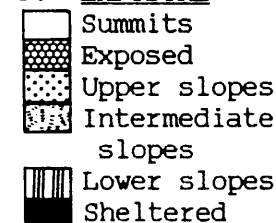
H. GEOMORPHOLOGY SLOPES



I. SLOPE MAGNITUDE



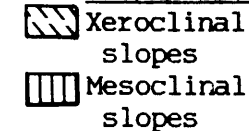
J. EXPOSURE



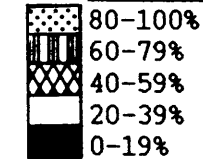
K. ASPECT



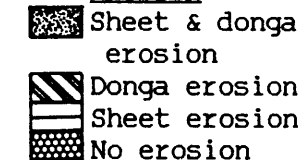
L. MESO- & XEROCLINAL SLOPES



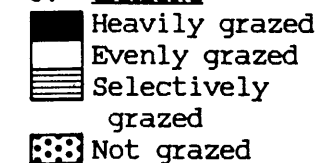
M. CANOPY COVER



N. EROSION



O. GRAZING



P. FIRE



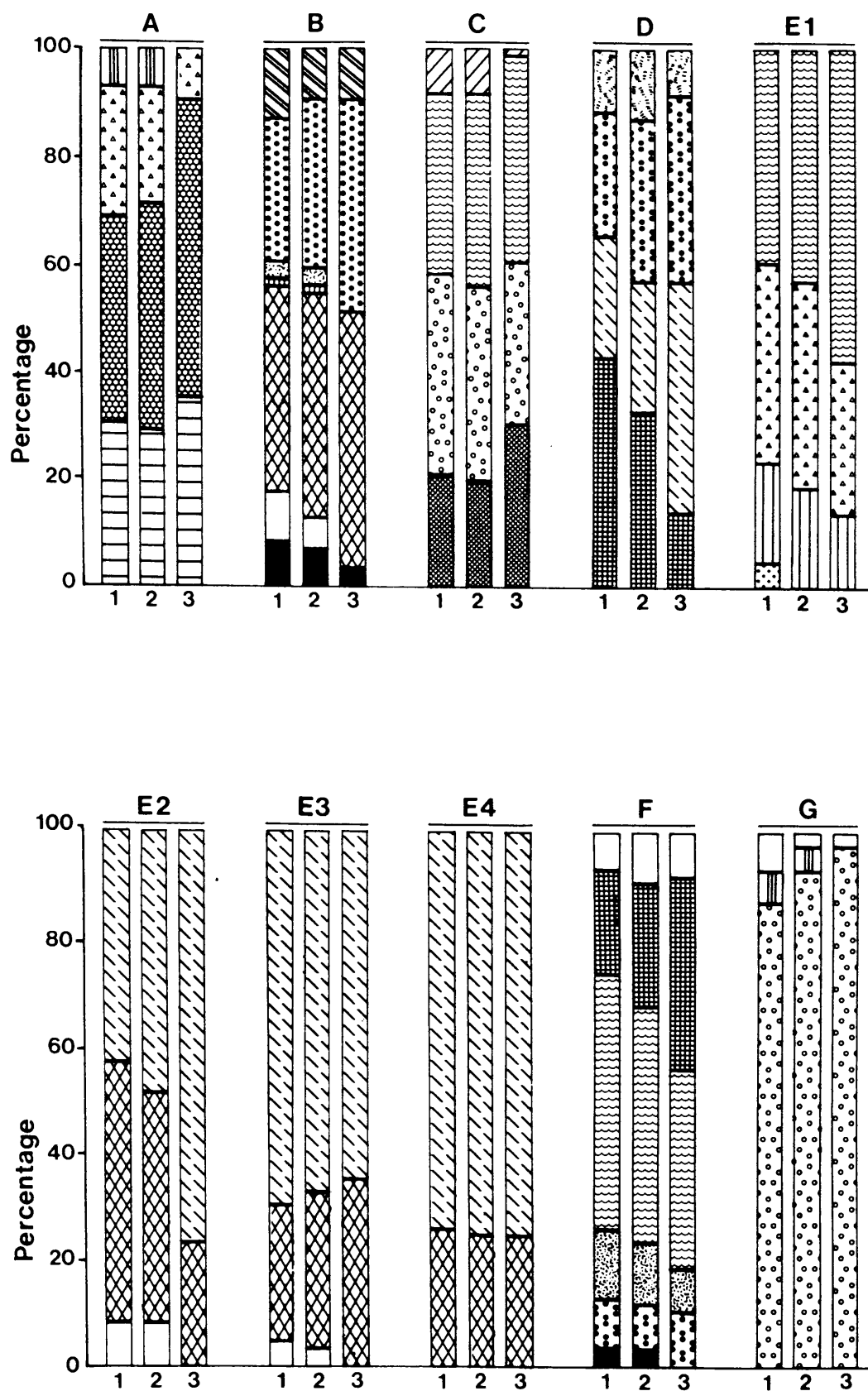


FIGURE 7.4a Comparison of the habitat data for the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (1), the *Eragrostis plana-Conyza podocephala* Closed Grassland Unit (2) and the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (3).

the *Hermannia depressa-Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit occurs predominantly on vertic and Mispah soils, and has fewer Mispah soils than the former Vegetation Sub-Unit. The *Hermannia depressa-Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit (Figure 7.3:F) has a higher percentage of soils with a high ($\geq 35-55\%$) clay content in the A horizon as a result of the higher percentage of vertic soils in this Vegetation Sub-Unit (Figure 7.3:D).

The *Hermannia depressa-Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit (Figure 7.3:N) has a lower percentage of land that has not been eroded and a higher percentage of land that has been badly eroded (donga plus donga and sheet erosion) than the *Hermannia depressa-Eragrostis plana* Closed Grassland Sub-Unit.

7.4 COMPARISON OF THE HABITATS OF THE *Eragrostis plana-Aristida bipartita* CLOSED GRASSLAND UNIT, THE *Eragrostis plana-Conyza podocephala* CLOSED GRASSLAND UNIT AND THE *Eragrostis plana-Paspalum dilatatum* CLOSED GRASSLAND UNIT

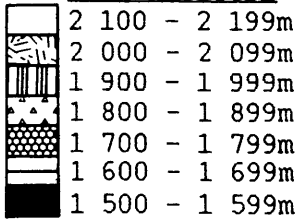
The Vegetation Units of the *Eragrostis chloromelas-Eragrostis plana* Closed Grassland Type represent a gradient from the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit to the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (see Figure 5.1). Only half of the constituent Variants occur in one Vegetation Unit only, and the remainder are common to two or all three of the Vegetation Units.

7.4.1 COMPARISON OF THE HABITATS OF THE *Eragrostis plana-Aristida bipartita* CLOSED GRASSLAND UNIT AND THE *Eragrostis plana-Conyza podocephala* CLOSED GRASSLAND UNIT

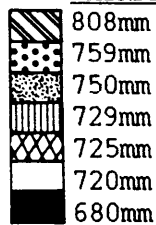
Four of the seven Variants that constitute the *Eragrostis plana-Aristida bipartita* and the *Eragrostis plana-Conyza podocephala* Closed Grassland Units are common to both Units (see Figure 5.1), with the result that the only significant difference relates to their geomorphology (Figure 7.4:H). The *Eragrostis plana-Aristida bipartita* Closed Grassland Unit has more debris slopes and fewer midslopes than the *Eragrostis plana-Conyza podocephala* Closed Grassland Unit.

LEGEND

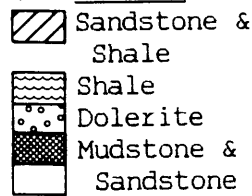
A. MEAN ALTITUDE



B. MEAN ANNUAL RAINFALL



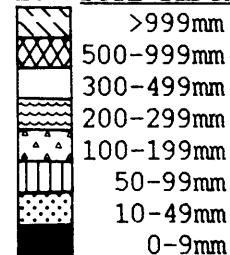
C. GEOLOGY



D. SOIL TYPES

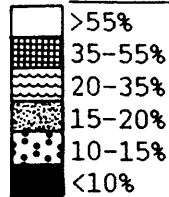


E. SOIL DEPTHS

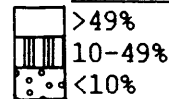


- E1. Mispah soils
E2. Vertic soils
E3. Soils with restricted drainage
E4. Freely drained soils

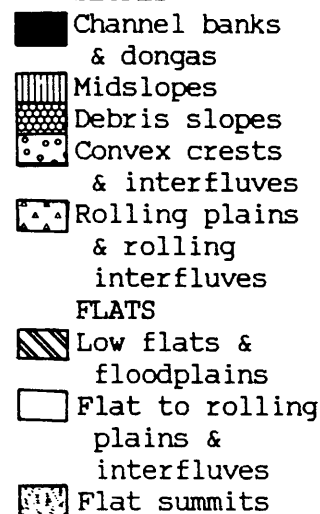
F. CLAY CONTENT IN THE A HORIZON OF THE SOIL



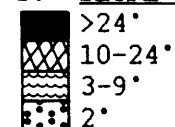
G. MEAN ROCK COVER



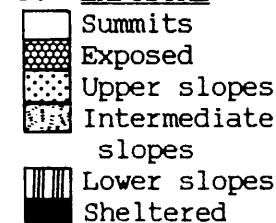
H. GEOMORPHOLOGY SLOPES



I. SLOPE MAGNITUDE



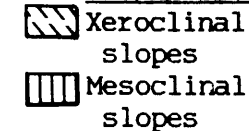
J. EXPOSURE



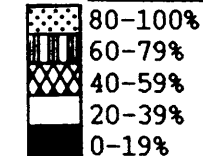
K. ASPECT



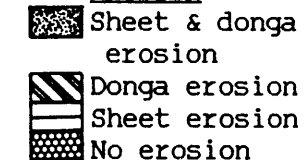
L. MESO- & XEROCLINAL SLOPES



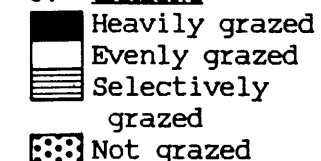
M. CANOPY COVER



N. EROSION



O. GRAZING



P. FIRE



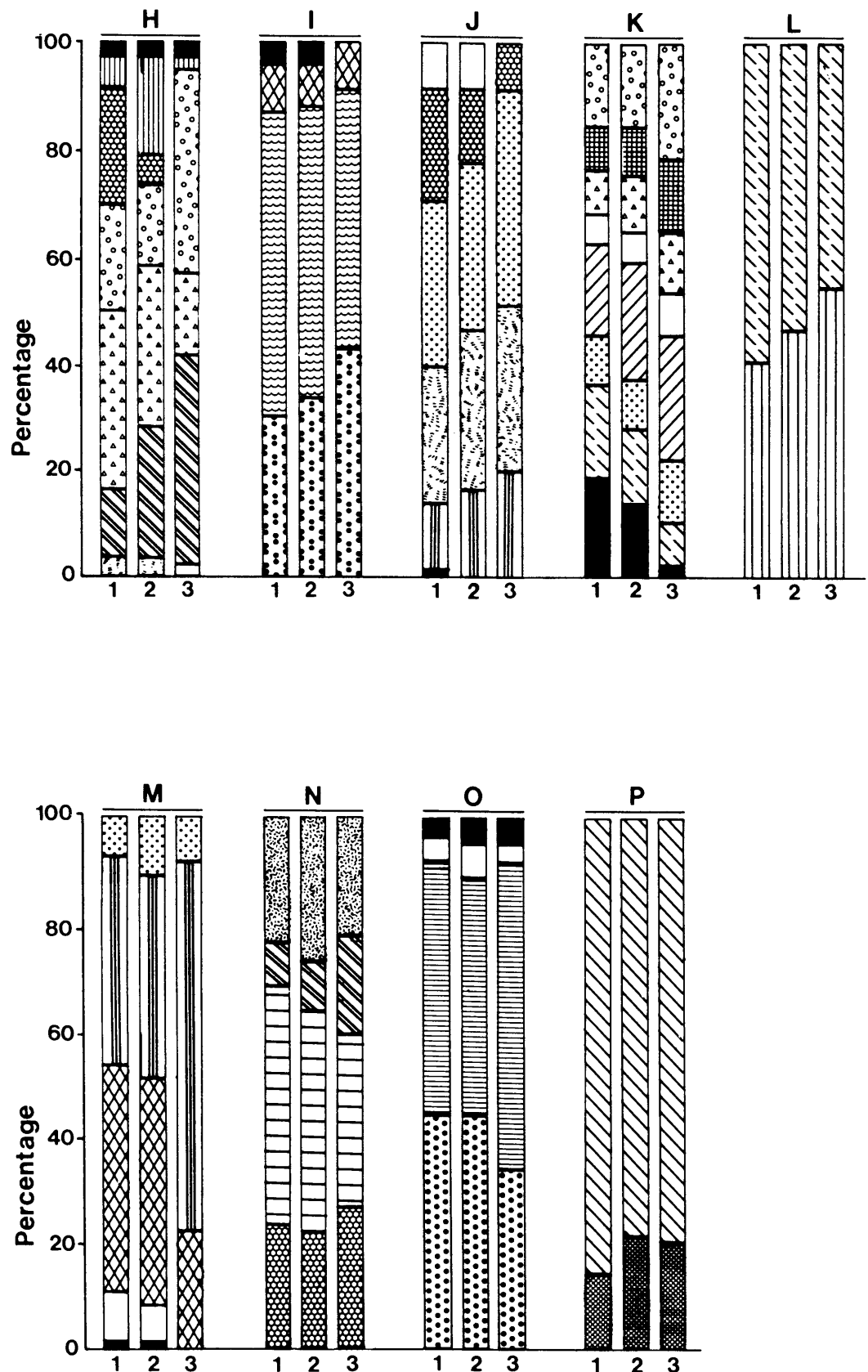


FIGURE 7.4b Comparison of the habitat data for the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (1), the *Eragrostis plana-Conyza podocephala* Closed Grassland Unit (2) and the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (3).

7.4.2 COMPARISON OF THE HABITATS OF THE *Eragrostis plana-Conyza podocephala* CLOSED GRASSLAND UNIT AND THE *Eragrostis plana-Paspalum dilatatum* CLOSED GRASSLAND UNIT

Of the eight Variants constituting the *Eragrostis plana-Conyza podocephala* and the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Units, only two Variants are common to both Units (see Figure 5.1), resulting in a number of statistically significant habitat differences between them. Both Vegetation Units (Figure 7.4:A) occur predominantly at low (<1 800m) altitude, but the *Eragrostis plana-Conyza podocephala* Closed Grassland Unit attains a higher maximum altitude, has more sub-sample relevés at high ($\geq$ 1 800m) altitude, and has the higher mean altitude (Appendix 3:9).

The *Eragrostis plana-Conyza podocephala* Closed Grassland Unit (Figure 7.4:H) has more sloped planes, it has debris slopes and more midslopes than the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit, which has predominantly convex crests and interfluves, and no debris slopes.

The *Eragrostis plana-Conyza podocephala* Closed Grassland Unit (Figure 7.4:I) has more slopes of $\geq 10^\circ$ and these slopes have a higher mean magnitude than those of the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (Appendix 3:9). The *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (Figure 7.4:D) has fewer Mispah soils and more vertic soils which are deeper (Figure 7.4:E2) than those of the *Eragrostis plana-Conyza podocephala* Closed Grassland Unit.

7.4.3 COMPARISON OF THE HABITATS OF THE *Eragrostis plana-Aristida bipartita* CLOSED GRASSLAND UNIT AND THE *Eragrostis plana-Paspalum dilatatum* CLOSED GRASSLAND UNIT

Only one of the ten Variants that constitute the *Eragrostis plana-Aristida bipartita* and the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Units is common to both Units (see Figure 5.1), with the result that there are a number of statistically significant differences in their habitats. Both the *Eragrostis plana-Aristida bipartita* and the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Units (Figure 7.4:A) occur predominantly at low (<1 800m) altitude, but the former attains a higher maximum altitude, has more sub-sample relevés at high ($\geq$ 1 800m) altitude, and has the higher mean altitude (Appendix 3:11).

The primary difference in the geomorphology of these two Vegetation Units (Figure 7.4:H) is that although sloped planes predominate in both, the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit has more flat planes. In the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit the sloped planes are predominantly convex crests and interfluves, and there are no debris slopes, whereas in the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit there are approximately equal percentages of convex crests and interfluves, rolling plains and rolling interfluves, and debris slopes.

The *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (Figure 7.4:D) occurs predominantly on Mispah soils whereas the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit occurs on vertic soils and soils with restricted drainage. The vertic soils in the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (Figure 7.4:E2) are deeper than those of the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit. The *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (Figure 7.4:M) has a lower mean percentage maximum canopy cover (Appendix 3:11), but it has the higher mean percentage of rock cover (Figure 7.4:G & Appendix 3:11). Twelve percent of the sub-sample relevés in the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (Figure 7.4:G) have a rock cover of $\geq 10\%$, as opposed to only 2% in the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit.

CHAPTER 8

ANALYSIS OF THE SPECIES COMPOSITION OF THE
AMERSFOORT VEGETATION

It has been established that the *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type and the *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type are well defined floristically and that they occur in specific habitats (see Chapters 5 & 6). The two remaining Vegetation Types, the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Types, and the lower syntaxa thereof, are well defined floristically by either the presence or the absence of diagnostic species, but there is considerable overlap in the range of habitats in which they occur (see Chapters 5, 6 & 7). Statistically there are significant differences in the habitats in which these syntaxa occur (see Chapter 7), but it is not possible to typify any of them according to a set of specific habitat parameters.

In order to investigate the dynamics of the Amersfoort Vegetation the species composition data collected during this survey were compared with the data collected for the area by Acocks (1953, 1988), and in a similar manner, the data for the Vegetation Types and Vegetation Units classified during this survey were compared with one another to determine the major trends in the vegetation (see Section 4.3.5). In these comparisons, seven grass species will be seen to be of significance and therefore their fodder value and ecological importance in the southern African context is briefly described below.

Themeda triandra is considered to be highly palatable and one of the most desirable grass species in southern Africa (Chippindall & Crook 1976; Tainton et al. 1979; Dannhauser 1980; Barnes et al. 1984, 1985; Müller 1984). The presence of *Themeda triandra* is generally associated with veld in good condition (Glover 1937; Chippindall & Crook 1976; Field 1976; Dannhauser 1980) but it becomes less abundant or disappears from the vegetation under conditions of mismanagement (Chippindall & Crook 1976).

Digitaria tricholaenoides is a highly palatable grass (Tainton et al. 1979; Barnes et al. 1984, 1985) associated with veld in good condition (Glover 1937), but it is sensitive to selective grazing, especially by sheep (Tainton et al. 1979).

TABLE 8.1 Comparison of the relative abundance of some of the most commonly occurring species in the Amersfoort vegetation, as recorded by Acocks (1953) (A) and during the present survey (B).

ACOCKS (A)		AMERSFOORT (B)	
	%RA		%RA
<i>Themeda triandra</i>	100	<i>Themeda triandra</i>	100
<i>Tristachya leucothrix</i>	46	<i>Eragrostis plana</i>	89
<i>Heteropogon contortus</i>	38	<i>Heteropogon contortus</i>	67
<i>Digitaria tricholaenoides</i>	14	<i>Eragrostis chloromelas</i>	63
<i>Eragrostis racemosa</i>	10	<i>Tristachya leucothrix</i>	26
<i>Harpochloa falx</i>	6	<i>Helichrysum rugulosum</i>	13
<i>Elionurus muticus</i>	4	<i>Setaria nigrirostris</i>	13
<i>Microchloa caffra</i>	4	<i>Elionurus muticus</i>	11
<i>Trachypogon spicatus</i>	4	<i>Andropogon appendiculatus</i>	10
<i>Andropogon appendiculatus</i>	2	<i>Eragrostis racemosa</i>	10
<i>Brachiaria serrata</i>	<1	<i>Microchloa caffra</i>	9
<i>Eragrostis chloromelas</i>	<1	<i>Berkheya pinnatifida</i> ¹	7
<i>Eragrostis plana</i>	<1	<i>Setaria flabellata</i> ²	5
<i>Helichrysum rugulosum</i>	<1	<i>Harpochloa falx</i>	4
<i>Setaria flabellata</i>	<1	<i>Solanum panduriforme</i>	4
<i>Setaria nigrirostris</i>	<1	<i>Berkheya setifera</i>	3
		<i>Digitaria tricholaenoides</i>	3
		<i>Brachiaria serrata</i>	2
		<i>Trachypogon spicatus</i>	1

%RA = Percentage relative abundance

¹ *Berkheya pinnatifida* subsp. *ingrata*

² *Setaria flabellata* subsp. *natalensis*

Tristachya leucothrix is an indicator of veld in good condition (Glover 1937) and it is considered to be of intermediate palatability (Barnes et al. 1984, 1985). Dannhauser (1980), however, describes this grass as being a valuable, palatable species, and during the present survey it was noticed that this species was invariably heavily grazed in preference to other highly palatable species such as **Themeda triandra** and **Heteropogon contortus**. It is therefore concluded that in the Amersfoort area **Tristachya leucothrix** may be considered to be highly palatable.

Trachypogon spicatus and **Harpochloa falx** are both associated with veld in good condition (Glover 1937; Tainton et al. 1979) and they are valuable fodder species when young, but as they mature they become unacceptable to grazers (Chippindall & Crook 1976; Tainton et al. 1979; Dannhauser 1980).

Eragrostis chloromelas is described as being only moderately palatable (Dannhauser 1980; Barnes et al. 1984, 1985) and it is resistant to excessive trampling and heavy grazing (Roberts 1971; Dannhauser 1980). The presence of **Eragrostis chloromelas** therefore indicates disturbance of the vegetation.

Eragrostis plana is an undesirable (Tainton et al. 1979), "tough, long-lived pioneer" species (Chippindall & Crook 1976) which is not grazed readily, especially when mature (Chippindall & Crook 1976; Tainton et al. 1979; Barnes et al. 1984, 1985), and its presence indicates mismanagement or disturbance of the vegetation (Tainton et al. 1979).

These grass species may thus be divided into two categories, hereafter referred to as "desirable" species (**Themeda triandra**, **Digitaria tricholaenoides**, **Tristachya leucothrix**, **Trachypogon spicatus** and **Harpochloa falx**) and "indicator" species (**Eragrostis chloromelas** and **Eragrostis plana**), the latter term implying that the presence of such species is indicative of disturbed vegetation.

8.1 COMPARISON OF THE SPECIES COMPOSITION DATA FROM ACOCKS' (1953) SURVEY AND THE PRESENT SURVEY, FOR THE AMERSFOORT VEGETATION

In the comparison of the data collected by Acocks (1953, 1988) and the data collected for the Amersfoort vegetation during the present survey (Table 8.1), a number of changes in the vegetation are apparent:

- a) **Themeda triandra** is still the species with the highest relative abundance in the Amersfoort vegetation, but the degree of its dominance over the remaining species has greatly diminished. At the time of Acocks' (1953, 1988) survey

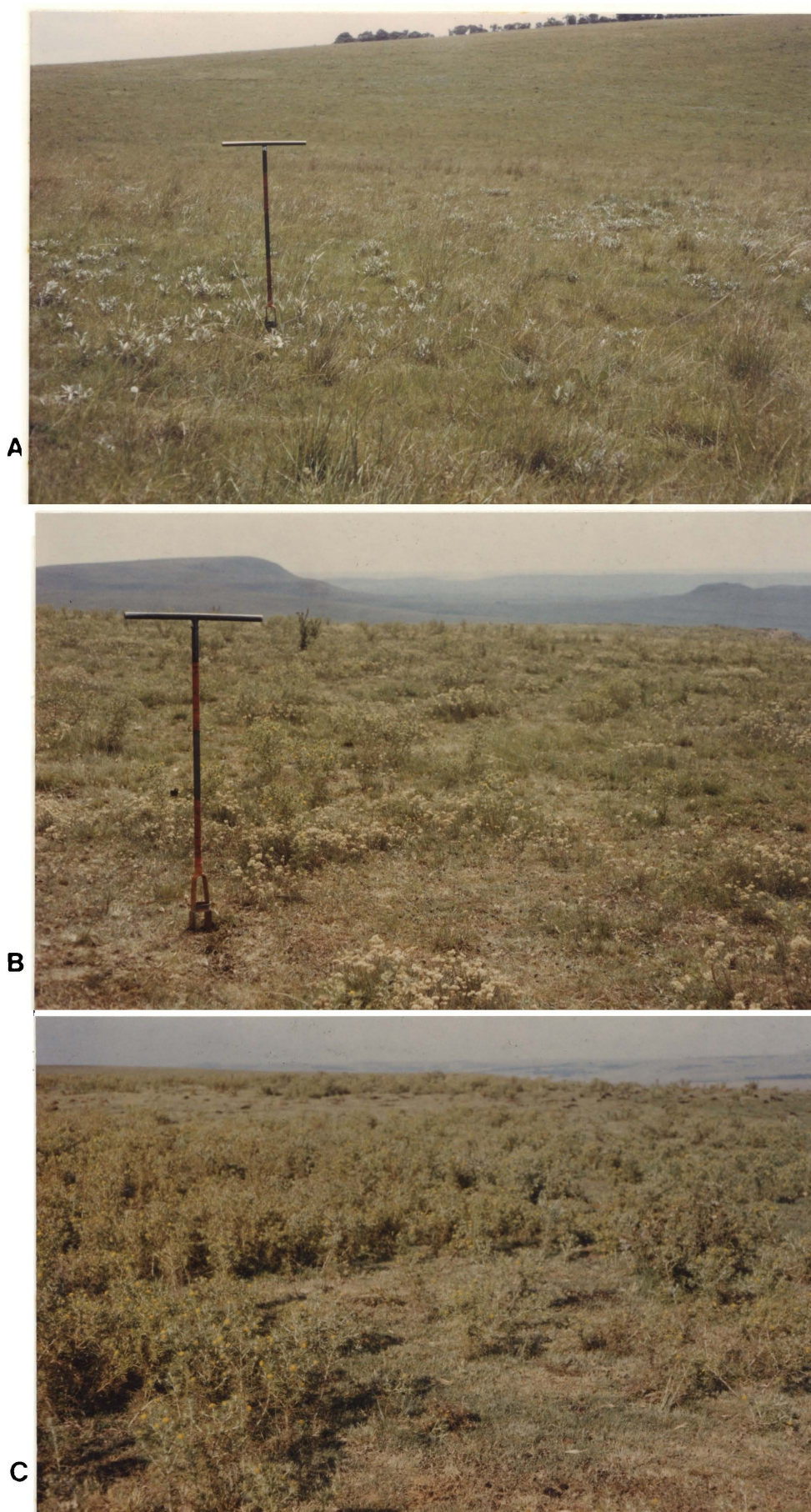


FIGURE 8.1 In poorly managed veld unpalatable indicator forbs such as *Helichrysum oreophilum* (A), *Helichrysum rugulosum* (B) and *Berkheya pinnatifida* subsp. *ingrata* (C) become established in the Amersfoort vegetation.

the species with the next highest relative abundance value was *Tristachya leucothrix*, which had a relative abundance value of only 46% relative to *Themeda triandra*. During the present survey the species with the next highest relative abundance value is *Eragrostis plana*, with a relative abundance value of 89% relative to *Themeda triandra*.

- b) The desirable grasses (*Digitaria tricholaenoides*, *Harpochloa falx*, *Trachypogon spicatus* and, to a lesser extent, *Tristachya leucothrix*) have moved down in the species sequence (Table 8.1) to assume rôles of lesser importance in the vegetation.
- c) There has been a considerable increase in the relative abundance of the indicator grasses *Eragrostis plana* and *Eragrostis chloromelas*, which have respectively become the second and fourth most abundant species in the vegetation.
- d) There are a number of forbs presently occurring in the Amersfoort vegetation which are unpalatable and indicators of disturbance, of which *Helichrysum rugulosum*, *Berkheya pinnatifida* subsp. *ingrata*, *Solanum panduriforme* and *Berkheya setifera* are amongst the most abundant. Acocks (1953, 1988) mentions only one of these species, namely *Helichrysum rugulosum*, which had a low relative abundance value relative to *Themeda triandra* (Table 8.1). During the present survey, however, it was found that the indicator forbs have assumed some importance in the vegetation (Figure 8.1).

All of the above facts indicate that there has been a considerable degradation in the species composition and hence in the condition of the Amersfoort vegetation over the last ca 35 years. There has been a decline in the desirable grasses with an increase in the grasses and forbs that are indicators of disturbance.

8.2 COMPARISON OF THE SPECIES COMPOSITION DATA OF THE DIFFERENT SYNTAXA IN THE AMERSFOORT VEGETATION

The pattern of vegetation change established above also explains the dynamics of the syntaxa established during the classification (see Figure 5.1), if the species are arranged into a sequence of decreasing relative abundance (see Section 4.3.5).

TABLE 8.2 Comparison of the relative abundance of some of the most commonly occurring species in the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type (A) and the *Eragrostis chloromelas*-*Eragrostis plana* (B) Closed Grassland Type.

VEGETATION TYPE A		VEGETATION TYPE B	
	%RA		%RA
<i>Themeda triandra</i>	100	<i>Eragrostis plana</i>	100
<i>Heteropogon contortus</i>	70	<i>Eragrostis chloromelas</i>	51
<i>Eragrostis plana</i>	45	<i>Themeda triandra</i>	14
<i>Eragrostis chloromelas</i>	42	<i>Berkheya pinnatifida</i> ¹	11
<i>Tristachya leucothrix</i>	28	<i>Andropogon appendiculatus</i>	9
<i>Elionurus muticus</i>	12	<i>Helichrysum rugulosum</i>	9
<i>Setaria nigristrostris</i>	12	<i>Setaria flabellata</i> ²	8
<i>Eragrostis racemosa</i>	10	<i>Heteropogon contortus</i>	5
<i>Helichrysum rugulosum</i>	9	<i>Solanum panduriforme</i>	4
<i>Microchloa caffra</i>	8	<i>Microchloa caffra</i>	3
<i>Andropogon appendiculatus</i>	8	<i>Setaria nigristrostris</i>	3
<i>Harpochloa falx</i>	5	<i>Berkheya setifera</i>	<1
<i>Berkheya setifera</i>	3	<i>Brachiaria serrata</i>	<1
<i>Digitaria tricholaenoides</i>	3	<i>Digitaria tricholaenoides</i>	<1
<i>Berkheya pinnatifida</i> ¹	2	<i>Elionurus muticus</i>	<1
<i>Brachiaria serrata</i>	2	<i>Eragrostis racemosa</i>	<1
<i>Solanum panduriforme</i>	2	<i>Harpochloa falx</i>	<1
<i>Trachypogon spicatus</i>	1	<i>Tristachya leucothrix</i>	<1
<i>Setaria flabellata</i> ²	<1	<i>Trachypogon spicatus</i>	0

%RA = Percentage relative abundance

¹*Berkheya pinnatifida* subsp. *ingrata*

²*Setaria flabellata* subsp. *natalensis*

TABLE 8.3 Comparison of the relative abundance of some of the most commonly occurring species in the *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit (A) and the *Themeda triandra*-*Hermannia depressa* (B) Closed Grassland Unit.

VEGETATION UNIT A		VEGETATION UNIT B	
	%RA		%RA
<i>Themeda triandra</i>	100	<i>Themeda triandra</i>	100
<i>Heteropogon contortus</i>	69	<i>Heteropogon contortus</i>	72
<i>Eragrostis plana</i>	47	<i>Eragrostis chloromelas</i>	49
<i>Tristachya leucothrix</i>	44	<i>Eragrostis plana</i>	42
<i>Eragrostis chloromelas</i>	36	<i>Elionurus muticus</i>	14
<i>Setaria nigristrostris</i>	13	<i>Microchloa caffra</i>	12
<i>Andropogon appendiculatus</i>	11	<i>Eragrostis racemosa</i>	10
<i>Eragrostis racemosa</i>	10	<i>Helichrysum rugulosum</i>	10
<i>Elionurus muticus</i>	9	<i>Tristachya leucothrix</i>	8
<i>Harpochloa falx</i>	8	<i>Berkheya pinnatifida</i> ¹	4
<i>Berkheya setifera</i>	6	<i>Setaria nigristrostris</i>	4
<i>Digitaria tricholaenoides</i>	6	<i>Brachiaria serrata</i>	3
<i>Helichrysum rugulosum</i>	6	<i>Andropogon appendiculatus</i>	2
<i>Microchloa caffra</i>	4	<i>Setaria flabellata</i> ²	2
<i>Solanum panduriforme</i>	2	<i>Solanum panduriforme</i>	2
<i>Trachypogon spicatus</i>	2	<i>Harpochloa falx</i>	1
<i>Berkheya pinnatifida</i> ¹	1	<i>Berkheya setifera</i>	<1
<i>Brachiaria serrata</i>	1	<i>Trachypogon spicatus</i>	<1
<i>Setaria flabellata</i> ²	<1	<i>Digitaria tricholaenoides</i>	0

%RA = Percentage relative abundance

¹*Berkheya pinnatifida* subsp. *ingrata*

²*Setaria flabellata* subsp. *natalensis*

8.2.1 COMPARISON OF THE SPECIES COMPOSITIONS OF THE *Tristachya leucothrix*-*Themeda triandra* CLOSED GRASSLAND TYPE AND THE *Eragrostis chloromelas*-*Eragrostis plana* CLOSED GRASSLAND TYPE

In the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (Table 8.2) *Themeda triandra* is no longer the species with the highest relative abundance, having been displaced by the indicator grasses *Eragrostis plana* and *Eragrostis chloromelas*. There has also been a considerable decrease in the desirable grasses *Tristachya leucothrix* and *Harpochloa falx*, and *Trachypogon spicatus* has disappeared from the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type. Furthermore, there has been a marked increase in the unpalatable indicator forbs *Helichrysum rugulosum* and *Solanum panduriforme*. The vegetation of the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type is thus in a more degraded condition than that of the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type.

8.2.2 COMPARISON OF THE SPECIES COMPOSITIONS OF THE *Themeda triandra*-*Berkheya setifera* CLOSED GRASSLAND UNIT AND THE *Themeda triandra*-*Hermannia depressa* CLOSED GRASSLAND UNIT

Themeda triandra is similarly dominant in these two Vegetation Units. In the *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit (Table 8.3), however, there has been a decrease in the desirable grasses *Tristachya leucothrix* and *Harpochloa falx*, and *Digitaria tricholaenoides* has disappeared from the *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit. There has also been a slight increase in the indicator grasses *Eragrostis chloromelas* and *Eragrostis plana*, and an increase in the indicator forbs *Helichrysum rugulosum* and *Berkheya pinnatifida* subsp. *ingrata*. The vegetation of the *Themeda triandra*-*Hermannia depressa* Closed Grassland Unit is thus in a more degraded condition than that of the *Themeda triandra*-*Berkheya setifera* Closed Grassland Unit.

TABLE 8.4 Comparison of the relative abundance of some of the most commonly occurring species in the *Eragrostis plana*-*Aristida bipartita* Closed Grassland Unit (A), the *Eragrostis plana*-*Conyza podocephala* Closed Grassland Unit (B) and the *Eragrostis plana*-*Paspalum dilatatum* (C) Closed Grassland Unit.

VEGETATION TYPE A		VEGETATION TYPE B		VEGETATION UNIT C	
	%RA		%RA		%RA
<i>Eragrostis plana</i>	100	<i>Eragrostis plana</i>	100	<i>Eragrostis plana</i>	100
<i>Eragrostis chloromelas</i>	72	<i>Eragrostis chloromelas</i>	59	<i>Eragrostis chloromelas</i>	20
<i>Berkheya pinnatifida</i> ¹	27	<i>Berkheya pinnatifida</i> ¹	23	<i>Themeda triandra</i>	19
<i>Helichrysum rugulosum</i>	16	<i>Themeda triandra</i>	15	<i>Andropogon appendiculatus</i>	18
<i>Themeda triandra</i>	16	<i>Helichrysum rugulosum</i>	14	<i>Setaria flabellata</i> ²	5
<i>Setaria flabellata</i> ²	10	<i>Setaria flabellata</i> ²	10	<i>Heteropogon contortus</i>	4
<i>Solanum panduriforme</i>	8	<i>Solanum panduriforme</i>	6	<i>Berkheya pinnatifida</i> ¹	3
<i>Heteropogon contortus</i>	6	<i>Setaria nigrirostris</i>	4	<i>Elionurus muticus</i>	2
<i>Microchloa caffra</i>	6	<i>Heteropogon contortus</i>	3	<i>Setaria nigrirostris</i>	1
<i>Setaria nigrirostris</i>	5	<i>Microchloa caffra</i>	3	<i>Helichrysum rugulosum</i>	1
<i>Andropogon appendiculatus</i>	1	<i>Andropogon appendiculatus</i>	1	<i>Berkheya setifera</i>	<1
<i>Berkheya setifera</i>	<1	<i>Berkheya setifera</i>	<1	<i>Brachiaria serrata</i>	<1
<i>Brachiaria serrata</i>	<1	<i>Berkheya setifera</i>	<1	<i>Digitaria tricholaenoides</i>	<1
<i>Digitaria tricholaenoides</i>	<1	<i>Digitaria tricholaenoides</i>	<1	<i>Eragrostis racemosa</i>	<1
<i>Elionurus muticus</i>	<1	<i>Elionurus muticus</i>	<1	<i>Harpochloa falx</i>	<1
<i>Eragrostis racemosa</i>	<1	<i>Eragrostis racemosa</i>	<1	<i>Microchloa caffra</i>	<1
<i>Harpochloa falx</i>	<1	<i>Harpochloa falx</i>	<1	<i>Solanum panduriforme</i>	<1
<i>Tristachya leucothrix</i>	<1	<i>Tristachya leucothrix</i>	<1	<i>Trachypogon spicatus</i>	0
<i>Trachypogon spicatus</i>	0	<i>Trachypogon spicatus</i>	0	<i>Tristachya leucothrix</i>	0

%RA = Percentage relative abundance

¹ *Berkheya pinnatifida* subsp. *ingrata*

² *Setaria flabellata* subsp. *natalensis*

8.2.3 COMPARISON OF THE SPECIES COMPOSITIONS OF THE *Eragrostis plana*-*Aristida bipartita* CLOSED GRASSLAND UNIT, THE *Eragrostis plana*-*Conyza podocephala* CLOSED GRASSLAND UNIT AND THE *Eragrostis plana*-*Paspalum dilatatum* CLOSED GRASSLAND UNIT

Themeda triandra has lost its dominance to *Eragrostis plana* in the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (see Section 8.2.1), and in the three Vegetation Units of this Vegetation Type *Eragrostis plana* becomes progressively more dominant relative to the species with the next highest relative abundance value, i.e. *Eragrostis chloromelas* (Table 8.4). In the *Eragrostis plana*-*Aristida bipartita* Closed Grassland Unit *Eragrostis chloromelas* has a relative abundance value of 72% relative to *Eragrostis plana*, whereas in the *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit it has a value of only 20%.

There is little difference in the species compositions of the *Eragrostis plana*-*Aristida bipartita* and the *Eragrostis plana*-*Conyza podocephala* Closed Grassland Units (Table 8.4), excepting for the increase in the dominance of *Eragrostis plana* in the latter Vegetation Unit.

The marked dominance of *Eragrostis plana* in the *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit (Table 8.4) has resulted in the seemingly anomalous situation where the indicator forbs *Berkheya pinnatifida* subsp. *ingrata*, *Helichrysum rugulosum*, *Berkheya setifera* and *Solanum panduriforme* have become less important constituents of the vegetation, as opposed to their importance in the *Eragrostis plana*-*Aristida bipartita* Closed Grassland Unit. It is suggested, however, that this is directly as a result of the fact that *Eragrostis plana* is the more successful competitor under the prevailing disturbed conditions, and that the decreased relative abundance of these forbs does not indicate an improvement in the condition of the vegetation. The extent of the degradation in the vegetation thus increases from the *Eragrostis plana*-*Aristida bipartita* Closed Grassland Unit to the *Eragrostis plana*-*Paspalum dilatatum* Closed Grassland Unit.

CHAPTER 9

DISCUSSION AND CONCLUSIONS9.1 METHODOLOGY9.1.1 SAMPLING STRATEGY

The sub-sampling procedure used was not successful since the floristic and habitat data of the relevés were heterogeneous (see Section 4.3.3). In future, therefore, either the sub-samples should be placed subjectively to ensure homogeneity, or else a single, large quadrat should be used, as was done by e.g. Bredenkamp (1975, 1981), Scheepers (1975), Westfall (1981), Deall (1985), Bezuidenhout (1989) and Bloem (1989).

9.1.2 DATA PROCESSING

Data processing was initially problematic owing to the inherent heterogeneity of the relevé data, and then because of the large size of the sub-sample relevé data set (see Section 4.3.3). Splitting the sub-sample relevé data set into three separate phytosociological tables made the data more manageable and the salient features of the different syntaxa were more readily apparent. It was found, however, that re-combining the separate tables was difficult because of species that were diagnostic for syntaxa in more than one table, which made the species order in the combined synoptic table (Table 5.6) difficult to determine. Deall (1985), Bezuidenhout (1989) and Bloem (1989) encountered similar difficulties as a result of splitting their phytosociological tables.

The TWINSpan analysis of the data was the most interpretable although extensive manual sorting had to be carried out to refine the sub-sample relevé ordering (see Section 4.3.3). The PHYTOTAB program package was found to be very useful although much time was wasted using the programs PHYTO21, PHYTO23 and PHYTO39, the results of which were of little value (see Section 4.3.3).

The DECORANA ordination revealed few habitat gradients that could be correlated with the different syntaxa (see Chapter 6). This is, however, primarily owing to the fact that the syntaxa are very heterogeneous with respect to habitat (see Chapters 5 & 7), with the result that the statistical analysis of the habitat data was more successful, although in some instances the data sets were rather small (see Chapter 7).

9.2 RESULTS

9.2.1 CLASSIFICATION

The Vegetation Types, Units and Sub-Units are floristically well differentiated by the presence or absence of characteristic species (see Table 5.6). At the level of Variants, however, the situation deteriorates. Six Variants are differentiated on the presence of one species only, many of the sub-sample relevés within a Variant have none or only a few of the characteristic species and "species gradients" (see Table 4.2) within the characteristic species groups are ubiquitous (see Tables 5.2 & 5.3).

Only four syntaxa occur in habitats that are specific in some respect: the *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type, the *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type, the *Themeda triandra*-*Limeum viscosum* subsp. *viscosum* Closed Grassland Variant and the *Eragrostis plana*-*Nidorella anomala* Closed Grassland Variant (see Chapter 5). The remaining syntaxa occur over a wide range of habitat conditions and what differentiates between them is not readily apparent.

9.2.2 ORDINATION

The DECORANA analysis supports the results of the classification in that the four Vegetation Types are clearly discernable in the ordination diagram (see Figure 6.1), as are the Vegetation Units and Sub-Units of the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types (see Figures 6.2 & 6.4). The Variants could not, however, be identified in the ordination diagrams (see Section 4.3.3).

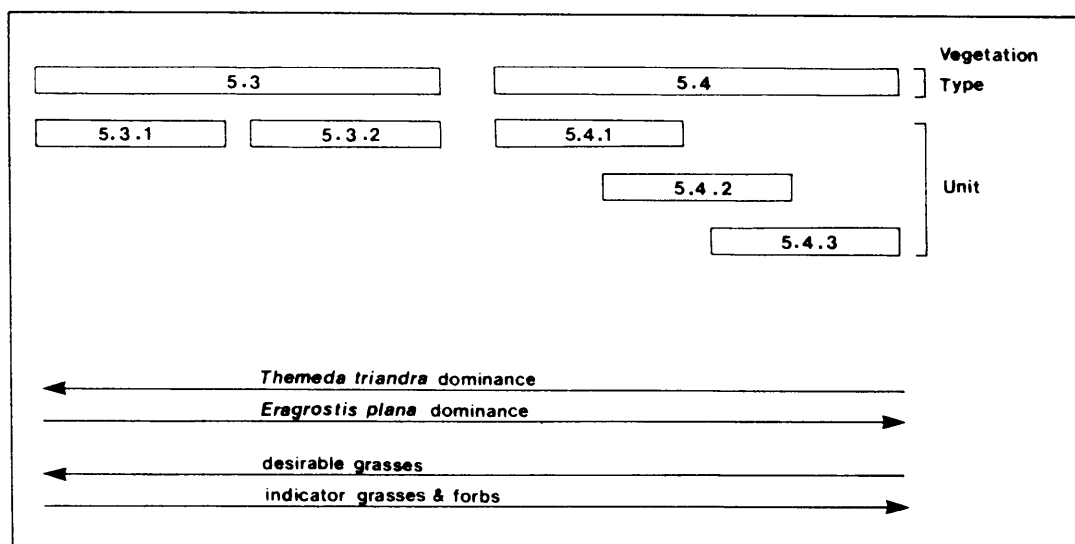


FIGURE 9.1 Floristic gradients operative within the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type and the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (see Figure 5.1), where the direction of an arrow indicates the direction in which a variable increases.

The DECORANA ordination detects the high beta diversity in the floristics of the *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type and the *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type (see Figure 6.1), but the habitat correlation only detects the differences between them and the remaining Vegetation Types and does not elucidate in what respect they differ from one another.

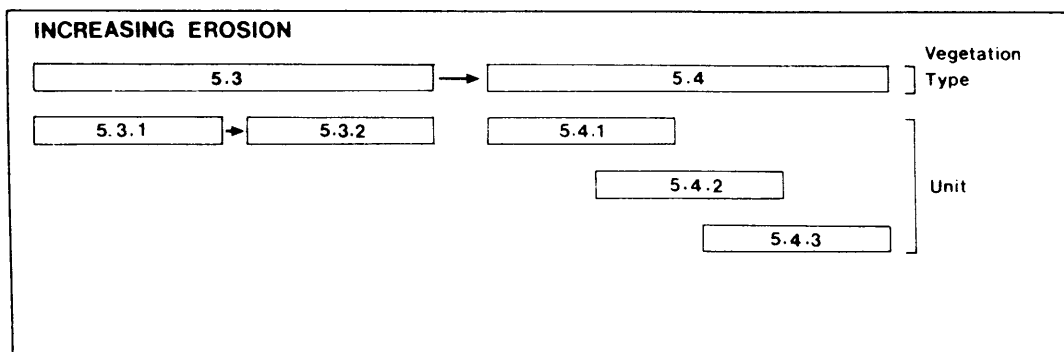
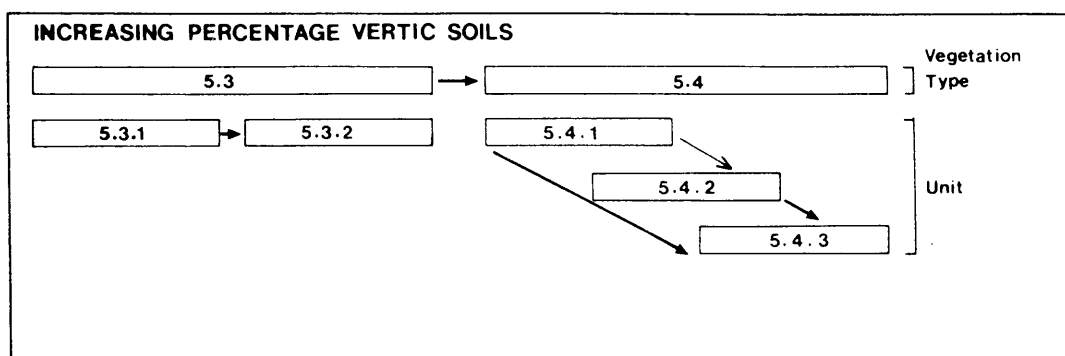
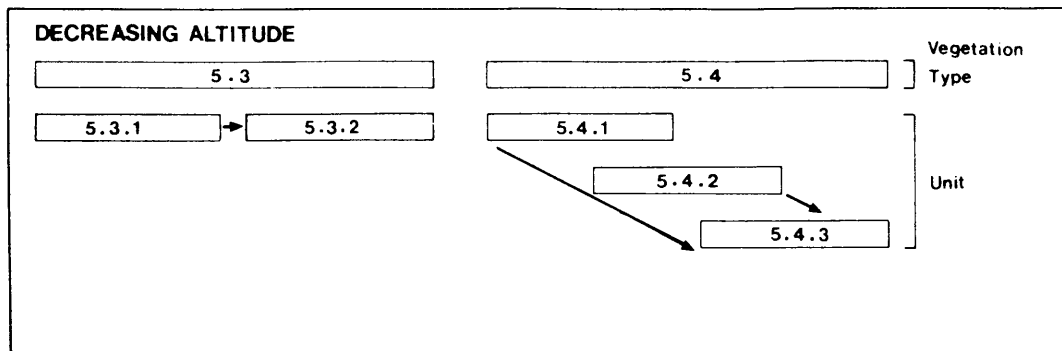
A number of differences in the habitats of the remaining syntaxa are established, but not all are confirmed by the statistical analysis of the data (see Chapter 6).

9.2.3 STATISTICAL ANALYSIS

The statistical analysis of the data shows that although the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Types, and the Vegetation Units and Sub-Units thereof, occur over a wide range of habitat conditions there are statistically significant differences between them (see Chapter 7). Thus although it is not possible to exactly correlate one syntaxon with a precise set of habitat conditions, it is possible to differentiate and characterize it according to the most commonly occurring habitat features that are statistically significantly different from the most commonly occurring features of a comparable syntaxon.

9.2.4 SPECIES COMPOSITION ANALYSIS

It is apparent that there has been a marked degradation in the species composition of the vegetation occurring at present in the Amersfoort area relative to its composition at the time of Acocks' (1953) survey (see Chapter 8). Furthermore, there is presently a gradient of increasing degradation of the vegetation operative from the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type to the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type, and within the lower syntaxa thereof (i.e. from left to right across the combined synoptic table, Table 5.6, but excluding the *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types) (Figure 9.1). Along this gradient *Eragrostis plana* replaces *Themeda triandra* as the most dominant species and there is a decrease in the relative abundance of the



- indicates a statistically significant difference
- indicates a difference which is not statistically significant

FIGURE 9.2 Habitat gradients operative within the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type and the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (see Figure 5.1).

desirable grasses, with an increase in the relative abundance of the indicator grasses and forbs.

9.3 INTERPRETATION OF THE DYNAMICS OF THE AMERSFOORT VEGETATION

In view of the deterioration in the species composition of the vegetation since Acocks' (1953) survey, and the gradient of veld degradation in the presently occurring Amersfoort vegetation (see Chapter 8), it is speculated that the present vegetation has developed in response to a long history of mismanagement. The degradation of the vegetation has proceeded to the extent that its normal response to habitat variations is completely overridden, hence the general lack of correlation between the syntaxa and the habitat data.

Only three habitat factors forming uni-directional gradients resembling the floristic gradient (see Figure 9.1) could be established, but these support the postulated gradient of increasing degradation of the vegetation. From left to right (Figure 9.2) there is a decrease in the mean altitude and an increase in the percentage of vertic soils and the extent of soil erosion. These three gradients may be correlated with the floristic gradient as follows.

The syntaxa at the right-hand side of the gradient generally occur at lower altitudes than those on the left-hand side, which may be significant in two respects. In the first instance land at lower altitudes may be more easily accessible to the grazers, resulting in higher concentrations of animals and hence increased grazing and trampling pressure. In the second instance, the lower altitude areas are subject to additional erosional pressure by virtue of the rainfall water from the higher altitudes moving down to the lower-lying areas, this being in addition to the rainfall falling directly upon these areas. This situation is exacerbated in the *Eragrostis chloromelas-Eragrostis plana* Closed Grassland Type (Vegetation Type 5.4 in Figure 9.2) since this Vegetation Type receives more high ($\geq 750\text{mm}$) rainfall and has a statistically higher mean annual rainfall than the *Tristachya leucothrix-Themeda triandra* Closed Grassland Type (Vegetation Type 5.3 in Figure 9.2) (see Chapter 7).

The syntaxa on the right-hand side of the gradient have the greatest percentage of vertic soils. No chemical analyses were made of the soils in the Amersfoort area during this survey. However, from the limited soil chemistry data available

A



B



FIGURE 9.3 Incorrect management practices may have the consequence of heavy overgrazing (**A**) and/or selective grazing (**B**), particularly on the vertic soils in the Amersfoort area.

for the land types that occur in the study area (Land Type Survey Staff 1985, 1986) (see Section 2.4), vertic soils (Arcadia Form) have up to seven times the quantity of sodium (Na), 140 times the quantity of calcium (Ca) and 268 times the quantity of magnesium (Mg) than is found in non-vertic soils (Milkwood, Kroonstad, Hutton and Griffin Forms).

The presence of 3-5% Na on the exchange complex in a vertic soil may be enough to disperse the clay particles, especially if the Mg:Ca ratio is unfavourable (e.g. Nel 1989). Na is a large hydrated ion and therefore causes a thick double layer and dispersion (e.g. Nel 1989). The higher Na content, and especially the higher Mg:Ca ratios found during the land type survey, indicate that these factors may aggravate the erosion on the vertic soils in this area.

As a result of the higher base (Ca and Mg) status of the vertic soils in the Amersfoort area, the vegetation growing on these soils should be sweeter, more palatable and have a higher nutritional value than the vegetation growing on soils with a lower base status (Laker pers. comm.¹). Animals therefore graze the vegetation growing on the vertic soils preferentially, and with incorrect management, overgrazing and/or selective grazing may result (Figure 9.3). This has the effect of decreasing the quantity of organic matter returning to the soil, which leads to a less stable soil structure. Furthermore, with overgrazing and/or selective grazing, bare patches of soil develop, and the soil in these patches is then more susceptible to physical disintegration of the surface structure by raindrop impact (Laker pers. comm.). All of the above factors, plus the damage done to the surface structure of the soil by the excessive trampling which accompanies a heavy grazing pressure, makes the vertic soils in the Amersfoort area very prone to erosion by water, especially if there is little plant protection (Figure 9.4).

The combination of lower altitude, higher rainfall and more vertic soils thus predisposes the syntaxa on the right-hand side of the gradient to disturbance resulting from the interaction of soil dispersion, overgrazing and selective grazing, the lowering of the organic matter content of the soil, the formation of bare patches and excessive trampling, all of which make the vertic soils in the Amersfoort area very susceptible to erosion.

The **Themeda triandra-Berkheya setifera** Closed Grassland Unit (Vegetation Unit 5.3.1 in Figure 9.2) occurs at higher altitudes, has fewer vertic soils and

¹Prof. M.C. Laker, Department of Soil Science, University of Pretoria, 0002.

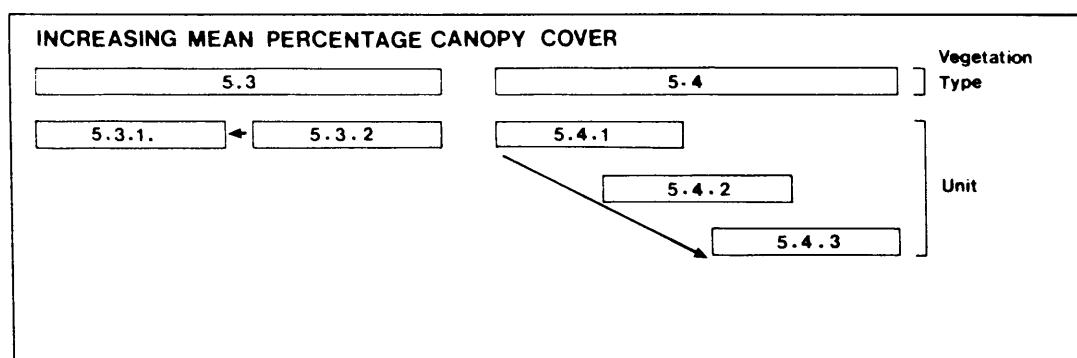


FIGURE 5.2 The *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type is characterized by a high rock cover and a low maximum canopy cover.

conversely more non-vertic soils than the other Vegetation Units. In addition to not being as prone to erosion for the reasons outlined above which affect vertic soils, the non-vertic soils (Milkwood and Hutton Forms) may have up to eight times the quantity of free iron (Fe) than is found in the vertic soils in the area (Land Type Survey Staff 1985, 1986), which makes them more stable and less susceptible to erosion (Laker pers. comm.). This Vegetation Unit has therefore been able to withstand the poor management practices applied (as indicated by the decline in the species composition of the vegetation since Acocks' (1953) survey: see Chapter 8). As a result, this syntaxon has the most desirable species composition of all the Vegetation Units (see Table 8.3) as well as a high mean percentage canopy cover (Figure 9.5), and it is the least eroded (Figure 9.2).

With a decrease in the mean altitude and an increase in the quantity of vertic soils, the *Themeda triandra-Hermannia depressa* Closed Grassland Unit (Vegetation Unit 5.3.2 in Figure 9.2) is less resistant to disturbance, hence the increased erosion and the deterioration in the species composition of the vegetation (see Table 8.3). An initial consequence of vegetation degradation is a breakdown in the canopy cover, hence the statistically significantly lower mean percentage canopy cover in the *Themeda triandra-Hermannia depressa* Closed Grassland Unit (Figure 9.5), as compared to the former Vegetation Unit.

The Vegetation Units of the *Eragrostis chloromelas-Eragrostis plana* Closed Grassland Type (Figure 9.2) are progressively more sensitive to disturbance as a result of the progressively lower altitudes and the increase in the percentage of vertic soils from the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (Vegetation Unit 5.4.1 in Figure 9.2) to the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (Vegetation Unit 5.4.3 in Figure 9.2). There is thus a corresponding increase in the degree of veld degradation from left to right (see Table 8.4). However, there is also a statistically significant increase in the mean percentage canopy cover from left to right (Figure 9.5). It is suggested that the prevailing disturbed conditions that have favoured the establishment and spread of the indicator grasses (see Table 8.4) have ultimately resulted in an increase in the canopy cover of this vegetation. The high cover provided by the indicator grasses may well have then afforded some protection to the soil, so decelerating the rate of erosion with the result that there is no statistically significant increase in erosion from the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit to the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (Figure 9.2).



→ indicates a statistically significant difference

FIGURE 9.5 Gradients of increasing mean percentage canopy cover within the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type and the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type (see Figure 5.1).

The *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types have been excluded from the discussion of the gradients in the vegetation, primarily because they have few of the plant species that have been shown to be sensitive to mismanagement. Their placement on the extreme left-hand side of the combined synoptic table (Table 5.6) is, however, considered justified since these two Vegetation Types probably represent the most natural, undisturbed vegetation in the study area. Not only do both occur at high altitude in mountainous regions (thus being less easily accessible to grazers), but the high rock cover and low canopy cover (which are indicative of the sparsity of fodder) of the *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type, and the steep slopes of the *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type (see Chapter 5) would make these two Vegetation Types unattractive to grazing animals. In addition to the adverse habitat conditions, palatable grasses are scarce in both Vegetation Types (see Table 5.1). It is therefore unlikely that grazing pressures have wrought much change in the development of these two syntaxa.

The 29 Variants described in Chapter 5 are considered to be artifacts of the classification, this assumption being supported by the fact that discrete Variants could not be identified in the DECORANA analysis of the data (see Section 4.3.3). The Variants appear to represent very localized variations in the response of the vegetation to differing degrees of mismanagement, since they all occur over a wide range of habitat conditions and it is not possible to correlate them with any specific habitat parameters, with the exception of the *Themeda triandra*-*Limeum viscosum* subsp. *viscosum* Closed Grassland Variant and the *Eragrostis plana*-*Nidorella anomala* Closed Grassland Variant (see Chapter 5).

9.4 OBJECTIVES REVIEWED

Only one of the objectives of this survey has thus been realized (see Chapter 1), namely that of classifying and describing the vegetation. There is evidence that the classification is valid to the level of the Vegetation Sub-Units since these syntaxa were supported by the DECORANA analysis (see Chapter 6). It is possible to draw conclusions from the data as to what factors are responsible for the differentiation of the different Vegetation Types, Units and Sub-Units, but with the exception of the *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types, the syntaxa could not be

correlated with specific habitat conditions (see Chapter 5). The vegetation appears to be responding primarily to a history of mismanagement as evidenced by the marked deterioration in the species composition of the Amersfoort vegetation since Acocks' (1953, 1988) survey of ca 35 years ago. The supposition that the vegetation has been mismanaged is supported by the fact that it is estimated that only 12% of the vegetation in the south-eastern Transvaal is in a good condition (Aucamp & Danckwerts 1989).

It is not possible to map any of the syntaxa described since their constituent sub-sample relevés are scattered throughout the study area. The two exceptions are the *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types, but these have been described from four or five sub-sample relevés taken at, in each case, a single sampling locality.

TABLE 10.1 Analysis of the plant taxa collected in the Amersfoort area of the south-eastern Transvaal.

FAMILY	GENERA	SPECIES*	FAMILY	GENERA	SPECIES*
<u>PTERIDOPHYTA</u>			Oxalidaceae	1	4
Adiantaceae	2	5	Linaceae	1	1
Aspleniaceae	1	1	Polygalaceae	1	5
Sub-total	<u>3</u>	<u>6</u>	Euphorbiaceae	5	9
<u>ANGIOSPERMAE</u>			Anacardiaceae	1	2
<u>MONOCOTYLEDONAE</u>			Celastraceae	1	1
Typhaceae	1	1	Meliantaceae	1	1
Poaceae	48	93	Malvaceae	2	4
Cyperaceae	12	26	Sterculiaceae	1	9
Commelinaceae	2	3	Clusiaceae	1	2
Juncaceae	1	2	Thymelaeaceae	1	9
Liliaceae	14	25	Lythraceae	1	3
Amaryllidaceae	4	5	Onagraceae	1	3
Hypoxidaceae	2	7	Apiaceae	4	4
Iridaceae	7	14	Myrsinaceae	1	1
Sub-total	<u>91</u>	<u>176</u>	Ebenaceae	1	1
<u>DICOTYLEDONAE</u>			Gentianaceae	2	3
Santalaceae	1	3	Periplocaceae	1	2
Polygonaceae	2	8	Asclepiadaceae	4	5
Chenopodiaceae	1	3	Convolvulaceae	5	11
Amaranthaceae	3	4	Boraginaceae	2	2
Aizoaceae	2	4	Verbenaceae	2	3
Phytolaccaceae	1	1	Lamiaceae	8	11
Mesembryanthemaceae	1	2	Solanaceae	3	5
Portulacaceae	1	1	Scrophulariaceae	10	17
Caryophyllaceae	1	1	Selaginaceae	2	3
Illecebraceae	3	4	Acanthaceae	4	7
Ranunculaceae	1	2	Plantaginaceae	1	3
Brassicaceae	3	5	Rubiaceae	5	14
Crassulaceae	1	8	Dipsacaceae	1	1
Rosaceae	3	3	Cucurbitaceae	1	2
Fabaceae	12	30	Campanulaceae	1	2
Geraniaceae	2	8	Lobeliaceae	3	6
			Asteraceae	39	93
			Sub-total	<u>156</u>	<u>336</u>
			Total	<u>250</u>	<u>518</u>

* Including subspecies and varieties

CHAPTER 10

CHECKLIST

The reference specimens for the plants collected during this survey are housed at the National Herbarium, Pretoria (PRE) or as live specimens in the nursery of the Pretoria National Botanical Garden. They are listed below and have been named and arranged according to the system used by PRE. The numbers in parentheses following a plant name indicate the author's collection number and naturalized species are indicated by an asterisk (*).

The Pteridophyta are arranged according to Schelpe & Anthony (1986) and the Angiospermeae follow the system of De Dalla Torre & Harms (1958, in Dyer 1975, 1976; Gibbs Russell et al. 1985, 1987, 1988), with the exception of the Poaceae, which are numbered according to the system used by the Royal Botanic Gardens, Kew (Dyer 1976). The Kew numbers are preceded by a "K", with the numbers assigned by De Dalla Torre & Harms (1985, in Dyer 1975, 1976) following in parentheses (Dyer 1976).

One grass species, namely *Setaria flabellata* subsp. *natalensis*, is recognised based on Chippindall's (1955) description, although PRE follows Clayton & Renvoize's (1982) system where this species is identified as *Setaria sphacelata* var. *torta*. The latter species is described as being a problematic "polyploid complex" comprising a number of intergrading varieties (Clayton & Renvoize 1982), and since the plants occurring in the study area match the description of Chippindall (1955), this nomenclature was retained.

A total of 250 genera and 518 species in 61 families were recorded during the present survey (Table 10.1), with the Poaceae and Asteraceae being the largest families represented. Three species which are new records for PRE in the Transvaal were collected, namely *Hirpicium amerioides* (Asteraceae), *Ifloga decumbens* (Asteraceae) and *Helichrysum ammitophilum* (Asteraceae), and one previously undescribed species, *Lotononis* sp. nov. (1468, 1624) (Fabaceae), was also collected.

PTERIDOPHYTAADIANTACEAE*Cheilanthes* Swartz

- C. eckloniana* (Kunze) Mett. (620)
- C. hirta* Swartz (1255)
- C. involuta* (Swartz) Schelpe & N.C. Anthony var. *involuta* (1302)
- C. quadripinnata* (Forssk.) Kuhn (1258)

Pellaea Link

- P. calomelanos* (Swartz) Link (1456)

ASPLENIACEAE*Asplenium* L.

- A. varians* Wall. ex Hook. & Grev. subsp. *fimbriatum* (Kunze) Schelpe (1438A)

ANGIOSPERMAEMONOCOTYLEDONAETYPHACEAE49 *Typha* L.

- T. capensis* (Rohrb.) N.E. Br. (1614)

POACEAE

- K21(127a) *Hemarthria* R. Br.
 - H. altissima* (Poir.) Stapf & C.E. Hubb. (916)
- K28(132) *Elionurus* Kunth ex Willd.
 - E. muticus* (Spreng.) Kunth (307)
- K37(109) *Imperata* L.
 - I. cylindrica* (L.) Raeuschel (541)
- K38 *Miscanthus* Anderss.
 - M. junceus* (Stapf) Gibbs Russel MS. (725)
- K71(134) *Andropogon* L.
 - A. appendiculatus* Nees (441)

- A. huillensis** Rendle (1240)
A. schirensis A. Rich. (881)
- K72(134g) **Cymbopogon** Spreng.
 C. dieterlenii Stapf ex Phill. (566)
 C. excavatus (Hochst.) Stapf ex Burt Davy 1 (666)
 C. plurinodis (Stapf) Stapf ex Burt Davy 1 (573)
 C. prolixus (Stapf) Phill. 1 (734)
- K73(134h) **Hyparrhenia** Fourn.
 H. anamesa Clayton (414)
 H. dregeana (Nees) Stapf (667)
 H. hirta (L.) Stapf (625)
- K75(134i) **Monocymbium** Stapf
 M. ceresiiforme (Nees) Stapf (1081)
- K78(131) **Trachypogon** Nees
 T. spicatus (L. f.) Kuntze (1532)
- K80(134j) **Heteropogon** Pers.
 H. contortus (L.) Roem. & Schult. (512)
- K81 **Diheteropogon** Stapf
 D. amplexans (Nees) Clayton (1047)
- K83(136) **Themeda** Forssk.
 T. triandra Forssk. (268)
- K89(166f) **Digitaria** Haller
 D. diagonalis (Nees) Stapf var. **diagonalis** (1548)
 D. eriantha Steud. (784)
 D. eylesii C.E. Hubb. (629)
 D. monodactyla (Nees) Stapf (785)
 D. ternata (A. Rich.) Stapf (945)
 D. tricholaenoides Stapf (708)
- K94(166a) **Alloteropsis** C.B. Presl
 A. semialata (R. Br.) Hitchc. subsp. **semialata** (474)
- K104(166c) **Brachiaria** (Trin.) Griseb.
 B. eruciformis (J.E. Sm.) Griseb. (685)
 B. serrata (Thunb.) Stapf (451)
- K107(161) **Paspalum** L.
 P. dilatatum Poir. (665) *
 P. paspalodes (Michx.) Scribn. (758)
- K110(166b) **Urochloa** Beauv.
 U. panicoides Beauv. (1627)

- K112(166d) *Echinochloa* Beauv.
E. colona (L.) Link (762)
- K116(166) *Panicum* L.
P. dregeanum Nees (498)
P. schinzii Hack. (1400)
- K128(171) *Setaria* Beauv.
S. flabellata Stapf subsp. *natalensis* (1232)
S. incrassata (Hochst.) Hack. (780)
S. nigrirostris (Nees) Dur. & Schinz (425)
S. pallide-fusca (Schumach.) Stapf & C.E. Hubb. 1 (756)
- K132a(168a) *Rhynchelytrum* Nees
R. nerviglume (Franch.) Chiov. (627)
- K139(175) *Pennisetum* Rich.
P. sphacelatum (Nees) Dur. & Schinz (779)
P. thunbergii Kunth (418)
P. villosum R. Br. ex Fresen (1273) *
- K159(194) *Leersia* Swartz
L. hexandra Swartz (684)
- K163(204) *Phalaris* L.
P. arundinacea L. (640) *
- K173(153) *Arundinella* Raddi
A. nepalensis Trin. (709)
- K174(277) *Tristachya* Nees
T. leucothrix Nees (285)
- K195(273) *Avena* L.
A. sativa L. (204) *
- K197(273a) *Helictotrichon* Schult.
H. turgidulum (Stapf) Schweick. (502)
Helictotrichon sp. (768)
- K214(333) *Phragmites* Adanson
P. australis (Cav.) Steud. (1613)
- K243(242) *Agrostis* L.
A. eriantha Hack. var. *eriantha* (1327)
A. lachnantha Nees var. *lachnantha* (503)
- K262(208) *Aristida* L.
A. adscensionis L. subsp. *adscensionis* (668)
A. bipartita (Nees) Trin. & Rupr. (465)
A. congesta Roem. & Schult. subsp. *congesta* (680)

- A. diffusa* Trin. subsp. *burkei* (Stapf) Meld. (653)
A. junciformis Trin. & Rupr. subsp. *junciformis* (622)
- K274(143) *Tragus* Haller
T. racemosus (L.) All. (964)
- K283(230) *Sporobolus* R. Br.
S. africanus (Poir.) Robyns & Tournay (1015)
S. centrifugus (Trin.) Nees (562)
S. discosporus Nees (702)
 cf. *Sporobolus pectinatus* Hack. (971)
 cf. *Sporobolus* sp. (1661)
- K286(341) *Eragrostis* Wolf
E. capensis (Thunb.) Trin. (306)
E. chloromelas Steud. (870)
E. curvula (Schrad.) Nees (438)
E. gummiflua Nees (1076)
E. micrantha Hack. (767)
E. patentissima Hack. (1524)
E. plana Nees (662)
E. planiculmis Nees (706)
E. racemosa (Thunb.) Steud. (348)
E. sclerantha Nees subsp. *sclerantha* (1530)
E. tef (Zucc.) Trotter (1509) *
- K294(281) *Microchloa* R. Br.
M. caffra Nees (349)
- K294b(281b) *Catalepis* Stapf & Stent
C. gracilis Stapf & Stent (694)
- K296(282) *Cynodon* Rich.
C. dactylon (L.) Pers. (678)
C. hirsutus Stent (384)
C. transvaalensis Burt Davy (628)
- K298(285) *Harpochloa* Kunth
H. falx (L. f.) Kuntze (1148)
- K301(288) *Chloris* Swartz
C. virgata Swartz (608)
- K331(304) *Eleusine* Gaertn.
E. coracana (L.) Gaertn. subsp. *africana* (K. O'Byrne) Hilu & De Wet (1506)

- E. indica* (L.) Gaertn. subsp. *africana* (K. O'Byrne) S.M. Phillips (659)
- E. multiflora* A. Rich. (1508) *
- K334(337a) *Pogonarthria* Stapf
- P. squarrosa* (Roem. & Schult.) Pilg. (1697)
- K353(337c) *Trichoneura* N.J. Anderss.
- T. grandiglumis* (Nees) Ekman (965)
- K371(326) *Fingerhuthia* Nees
- F. sesleriiformis* Nees (535)
- K374(346) *Koeleria* Pers.
- K. capensis* (Steud.) Nees (305)
- K407(378) *Poa* L.
- P. annua* L. (214) *
- K428(389) *Bromus* L.
- B. leptoclados* Nees (504)
- B. unioloides* H. B. K. (619) *
- K432(393) *Brachypodium* Beauv.
- B. flexum* Nees (1433)
- K433(395) *Lolium* L.
- L. multiflorum* Lam. (213)

CYPERACEAE

- 457 *Cyperus* L.
- C. cuspidatus* H. B. K. (1656)
- C. denudatus* L. f. (427)
- C. esculentus* L. (1489)
- C. fastigiatus* Rottb. (421)
- C. marginatus* Thunb. (724)
- C. obtusiflorus* Vahl var. *flavissimus* Boeck. (846)
- C. rigidifolius* Steud. (1507)
- C. semitrifidus* Schrad. (340)
- 459a *Pycnus* Beauv.
- P. macranthus* C.B. Cl. (397)
- P. unioloides* (R. Br.) Urb. (602)
- 459c *Mariscus* Gaertn.
- M. capensis* (Steud.) Schrad. (843)
- M. congestus* (Vahl) C.B. Cl. (1383)
- M. uitenhagensis* Steud. (1095)

- 462 *Kyllinga* Rottb.
 K. erecta Schumach. (891)
 K. pulchella Kunth (1391)
- 467 *Fuirena* Rottb.
 F. coerulescens Steud. (923)
 F. pubescens (Poir.) Kunth (398)
- 468 *Scirpus* L.
 S. burkei C.B. Cl. (1079)
- 468a *Schoenoplectus* Palla
 S. decipiens (Nees) J. Raynal (362)
- 469 *Eleocharis* R. Br.
 E. palustris R. Br. (411)
- 471a *Bulbostylis* Kunth
 B. humilis (Kunth) C.B. Cl. (969)
- 471b *Abildgaardia* Vahl
 A. ovata (Burm. f.) Kral (263)
- 521 *Schoenoxiphium* Nees
 S. sparteum (Wahlenb.) C.B. Cl. (853)
 Schoenoxiphium sp. prob. *S. sparteum* (Wahlenb.) C.B. Cl. (1251)
- 525 *Carex* L.
 C. glomerabilis Krecz. (439)
 C. schlechteri Nelmes (468)

COMMELINACEAE

- 896 *Commelina* L.
 C. africana L. var. *africana* (1028)
 C. subulata Roth (1465)
- 904 *Cyanotis* D. Don
 C. speciosa (L. f.) Hassk. (320)

JUNCACEAE

- 936 *Juncus* L.
 J. exsertus Buchen. (600)
 J. oxycarpus E. Mey. ex Kunth (1671)

LILIACEAE

- 969 *Androcymbium* Willd.
 A. melanthioides Willd. var. *striatum* Bak. (324)

- 985 *Bulbine* Willd.
B. filifolia Bak. (332)
- 985a *Trachyandra* Kunth
T. asperata Kunth var. *carolinensis* Oberm. (1142)
T. asperata Kunth var. *macowanii* (Bak.) Oberm. (403)
T. asperata Kunth var. *nataglencoensis* (Kuntze) Oberm. (434)
T. reflexipilosa (Kuntze) Oberm. (918)
T. saltii (Bak.) Oberm. var. *saltii* (1178)
- 989 *Anthericum* L.
A. fasciculatum Bak. (691)
- 1012 *Eriospermum* Jacq. ex Willd.
Eriospermum sp. prob. *E. luteo-rubrum* Bak. (1460)
- 1024 *Kniphofia* Moench
K. linearifolia Bak. (1243)
- 1026 *Aloe* L.
Aloe davyana Schonl. (599)
- 1046 *Agapanthus* L'Herit.
A. campanulatus Leighton subsp. indet. (1451)
- 1047 *Tulbaghia* L.
T. acutiloba Harv. (338)
- 1079 *Albuca* L.
A. setosa Jacq. (413)
- 1084 *Dipcadi* Medik.
D. viride (L.) Moench (430)
- 1090 *Drimiopsis* Lindl.
D. burkei Bak. (1153)
cf. *Drimiopsis burkei* Bak. (797)
- 1090a *Ledebouria* Roth.
L. ovatifolia (Bak.) Jessop (1107)
L. revoluta (L. f.) Jessop (319)
L. undulata (Jacq.) Jessop (prob.) (1084)
Ledebouria sp. cf. *L. marginata* (Bak.) Jessop (1175)
Ledebouria sp. prob. *L. revoluta* (L. f.) Jessop (963)
cf. *Ledebouria cooperi* (Hook. f.) Jessop (1672)
- 1113a *Protasparagus* Oberm.
P. edulis Oberm. sp. nov. ined. (1551)
P. laricinus (Burch.) Oberm. (1257)

AMARYLLIDACEAE

- 1168 *Haemanthus* L.
 H. humilis Jacq. subsp. *hirsutus* (Bak.) Snijman (636)
- 1175 *Nerine* Herb.
 N. platypetala MacNeil (1329)
- 1189 *Crinum* L.
 C. bulbispermum (Burm. f.) Milne-Redh. & Schweick. (1123)
- 1191 *Cyrtanthus* L.f.
 C. breviflorus Harv. (1576)
 C. tuckii Bak. var. *transvaalensis* Verdoorn (1212)

HYPOXIDACEAE

- 1229a *Empodium* Salisb.
 E. elongatum (Nel) B.L. Burtt (1176)
- 1230 *Hypoxis* L.
 H. acuminata Bak. (284)
 H. argentea Harv. ex Bak. (1152)
 H. gerrardii Bak. (1144)
 H. iridifolia Bak. (1173)
 H. multiceps Buchinger (1127A)
 ? *H. rigidula* Bak. (1129)

IRIDACEAE

- 1265 *Moraea* Mill.
 M. thomsonii Bak. (1160)
- 1277 *Homeria* Vent.
 H. pallida Bak. (1124)
- 1295 *Aristea* Ait.
 A. montana Bak. (1317)
- 1299 *Schizostylis* Backh. & Harv.
 S. coccinea Backh. & Harv. (1315)
- 1303 *Dierama* K. Koch
 D. insigne N.E. Br. (371)
 Dierama sp. (953)
 Dierama sp. (1571)
- 1306 *Tritonia* Ker-Gawl.
 T. lineata (Salisb.) Ker-Gawl. (279)
 Tritonia sp. (poss.) (852)

1311 *Gladiolus* L.*G. crassifolius* Bak. (1399)*G. longicollis* Bak. var. *platypetalus* (Bak.) Oberm. (304)*G. robertsoniae* F. Bol. (432)*G. sericeo-villosus* Hook. f. forma *sericeo-villosus* (1262)*Gladiolus* sp. poss. *G. crassifolius* Bak. (924)DICOTYLEDONAESANTALACEAE2118 *Thesium* L.*T. burkei* A.W. Hill (1149)*T. exile* N.E. Br. (1164)*Thesium* sp. (943)POLYGONACEAE2195 *Rumex* L.*R. angiocarpus* Murb. (875) **R. bequaertii* De Wild. (1208)*R. lanceolatus* Thunb. (288)*R. sagittatus* Thunb. (1591)*Rumex* sp. cf. *R. crispus* L. (1484) *2201 *Polygonum* L.*P. aviculare* L. (1505) **P. plebeium* R. Br. (720)*P. salicifolium* Willd. (754)CHENOPODIACEAE2223 *Chenopodium* L.*C. album* L. (743) **C. glaucum* L. (1115) **C. schraderanum* Roem. & Schult. (1583) *AMARANTHACEAE2299 *Amaranthus* L.*A. capensis* Thell. (1587)*A. hybridus* L. subsp. *hybridus* var. *hybridus* (1500) *

- 2330 *Brayulinea* Small
 B. densa (Willd.) Small (1504) *
- 2335 *Alternanthera* Forssk.
 A. pungens H. B. K. (1116) *

AIZOACEAE

- 2376 *Limeum* L.
 L. pauciflorum Moq. (1512)
 L. viscosum (Gay) Fenzl subsp. *transvaalense* Friedr. (914)
 L. viscosum (Gay) Fenzl subsp. *viscosum* var. *glomeratum* (Eckl. & Zeyh.)
 Friedr. (1068)
- 2379 *Psammotropha* Dinter & Schwant.
 P. myriantha Sond. (830)

PHYTOLACCACEAE

- 2380 *Phytolacca* L.
 P. heptandra Retz. (1263)

MESEMBRYANTHEMACEAE

- 2405 *Delosperma* N.E. Br.
 D. cooperi (Hook. f.) L. Bol. (1458)
 D. sutherlandii (Hook. f.) N.E. Br. (380)

PORTULACACEAE

- 2421 *Portulaca* L.
 P. oleracea L. (1626) *

CARYOPHYLLACEAE (Part A)

- 2430 *Cerastium* L.
 C. capense Sond. (406)

ILLECEBRACEAE

- 2476 *Herniaria* L.
 H. erckertii Herm. subsp. *erckertii* var. *erckertii* (1239)
- 2490 *Silene* L.
 S. burchellii Otth var. *angustifolia* Sond. (692)
- 2502 *Dianthus* L.
 D. basuticus Burttt Davy subsp. *basuticus* var. *grandiflorus* Hooper (690)

- D. mooiensis* F.N. Williams subsp. *mooiensis* var. *dentatus* Burt Davy
(378)

RANUNCULACEAE

- 2546 *Ranunculus* L.
 R. meyeri Harv. (416)
 R. multifidus Forssk. (252)

BRASSICACEAE

- 2883 *Lepidium* L.
 L. africanum (Burm. f.) DC. subsp. *africanum* (1502)
 L. trifurcum (Sond.) Marais (325)
2917 *Sisymbrium* L.
 S. burchellii DC. var. *burchellii* (1117)
 S. thellungii O.E. Schulz (1590)
2965 *Rorippa* Scop.
 R. nudiuscula Thell. (1426)

CRASSULACEAE

- 3168 *Crassula* L.
 C. alba Forssk. var. *alba* (1306)
 C. lanceolata (Eckl. & Zeyh.) Endl. ex Walp. subsp. *lanceolata* (1455)
 C. lanceolata (Eckl. & Zeyh.) Endl. ex Walp. subsp. *transvaalensis*
 (Kuntze) Toelken (1029)
 C. peploides Harv. (1469)
 C. sarcocaulis Eckl. & Zeyh. subsp. *sarcocaulis* (788)
 C. setulosa Harv. cf. var. *jenkinsii* Schonl. (1256)
 C. setulosa Harv. var. *setulosa* (1454)
 C. vaginata Eckl. & Zeyh. subsp. *vaginata* (1401)

ROSACEAE

- 3353 *Rubus* L.
 R. ludwigii Eckl. & Zeyh. subsp. *ludwigii* (381)
3375 *Alchemilla* L.
 A. kiwuensis Engl. (1277)
3379 *Leucosidea* Eckl. & Zeyh.
 L. sericea Eckl. & Zeyh. (1195)

FABACEAE

- 3657 **Lotononis** (DC.) Eckl. & Zeyh.
 L. calycina (E. Mey.) Benth. var. *hirsutissima* Dummer (376)
 L. eriantha Benth. var. *eriantha* (1319)
 Lotononis sp. nov. (1468, 1624)
- 3665 **Melolobium** Eckl. & Zeyh.
 M. calycinum Benth. (737)
- 3673 **Argyrolobium** Echl. & Zeyh.
 A. pauciflorum Eckl. & Zeyh. var. *pauciflorum* (792)
 A. tuberosum Eckl. & Zeyh. (359)
 Argyrolobium sp. cf. *A. pauciflorum* Eckl. & Zeyh. (1589)
 Argyrolobium sp. cf. *A. tuberosum* Eckl. & Zeyh. (1373)
 Argyrolobium sp. (1651)
 cf. *Argyrolobium* sp. (1358)
- 3688 **Medicago** L.
 M. laciniata (L.) Mill. (1385)
- 3690 **Trifolium** L.
 T. africanum Ser. var. *africanum* (1241)
 T. africanum Ser. var. *glabellum* (E. Mey.) Harv. (774)
 T. africanum Ser. var. *lydenburgense* J.B. Gillett (1575)
- 3702 **Indigofera** L.
 I. frondosa N.E. Br. (791)
 I. hilaris Eckl. & Zeyh. (1204)
 I. pauxilla N.E. Br. (730A)
 I. rostrata H. Bol. (1395)
 Indigofera sp. cf. *I. hilaris* Eckl. & Zeyh. (1033)
 Indigofera sp. cf. *I. stricta* L. f. (1669)
- 3718 **Tephrosia** Pers.
 T. purpurea (L.) Pers. subsp. *leptostachya* (DC.) Brummitt (848)
 T. semiglabra Sond. (1072)
 Tephrosia sp. cf. *T. capensis* (Jacq.) Pers. (1300)
- 3852 **Vicia** L.
 V. sativa L. (1384) *
- 3870 **Erythrina** L.
 E. zeyheri Harv. (1330)
- 3897 **Rhynchosia** Lour.
 R. adenodes Eckl. & Zeyh. (317)
 R. reptabunda N.E. Br. (318)
 R. totta (Thunb.) DC. (949, 978)

- 3898 *Eriosema* (DC.) G. Don
 E. cordatum E. Mey. (1352)
- 3905 *Vigna* Savi
 V. vexillata (L.) A. Rich. (985)

GERANIACEAE

- 3925 *Monsonia* L.
 M. angustifolia E. Mey ex A. Rich. (1472)
 M. attenuata Harv. (769)
 M. brevirostrata Knuth (1561)
- 3928 *Pelargonium* L'Herit.
 P. alchemilloides (L.) L'Herit. (634)
 P. dolomiticum Knuth (1139)
 P. fumarioides L'Herit. ex Harv. (1113)
 P. luridum (Andr.) Sweet (1188)
 P. sidifolium (Thunb.) Knuth (1266)

OXALIDACEAE

- 3936 *Oxalis* L.
 O. corniculata L. (1002) *
 O. depressa Eckl. & Zeyh. (375)
 O. obliquifolia Steud. ex Rich. (844)
 O. smithiana Eckl. & Zeyh. (632)

LINACEAE

- 3945 *Linum* L.
 L. thunbergii Eckl. & Zeyh. (1324)

POLYGALACEAE

- 4273 *Polygala* L.
 P. amatymbica Eckl. & Zeyh. (957)
 P. gerrardii Chod. (1089)
 P. hottentotta Presl (641)
 P. uncinata E. Mey. ex Meisn. (361)
 Polygala sp. (1658)

EUPHORBIACEAE

- 4299 *Phyllanthus* L.
 P. maderaspatensis L. (1051)

- 4407 *Acalypha* L.
 A. angustata Sond. var. *glabra* Sond. (800)
 A. caperonioides Baill. (1135, 1205)
- 4448 *Clutia* L.
 C. affinis Sond. (1442)
 C. natalensis Bernh. ex Krauss (1246)
- 4498 *Euphorbia* L.
 E. clavarioides Boiss. var. *trutcata* (N.E. Br.) White, Dyer & Sloane (1474A)
 E. striata Thunb. (1110)
- 4498a *Chamaesyce* S.F. Gray
 C. inequilatera (Sond.) Sojak (1513)
 C. prostrata (Ait.) Small (1056) *

ANACARDIACEAE

- 4594 *Rhus* L.
 R. dentata Thunb. (385)
 R. discolor E. Mey. ex Sond. (775)

CELASTRACEAE

- 4626 *Maytenus* Molina
 M. heterophylla (Eckl. & Zeyh.) N.K.B. Robson (1450)

MELIANTHACEAE

- 4854 *Melianthus* L.
 M. comosus Vahl (575)

MALVACEAE

- 4987 *Modiola* Moench
 M. caroliniana (L.) G. Don (1216) *
- 5013 *Hibiscus* L.
 H. aethiopicus L. var. *ovatus* Harv. (816)
 H. microcarpus Garcke (530)
 H. trionum L. (1336)

STERCULIACEAE

- 5056 *Hermannia* L.
 H. coccocarpa (Eckl. & Zeyh.) Kuntze (1213)
 H. cordata (E. Mey. ex Phill.) De Winter (1248)

APIACEAE

- 5894 *Centella* L.
 C. asiatica (L.) Urb. (872)
- 5922 *Alepidea* De le Roche
 A. basinuda Pott var. *basinuda* (1382)
- 5994 *Bupleurum* L.
 B. mundtii Cham. & Schlechtd. (1440)
- 6038a *Berula* Koch
 B. erecta (Hudson) Cov. (1282)

MYRSINACEAE

- 6313 *Myrsine* L.
 M. africana L. (1443)

EBENACEAE

- 6406 *Diospyros* L.
 D. lycioides Desf. subsp. *guerkei* (Kuntze) De Winter (742)

GENTIANACEAE

- 6481 *Sebaea* Soland. ex R. Br.
 S. exigua (Oliv.) Schinz (927)
 S. leiostyla Gilg (722)
- 6503 *Chironia* L.
 cf. *Chironia palustris* Burch. subsp. *palustris* (1064)

PERIPLOCACEAE

- 6747 *Raphionacme* Harv.
 R. hirsuta (E. Mey.) R.A. Dyer ex Phill. (1146)
 Raphionacme sp. (1013)

ASCLEPIADACEAE

- 6777 *Xysmalobium* R. Br.
 X. undulatum (L.) Ait. f. (1408)
- 6778 *Schizoglossum* E. Mey.
 S. stenoglossum Schltr. subsp. *stenoglossum* (630)
- 6791 *Asclepias* L.
 A. gibba (E. Mey.) Schltr. (1137)
 Asclepias sp. (262)

- 6870 *Brachystelma* R. Br.
cf. *Brachystelma foetidum* Schltr. (1602)

CONVOLVULACEAE

- 6972 *Falkia* L.f.
F. oblonga Bernh. ex Krauss (1125)
- 6993 *Convolvulus* L.
C. arvensis L. (1159) *
C. natalensis Bernh. apud Krauss var. *natalensis* (1217)
C. natalensis Bernh. apud Krauss var. *transvaalensis* (Schltr.) A. Meeuse (302)
C. sagittatus Thunb. subsp. *sagittatus* var. *sagittatus* (346)
C. sagittatus Thunb. subsp. *sagittatus* var. *hirtellus* (Hallier f.) A. Meeuse (778)
C. sagittatus Thunb. subsp. *sagittatus* var. *phyllosepalus* (Hallier f.) A. Meeuse (939)
- 6997 *Merremia* Dennst.
M. tridentata (L.) Hallier f. subsp. *angustifolia* (Jacq.) Ooststr. (1097)
- 7003 *Ipomoea* L.
I. atherstonei Bak. (783)
I. crassipes Hook. (298)
- 7008a *Turbina* Rafin.
T. oblongata (E. Mey. ex Choisy) A. Meeuse (1496)

BORAGINACEAE

- 7064 *Cynoglossum* L.
C. hispidum Thunb. (841)
- 7118 *Echium* L.
E. plantagineum L. (267) *

VERBENACEAE

- 7138 *Verbena* L.
V. brasiliensis Vell. (1005) *
V. venosa Gill. & Hook. (782) *
- 7144 *Lantana* L.
L. mearnsii Moldenke var. *latibracteolata* Moldenke (1552)

LAMIACEAE

- 7211 *Ajuga* L.
A. ophrydis Burch. ex Benth. (1168)
- 7264 *Leonotis* (Pers.) R. Br.
L. ocymifolia (Burm. f.) Iwarsson var. *ocymifolia* (1011)
L. ocymifolia (Burm. f.) Iwarsson var. *raineriana* (Visiani) Iwarsson (740)
- 7281 *Stachys* L.
S. hyssopoides Burch. ex Benth. (290)
S. nigricans Benth. (839)
- 7290 *Salvia* L.
S. repens Burch. ex Benth. var. *repens* (1119)
S. repens Burch. ex Benth. var. *transvaalensis* Hedge (803)
- 7328 *Mentha* L.
M. aquatica L. (1286)
- 7350 *Plectranthus* L'Herit.
P. grallatus Briq. (1432)
- 7350c *Rabdosiella* Codd
R. calycina (Benth.) Codd (741)
- 7366a *Becium* Lindl.
B. obovatum (E. Mey. ex Benth.) N.E. Br. var. *obovatum* (316)

SOLANACEAE

- 7400 *Withania* Pauquy
W. somnifera (L.) Dun. (770)
- 7401 *Physalis* L.
P. angulata L. (1629) *
- 7407 *Solanum* L.
S. panduriforme E. Mey. (1120)
S. pseudocapsicum L. (388) *
S. retroflexum Dun. (1592)

SCROPHULARIACEAE (Part A)

- 7476 *Nemesia* Vent.
N. fruticans (Thunb.) Benth. (1003)
- 7477 *Diclis* Benth.
D. reptans Benth. (925)
D. rotundifolia (Hiern) Hilliard & Burttt (394)

- 7519 *Sutera* Roth
 S. aurantiaca (Burch.) Hiern (255)
 S. caerulea (L. f.) Hiern (1018)
 S. floribunda (Benth.) Kuntze (727)
 S. neglecta (Wood & Evans) Hiern (1560)
 S. pinnatifida (Benth.) Kuntze (909)
 Sutera sp. cf. *S. pristisepala* Hiern (789)
 Sutera sp. (1501)
- 7523 *Zaluzianskya* F.W. Schmidt
 Z. elongata Hilliard & Burt (1641)
- 7524 *Mimulus* L.
 M. gracilis R. Br. (424)
- 7558 *Limosella* L.
 L. longiflora Kuntze (1114A)

SELAGINACEAE

- 7566 *Hebenstretia* L.
 H. oatesii Rolfe subsp. *oatesii* (321)
 H. rehmannii Rolfe (1467)
- 7568a *Walafrida* E. Mey.
 W. densiflora (Rolfe) Rolfe (1067)

SCROPHULARIACEAE (Part B)

- 7579 *Veronica* L.
 V. anagallis-aquatica L. (753)
- 7597a *Alectra* Thunb.
 A. orobanchoides Benth. (868)
- 7624 *Rhamphicarpa* Benth.
 R. fistulosa (Hochst.) Benth. (417)
- 7625 *Striga* Lour.
 S. bilabiata (Thunb.) Kuntze (467)

ACANTHACEAE

- 7914 *Thunbergia* Retz.
 T. artiplicifolia E. Mey. ex Nees (323)
- 7941 *Chaetacanthus* Nees
 C. burchellii Nees (899)
 C. setiger (Pers.) Lindl. (395)
 Chaetacanthus sp. (1247)

- 7972 *Crabbea* Harv.
 C. acaulis N.E. Br. (793)
 C. hirsuta Harv. (1309)
- 7980 *Blepharis* Juss.
 B. natalensis Oberm. (644)

PLANTAGINACEAE

- 8116 *Plantago* L.
 P. lanceolata L. (210) *
 P. myosuroides Lam. (258) *
 P. virginica L. (401) *

RUBIACEAE

- 8136f *Kohautia* Cham. & Schlecht.
 K. amatymbica Eckl. & Zeyh. (1201)
 K. caespitosa Schnizl. (960)
 K. cynanchica DC. (1536)
 Kohautia sp. (1295)
- 8348 *Pentanisia* Harv.
 P. angustifolia (Hochst.) Hochst. (1539)
 P. prunelloides (Eckl. & Zeyh.) Walp. (315)
- 8359 *Pachystigma* Hochst.
 Pachystigma sp. cf. *P. macrocalyx* (Sond.) Robyns (890)
 Pachystigma sp. cf. *P. pygmaeum* (Schltr.) Robyns (1396)
- 8438 *Anthospermum* L.
 A. pumilum Sond. subsp. *pumilum* (1664)
 A. pumilum Sond. subsp. *rigidum* (Eckl. & Zeyh.) Puff (834)
- 8486 *Galium* L.
 G. capense Thunb. subsp. *capense* (1192)
 G. capense Thunb. subsp. *garipense* (Sond.) Puff (915)
 G. scabrelloides Puff (1430)
 G. thunbergianum Eckl. & Zeyh. var. *thunbergianum* (1439)

DIPSACACEAE

- 8546 *Scabiosa* L.
 S. columbaria L. (261)

CUCURBITACEAE

- 8599 *Cucumis* L.
 C. hirsutus Sond. (631)
 C. myriocarpus Naud. (1274)

CAMPANULACEAE

- 8668 *Wahlenbergia* Schrad. ex Roth
 W. undulata (L. f.) A. DC. (1564)
 W. virgata Engl. (1200)

LOBELIACEAE

- 8681 *Cyphia* Berg.
 C. elata Harv. var. *elata* (880)
 8694 *Lobelia* L.
 L. angolensis Engl. & Diels (1280)
 L. flaccida (Presl) A. DC. subsp. *flaccida* (1199)
 Lobelia sp. (1662)
 8695 *Monopsis* Salisb.
 M. decipiens (Sond.) Thulin (1675)
 M. scabra (Thunb.) Urb. (894)

ASTERACEAE

- 8751 *Vernonia* Schreb.
 V. hirsuta (DC.) Sch. Bip. (1549)
 V. natalensis Sch. Bip. (276)
 8900 *Aster* L.
 A. bakeranus Burt Davy ex C.A. Sm. (633)
 8919 *Felicia* Cass.
 F. muricata (Thunb.) Nees subsp. *muricata* (1006)
 8925 *Nidorella* Cass.
 N. anomala Steetz (1370)
 N. resedifolia DC. subsp. *resedifolia* (1098)
 8926 *Conyza* Less.
 C. chilensis Spreng. (1323) *
 C. obscura DC. (1322)
 C. podocephala DC. (913)
 C. sumatrensis (Retz.) E.H. Walker (1378) *
 8949 *Denekia* Thunb.
 D. capensis Thunb. (405)

- 8967 *Ifloga* Cass.
 I. decumbens (Thunb.) Schltr. (1453)
- 8992a *Pseudognaphalium* Kirp.
 P. luteo-album (L.) Hilliard & Burt (331)
- 9006 *Helichrysum* Mill.
 H. ammitophilum Hilliard (1616)
 H. aureonitens Sch. Bip. (1393)
 H. aureum (Houtt.) Merr. var. *monocephalum* (DC.) Hilliard (275)
 H. caespititium (DC.) Harv. (732)
 H. callicomum Harv. (1321)
 H. cephaloideum DC. (1331)
 H. coriaceum Harv. (1101)
 H. melanacme DC. (1676)
 H. miconiifolium DC. (952)
 H. mundtii Harv. (1577)
 H. nudifolium (L.) Less. (1245)
 H. oreophilum Klatt (1296)
 H. pilosellum (L. f.) Less. (402)
 H. psilolepis Harv. (358)
 H. rugulosum Less. (808)
 H. splendidum (Thunb.) Less. (1428)
 Helichrysum sp. cf. *H. platypterum* DC. (1645)
 Helichrysum sp. (989)
 Helichrysum sp. (1351)
 Helichrysum sp. (1361)
- 9037 *Stoebe* L.
 S. vulgaris Levyns (1695)
- 9059 *Printzia* Cass.
 P. auriculata Harv. (1427)
- 9090 *Geigeria* Griesselich
 G. aspera Harv. var. *aspera* (642)
- 9130 *Acanthospermum* Schrank
 A. glabratum (DC.) Wild (755) *
- 9148 *Xanthium* L.
 X. spinosum L. (738) *
- 9155 *Zinnia* L.
 Z. peruviana (L.) L. (1593) *

- 9237 *Bidens* L.
 B. bipinnata L. (1471) *
 B. formosa (Bonato) Sch. Bip. (1657) *
- 9291 *Schkuhria* Roth
 S. pinnata (Lam.) Cabr. (961) *
- 9311 *Tagetes* L.
 T. minuta L. (1403) *
- 9351 *Cotula* L.
 C. anthemoides L. (201)
- 9356 *Schistostephium* Less.
 S. crataegifolium (DC.) Fenzl ex Harv. (882)
- 9406 *Cineraria* L.
 C. aspera Thunb. (1582)
 C. lobata L'Herit. (1449)
- 9411 *Senecio* L.
 S. affinis DC. (1437)
 S. coronatus (Thunb.) Harv. (1209)
 S. erubescens Ait. var. *crepidifolius* DC. (253)
 S. harveianus MacOwan (257)
 S. hieracioides DC. (329)
 S. inaequidens DC. (1618)
 S. isatideus DC. (1609)
 S. laevigatus Thunb. var. *integrifolius* Harv. (1112)
 S. macrocephalus DC. (1210)
 S. oxyriifolius DC. (1474)
 S. paucicalyculatus Klatt (1183)
 S. pleistocephalus S. Moore (1540)
 S. serratuloides DC. var. *gracilis* Harv. (723)
 Senecio sp. (956)
 Senecio sp. (1480)
 Senecio sp. (1517)
- 9417 *Euryops* Cass.
 E. transvaalensis Klatt subsp. *transvaalensis* (1297)
- 9426 *Garuleum* Cass.
 G. woodii Schinz (342)
- 9427 *Osteospermum* L.
 O. caulescens Harv. (1049)
- 9432 *Arctotis* L.
 A. arctotoides (L. f.) O. Hoffm. (330)

- 9432c *Haplocarpha* Less.
 H. lyrata Harv. (1151)
 H. nervosa (Thunb.) Beauv. (1126)
 H. scaposa Harv. (867)
- 9434 *Gazania* Gaertn.
 G. krebsiana Less. subsp. *arctotoides* (Less.) Roessler. (1171)
 G. krebsiana Less. subsp. *serrulata* (DC.) Roessler. (1215)
- 9435 *Hirpicium* Cass.
 H. armerioides (DC.) Roessler. (337)
- 9438 *Berkheya* Ehrh.
 B. pinnatifida (Thunb.) Thell. subsp. *ingrata* (H. Bol.) Roessler. (802)
 B. radula (Harv.) De Wild. (932)
 B. robusta Bohnen ex Roessler. (1578)
 B. setifera DC. (838)
 B. speciosa (DC.) O. Hoffm. subsp. *lanceolata* Roessler. (1388)
- 9462 *Cirsium* Mill. Emend. Scop.
 C. vulgare (Savi) Ten. (1237) *
- 9501 *Dicoma* Cass.
 D. anomala Sond. subsp. *cirsioides* (Harv.) Wild (828)
- 9528 *Gerbera* L.
 G. ambigua (Cass.) Sch. Bip. (1167)
 G. piloselloides (L.) Cass. (1036)
 G. viridifolia (DC.) Sch. Bip. subsp. *natalensis* (Sch. Bip.) H.V.
 Hansen (1133)
 Gerbera sp. cf. *G. ambigua* (Cass.) Sch. Bip. (1367)
- 9561 *Tolpis* Adans.
 T. capensis (L.) Sch. Bip. (1073)
- 9572 *Hypochoeris* L.
 H. radicata L. (296) *
- 9592 *Taraxacum* Wiggers
 T. breviscapum Richards (198) *
 T. hamatifforme Dahlst. (1667) *
 T. officinale Weber (sens. lat.) (860) *
- 9595 *Sonchus* L.
 S. gigas L. Boulos ex Humbert (360)
 S. nanus Sond. ex Harv. (982)
- 9596 *Lactuca* L.
 L. capensis Thunb. (328)

9605 **Crepis** L.

C. hypochoeridea (DC.) Thell. (1162)

SUMMARY

A PHYTOSOCIOLOGICAL STUDY OF THE SOUTH-EASTERN TRANSVAAL HIGHVELD GRASSLANDS

by

BEVERLEY JOY TURNER

Supervisor: Prof. G.K. Theron

Co-supervisor: Dr J.C. Scheepers

DEPARTMENT OF BOTANY
UNIVERSITY OF PRETORIA

MAGISTER SCIENTIAE

The objectives of this study were:

- a) to classify and describe the different vegetation communities in the Amersfoort area, using the Braun-Blanquet phytosociological approach,
- b) to correlate the distribution of the communities with environmental factors and
- c) to map the distribution of the communities.

The study area surrounds Amersfoort in the south-eastern Transvaal, Republic of South Africa. All geological strata are of the Karoo Sequence and the climate is warm temperate with summer rainfall and a mean annual temperature of ca 14°C.

The area was stratified on the basis of land types and geology and the vegetation was sampled using a sub-sampling strategy, with sub-samples distributed in a stratified random manner. A total of 507 sub-samples (3,5m²) were sampled at 127 localities. A list was made of all plant species occurring in each sub-sample and cover-abundance values were estimated for each species. Environmental and habitat data (e.g. altitude, geomorphology, geology, soil form, soil depth and slope) were recorded.

The floristic data were arranged into a Braun-Blanquet phytosociological table using the computer program TWINSpan and the PHYTOTAB program package. Four major

units were identified, namely the *Hebenstretia rehmannii*-*Microchloa caffra* Open Grassland Type, the *Leucosidea sericea*-*Andropogon appendiculatus* Closed Shrubland Type, the *Tristachya leucothrix*-*Themeda triandra* Closed Grassland Type and the *Eragrostis chloromelas*-*Eragrostis plana* Closed Grassland Type.

The first two Vegetation Types are floristically well differentiated and they occur in specific habitats. The latter two Vegetation Types, and the lower syntaxa thereof, are well differentiated floristically but cannot be correlated with specific habitat conditions. The DECORANA ordination of the data indicated several environmental trends, but the statistical analysis of the habitat data of the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types was of greater value, revealing statistically significant differences in the habitat features of these two Vegetation Types and their lower syntaxa, to the level of Vegetation Sub-Unit.

The comparison of the species composition data from the present survey with that of Acocks' (1953) survey indicates that there has been a marked deterioration in the species composition and the condition of the Amersfoort vegetation over the last ca 35 years. Furthermore, there is a gradient of increasing veld degradation within the syntaxa of the vegetation occurring at present in Amersfoort, and it is speculated that this vegetation has developed in response to a history of veld mismanagement.

OPSOMMING**'N FITOSOSIOLOGIESE STUDIE VAN DIE HOËVELD GRASVELDE
IN DIE SUID-OOS TRANSVAAL**

deur

BEVERLEY JOY TURNER

Leier: Prof. G.K. Theron

Medeleier: Dr. J.C. Scheepers

DEPARTEMENT PLANTKUNDE

UNIVERSITEIT VAN PRETORIA

MAGISTER SCIENTIAE

Die doel van hierdie studie was om:

- a) die verskillende plantegroegemeenskappe in die Amersfoortgebied te klassifiseer en te beskryf, met behulp van die Braun-Blanquet-fitososiologiese benadering,
- b) die verspreiding van die gemeenskappe met omgewingsfaktore te korreleer en
- c) die verspreiding van die gemeenskappe te karteer.

Die studiegebied is geleë in die omgewing van Amersfoort in die suidoostelike Transvaal, Republiek van Suid-Afrika. Al die geologiese formasies is van die Karoo Opeenvolging en die klimaat is warm en matig met somerreënval en 'n gemiddelde jaarlikse temperatuur van ca 14°C.

Die gebied is volgens landtipes en geologie gestratifiëer en die plantegroei is met 'n sub-monstermetode gemonster, met die sub-monsters in 'n gestratifiëerde ewekansige wyse uitgeplaas. 'n Totaal van 507 sub-monsters (3,5m²) is uitgeplaas by 127 lokaliteite. 'n Lys is opgestel van al die plantspesies wat in elke sub-monster voorkom, en 'n bedekkingsgetalsterktewaarde is vir elke spesie bepaal. Omgewings- en habitatsfaktore (bv. hoogte bo seespieël, geomorfologie, geologie, grondvorm, gronddiepte en helling) is aangeteken.

Die floristiese data is in 'n Braun-Blanquet-fitososiologiese tabel gerangskik met behulp van die rekenaarprogram TWINSPAN en die PHYTOTAB-programpakket. Vier hoofeenhede is geïdentifiseer, naamlik die *Hebenstretia rehmannii*-*Microchloa caffra*-oep grasveldtipe, die *Leucosidea sericea*-*Andropogon appendiculatus*-geslote struikveldtipe, die *Tristachya leucothrix*-*Themeda triandra*-geslote grasveldtipe en die *Eragrostis chloromelas*-*Eragrostis plana*-geslote grasveldtipe.

Die eerste twee plantegroeitipes is floristies goed gedifferensiëer en hulle kom voor in spesifieke habitats. Die laasgenoemde twee plantegroeitipes, en die laer sintaksons daarvan, is floristies goed gedifferensiëer maar hulle kan nie met spesifieke habitatstoestande gekorreleer word nie. Die DECORANA-ordening van die data dui op verskeie omgewingsneigings, maar die statistiese analise van die habitatsdata van die *Tristachya leucothrix*-*Themeda triandra* en die *Eragrostis chloromelas*-*Eragrostis plana* plantegroeitipes was meer waardevol en het statisties betekenisvolle verskille in die habitatskenmerke van hierdie twee plantegroeitipes en hulle laer sintaksons tot op vlak van plantegroei-subeenheid onthul.

Die vergelyking van die spesiesamestelling van die huidige opname met die van Acocks (1953) wys op 'n skerp agteruitgang van die spesiesamestelling en die toestand van die Amersfoort-plantegroei gedurende die afgelope ca 35 jaar. Daar is ook 'n gradiënt van toenemende veldagteruitgang binne die sintaksons van die plantegroei wat huidiglik in Amersfoort voorkom waargeneem. Hierdie plantegroei het waarskynlik ontwikkel in reaksie op 'n geskiedenis van wanbestuur van die veld.

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CURRICULUM VITAE

Beverley Joy Turner was born on 2nd November 1960 in Pretoria, Transvaal. She grew up in Pinetown, Natal, and matriculated from the Pinetown Girls' High School in 1978.

She then studied at the University of Natal, Pietermaritzburg, graduating with a B.Sc. degree majoring in Botany and Zoology in 1981, and a B.Sc. (Hons.) degree majoring in Botany (Ecology) in 1982.

In 1984 she joined the staff of the Botanical Research Institute in Pretoria and began researching the plant ecology of the grassland vegetation in the Amersfoort area in the south-eastern Transvaal. This research was submitted for her M.Sc. thesis at the University of Pretoria in 1989. She was transferred from the Botanical Research Institute to the Grassland Research Centre in Pretoria early in 1989.

She is a member of the South African Association of Botanists and the Grassland Society of South Africa.

APPENDIX 1

An alphabetical listing of the non-diagnostic plant species occurring in only one sub-sample relev  of phytosociological Tables 5.1, 5.2 and 5.3. The lists for Tables 5.2 and 5.3 respectively apply to the synoptic Tables 5.4 and 5.5 as well. For synoptic Table 5.6 the list indicates the non-diagnostic species occurring only in the *Hebenstretia rehmannii*-*Microchloa caffra* and the *Leucosidea sericea*-*Andropogon appendiculatus* Vegetation Types, and the non-diagnostic species occurring in only one of the Variants of the *Tristachya leucothrix*-*Themeda triandra* and the *Eragrostis chloromelas*-*Eragrostis plana* Vegetation Types. The numbers in parentheses following a plant name indicate the sub-sample relev  (Tables 5.1, 5.2 & 5.3) or Variant (Table 5.6) in which the species occurs.

TABLE 5.1 PHYTOSOCIOLOGICAL TABLE OF THE *Hebenstretia rehmannii*-*Microchloa caffra* OPEN GRASSLAND TYPE AND THE *Leucosidea sericea*-*Andropogon appendiculatus* CLOSED SHRUBLAND TYPE

Argyrolobium sp. cf. *A. tuberosum* (1373) (8), *Aristida congesta* subsp. *congesta* (4), *Bupleurum mundtii* (6), *Catalepis gracilis* (2), *Chaetacanthus setiger* (9), *Chamaesyce prostrata* (2), *Cineraria lobata* (8), *Clutia affinis* (6), *Eragrostis chloromelas* (4), *Galium thunbergianum* var. *thunbergianum* (6), *Haemanthus humilis* subsp. *hirsutus* (8), *Harpochloa falx* (9), *Helichrysum cephaloideum* (8), *Helictotrichon turgidulum* (6), *Hermannia coccocarpa* (2), *Hibiscus trionum* (1), *Hibiscus aethiopicus* (8), *Hyparrhenia dregeana* (9), *Koeleria capensis* (7), *Maytenus heterophylla* (8), *Monsonia angustifolia* (4), *Monsonia attenuata* (7), *Nemesia fruticans* (3), *Plectranthus grallatus* (6), *Printzia auriculata* (6), *Schkuhria pinnata* (4), *Senecio hieracioides* (4), *Senecio oxyriifolius* (5), *Sutera floribunda* (6).

TABLE 5.2 PHYTOSOCIOLOGICAL TABLE OF THE *Tristachya leucothrix*-*Themeda triandra* CLOSED GRASSLAND TYPE

Alectra orobanchoides (21), *Alternanthera pungens* (17), *Amaranthus hybridus* subsp. *hybridus* (242), *Andropogon huillensis* (245), *Anthospermum pumilum* subsp.

pumilum (308), *Aristea montana* (182), *Berkheya speciosa* subsp. *lanceolata* (228), *Bidens bipinnata* (208), *Brayulinea densa* (125), *Carex schlechteri* (262), *Chamaesyce inequilatera* (242), *Cheilanthes eckloniana* (249), *Cheilanthes quadripinnata* (283), *Cirsium vulgare* (50), *Clusia natalensis* (159), *Convolvulus sagittatus* subsp. *sagittatus* var. *hirtellus* (84), *Convolvulus sagittatus* subsp. *sagittatus* var. *phyllosepalus* (69), *Crabbea hirsuta* (177), *Crassula alba* var. *alba* (179), *Crassula lanceolata* subsp. *lanceolata* (91), *Cucumis myriocarpus* (126), *Cymbopogon dieterlenii* (3), *Cyperus obtusiflorus* var. *flavissimus* (7), *Cyphia elata* var. *elata* (28), *Diospyros lycioides* subsp. *guerkei* (249), *Eragrostis micrantha* (40), *Eragrostis tef* (242), *Helichrysum callicomum* (287), *Hemarthria altissima* (85), *Indigofera paxilla* (111), *Indigofera rostrata* (211), *Kyllinga pulchella* (213), *Lantana mearnsii* var. *latibracteolata* (249), *Leonotis ocymifolia* var. *ocymifolia* (92), *Lepidium trifurcum* (21), *Limeum viscosum* subsp. *viscosum* (47), *Linum thunbergii* (200), *Lotononis calycina* var. *hirsutissima* (50), *Mariscus capensis* (6), *Mariscus uitenhagensis* (131), *Melolobium calycinum* (141), *Monsonia attenuata* (200), *Osteospermum caulescens* (71), *Paspalum paspalodes* (194), *Physalis angulata* (307), *Plantago myosuroides* (217), *Plantago virginica* (274), *Protasparagus edulis* sp. nov. ined. (249), *Rhynchelytrum nerviglume* (132), *Senecio isatideus* (265), *Sporobolus africanus* (94), *Sporobolus discosporus* (227), *Stachys nigricans* (5), *Tagetes minuta* (259), *Tephrosia semiglabra* (120), *Trachyandra reflexipilosa* (48), *Tragus racemosus* (348), *Vernonia hirsuta* (249).

TABLE 5.3 PHYTOSOCIOLOGICAL TABLE OF THE *Eragrostis chloromelas*-*Eragrostis plana* CLOSED GRASSLAND TYPE

Abildgaardia ovata (133), *Agrostis lachnantha* var. *lachnantha* (61), *Amaranthus capensis* (113), *Andropogon schirensis* (103), *Arctotis arctotoides* (131), *Becium obovatum* var. *obovatum* (70), *Berula erecta* (39), *Bromus unioloides* (62), *Chamaesyce inequilatera* (93), *Cheilanthes involuta* var. *involuta* (146), *Chenopodium album* (93), *Chloris virgata* (80), *Conyza sumatrensis* (65), *Cynodon hirsutus* (130), *Cyperus cuspidatus* (126), *Dianthus mooiensis* subsp. *mooiensis* (20), *Digitaria monodactyla* (41), *Falkia oblonga* (125), *Galium capense* subsp. *garipense* (10), *Garuleum woodii* (11), *Gladiolus crassifolius* (74), *Helichrysum melanacme* (130), *Helichrysum miconiifolium* (15), *Helichrysum pilosellum* (16), *Helichrysum aureonitens* (71), *Hyparrhenia hirta* (65), *Ipomoea atherstonei* (59), *Juncus oxycarpus* (129), *Kohautia caespitosa* (145), *Kyllinga pulchella* (67), *Linum thunbergii* (57), *Lotononis eriantha* var. *eriantha* (55), *Mentha aquatica* (40),

Merremia tridentata subsp. *angustifolia* (30), *Nesaea sagittifolia* var. *ericiformis* (77), *Nidorella resedifolia* subsp. *resedifolia* (30), *Osteospermum caulescens* (25), *Paspalum paspalodes* (18), *Pelargonium alchemilloides* (6), *Physalis angulata* (123), *Pogonarthria squarrosa* (139), *Polygonum aviculare* (91), *Portulaca oleracea* (121), *Rhus discolor* (133), *Rorippa nudiuscula* (80), *Rumex* sp. cf. *R. crispus* (1484) (83), *Schizostylis coccinea* (72), *Sisymbrium thellungii* (113), *Tolpis capensis* (102), *Trifolium africanum* var. *lydenburgense* (111), *Vicia sativa* (66), *Xanthium spinosum* (112).

TABLE 5.6 SYNOPTIC TABLE OF THE AMERSFOORT VEGETATION

- A. NON-DIAGNOSTIC SPECIES OCCURRING IN THE *Hebenstretia rehmannii*-*Microchloa caffra* OPEN GRASSLAND TYPE

Senecio oxyriifolius.

- B. NON-DIAGNOSTIC SPECIES OCCURRING IN THE *Leucosidea sericea*-*Andropogon appendiculatus* CLOSED SHRUBLAND TYPE

Bupleurum mundtii, *Cineraria lobata*, *Clutia affinis*, *Galium thunbergianum* var. *thunbergianum*, *Haemanthus humilis* subsp. *hirsutus*, *Maytenus heterophylla*, *Plectranthus grallatus*, *Printzia auriculata*, *Sutera floribunda*.

- C. NON-DIAGNOSTIC SPECIES OCCURRING IN THE *Tristachya leucothrix*-*Themeda triandra* CLOSED GRASSLAND TYPE

Alectra orobanchoides (15), *Andropogon huillensis* (6), *Anthospermum pumilum* subsp. *pumilum* (1), *Aristea montana* (5), *Carex schlechteri* (14), *Clutia natalensis* (8), *Convolvulus sagittatus* subsp. *sagittatus* var. *phyllosepalus* (16), *Crabbea hirsuta* (5), *Crassula alba* var. *alba* (11), *Cymbopogon dieterlenii* (17), *Cyperus obtusiflorus* var. *flavissimus* (11), *Cyphia elata* var. *elata* (2), *Indigofera pauxilla* (11), *Indigofera rostrata* (5), *Lantana mearnsii* var. *latibracteolata* (1), *Leonotis ocymifolia* var. *ocymifolia* (15), *Lepidium trifurcum* (15), *Limeum viscosum* subsp. *transvaalense* (12), *Lotononis calycina* var. *hirsutissima* (7), *Mariscus capensis* (11), *Mariscus uitenhagensis* (11), *Melolobium calycinum* (16), *Protasparagus edulis* sp. nov. ined. (1), *Senecio isatideus* (7),

Sporobolus discosporus (6), *Stachys nigricans* (11), *Tephrosia semiglabra* (18), *Trachyandra reflexipilosa* (17), *Vernonia hirsuta* (1).

D. NON-DIAGNOSTIC SPECIES OCCURRING IN THE *Eragrostis chloromelas*-*Eragrostis plana* CLOSED GRASSLAND TYPE

Agrostis lachnantha var. *lachnantha* (9), *Arctotis arctotoides* (3), *Berula erecta* (8), *Bromus unioloides* (3), *Cheilanthes involuta* var. *involuta* (1), *Chenopodium album* (10), *Chloris virgata* (6), *Conyza sumatrensis* (4), *Cyperus cuspidatus* (3), *Digitaria monodactyla* (6), *Falkia oblonga* (8), *Garuleum woodii* (3), *Juncus oxycarpus* (8), *Kohautia caespitosa* (1), cf. *Ledebouria cooperi* (1672) (8), *Mentha aquatica* (8), *Merremia tridentata* subsp. *angustifolia* (5), *Nidorella resedifolia* subsp. *resedifolia* (5), *Pogonarthria squarrosa* (2), *Polygonum aviculare* (10), *Portulaca oleracea* (3), *Rorippa nudiuscula* (6), *Rumex* sp. cf. *R. crispus* (1484) (10), *Schizostylis coccinea* (8), *Sisymbrium thellungii* (3), *Sutera pinnatifida* (1), *Trifolium africanum* var. *lydenburgense* (8), *Vicia sativa* (9), *Xanthium spinosum* (3).

APPENDIX 2

The environmental and habitat data for the syntaxa identified in the Amersfoort vegetation. The data are arranged and numbered following the system used in Chapter 5, and the abbreviations used are given in Section 4.2.3, except for the geology, where the following abbreviations are used:

D: Dolerite
H: Shale
M: Mudstone and sandstone
S: Sandstone, shale and coal.

5.1 THE Hebenstretia rehmannii-Microchloa caffra OPEN GRASSLAND TYPE

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
2	26°58'38"	30°01'45"	1875	Ea25	M	32	Ms	70	<10	7	2	N	0	4	40	10	14
4	26°58'38"	30°01'45"	1875	Ea25	M	32	Ms	120	<10	20	7	E	0	4	40	10	24
1	26°58'38"	30°01'45"	1875	Ea25	M	32	Ms	1	<10	99	14	N	0	4	40	10	17
3	26°58'38"	30°01'45"	1875	Ea25	M	32	Ms	2	<10	95	16	E	0	4	40	10	17
5	26°58'38"	30°01'45"	1875	Ea25	M	32	Ms	0	<10	99	10	SE	0	4	40	10	15

5.2 THE Leucosidea sericea-Andropogon appendiculatus CLOSED SHRUBLAND TYPE

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
9	27°00'03"	30°01'43"	1844	Ea25	H	43	Ms	170	<10	50	36	SW	2	4	22	60	15
8	27°00'03"	30°01'43"	1844	Ea25	H	43	Ms	120	<10	30	37	SW	2	4	22	60	25
6	27°00'03"	30°01'43"	1844	Ea25	H	43	Ms	140	<10	20	39	SW	2	4	22	60	25
7	27°00'03"	30°01'43"	1844	Ea25	H	43	Ms	140	<10	40	31	SW	2	4	22	60	16

5.3 THE *Tristachya leucothrix*-*Themeda triandra* CLOSED GRASSLAND TYPE

5.3.1 THE *Themeda triandra*-*Berkheya setifera* CLOSED GRASSLAND UNIT

1. The *Berkheya setifera*-*Rhynchosia reptabunda* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
156	27°04'58"	30°03'24"	1783	Ea25	M	51	Ms	210	20-35	0	8	NE	2	3	36	60	16
158	27°04'58"	30°03'24"	1783	Ea25	M	51	Ms	240	20-35	0	9	E	2	3	36	60	17
318	27°16'52"	30°03'43"	1768	Fa393	D	51	Bv	550	35-55	0	6	E	2	3	36	60	23
248	26°58'53"	30°01'42"	1836	Ea25	M	51	Sd	1200	20-35	0	4	W	2	4	36	95	24
249	26°58'53"	30°01'42"	1836	Ea25	M	51	Ms	160	10-15	15	17	W	0	4	36	95	38
250	26°58'53"	30°01'42"	1836	Ea25	M	51	Sd	1200	20-35	0	4	W	0	4	36	95	19
165	27°05'15"	30°03'28"	1890	Ea25	D	11	Ms	60	20-35	0	2	SW	0	5	36	65	20
251	26°57'59"	30°01'44"	1875	Ea25	M	31	Ms	120	20-35	0	5	E	0	5	34	96	25
308	27°07'05"	30°03'56"	1768	Fa393	D	51	Ms	140	20-35	0	3	E	2	3	36	70	27
255	27°00'16"	30°03'56"	1768	Ac39	H	22	Ms	210	15-20	0	6	NW	0	2	35	80	29

2. The *Berkheya setifera*-*Hyparrhenia hirta* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
28	27°11'25"	30°03'12"	1951	Fa360	H	51	Hu	1200	20-35	0	3	E	2	4	36	75	18
29	27°11'25"	30°03'12"	1951	Fa360	H	51	Hu	1000	20-35	0	9	E	2	4	36	75	26
30	27°11'25"	30°03'12"	1951	Fa360	H	51	Ms	220	20-35	0	6	E	2	4	36	75	31
31	27°11'25"	30°03'12"	1951	Fa360	H	51	Ms	130	20-35	2	11	E	2	4	36	75	19
13	27°10'20"	30°03'13"	1844	Ca17	H	51	Ms	270	20-35	0	4	SW	2	4	36	90	17
15	27°10'20"	30°03'13"	1844	Ca17	H	51	Gf	1000	20-35	0	6	SW	2	4	36	90	15
97	27°07'57"	30°02'56"	1852	Fa393	D	31	Ms	220	20-35	0	3	S	2	5	36	50	18
99	27°07'57"	30°02'56"	1838	Fa393	M	31	Ms	150	20-35	0	2	E	2	4	36	40	24
164	27°05'15"	30°03'28"	1890	Ea25	D	11	Ms	80	15-20	0	2	NW	0	5	36	65	20
186	26°58'00"	30°02'27"	1737	Ac39	H	51	Bv	1200	20-35	0	7	SW	0	3	23	60	17
299	27°10'19"	30°00'31"	1783	Fa24	H	13	Ms	65	<10	50	2	W	0	4	36	80	29
306	27°04'07"	29°49'53"	1676	Ca2	D	22	Ms	140	20-35	2	4	SW	2	2	36	60	20
309	27°07'05"	30°03'56"	1768	Fa393	D	51	Ms	160	20-35	0	3	N	2	3	36	70	25
310	27°07'05"	30°03'56"	1768	Fa393	D	51	Ms	230	20-35	0	6	N	2	3	36	70	22
320	27°06'52"	30°03'43"	1768	Fa393	D	51	Bv	700	20-35	0	7	E	3	3	36	60	19
321	27°06'52"	30°03'43"	1768	Fa393	D	51	Bv	650	35-55	0	6	E	3	3	36	60	23
252	26°57'59"	30°01'44"	1875	Ea25	M	31	Ms	90	15-20	0	2	NE	0	5	34	96	24
253	26°57'59"	30°01'44"	1875	Ea25	M	31	Ms	120	20-35	0	4	E	0	5	34	95	21

3. The *Berkheya setifera*-*Euryops transvaalensis* subsp. *transvaalensis*
Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
173	27°01'06"	30°04'04"	1783	Ac39	M	22	Bv	1200	35-55	0	6	E	0	3	35	75	22
207	26°55'45"	30°04'46"	1669	Ac39	H	31	Av	750	20-35	0	2	N	0	3	35	60	23
229	26°55'23"	30°02'55"	1722	Ac39	D	72	Bv	1200	20-35	0	2	SW	0	2	35	85	16
230	26°55'23"	30°02'55"	1722	Ac39	D	72	Bv	1200	20-35	0	2	SW	0	2	35	85	13
201	26°55'13"	30°04'30"	1684	Ac39	D	31	Rg	600	35-55	0	4	S	0	3	35	90	15
206	26°55'45"	30°04'46"	1669	Ac39	H	31	Av	900	20-35	0	2	N	0	3	35	60	22
298	27°10'19"	30°00'31"	1783	Fa24	H	13	Ms	270	<10	0	2	W	0	4	36	80	29
198	26°55'13"	30°04'30"	1684	Ac39	D	31	Rg	1200	20-35	0	5	SW	0	3	35	90	17
199	26°53'13"	30°04'30"	1684	Ac39	D	31	RG	650	35-55	0	6	SW	0	3	35	90	19
202	26°55'08"	30°04'46"	1699	Ac39	D	31	Ms	270	35-55	0	4	SE	0	3	35	60	19
203	26°55'08"	30°04'46"	1699	Ac39	D	31	Ms	150	35-55	0	3	SE	0	3	35	90	20
205	26°55'45"	30°04'46"	1669	Ac39	H	31	Ms	270	35-55	0	2	N	0	3	35	60	15
208	26°55'45"	30°04'46"	1669	Ac39	H	31	Ms	200	35-55	0	2	N	0	3	35	60	26
214	26°56'21"	30°04'54"	1692	Ac39	H	21	Av	800	20-55	0	2	SE	0	3	35	60	14
236	27°10'45"	29°57'15"	1745	Ca2	M	72	Av	1200	35-55	0	2	SE	1	2	35	80	21
238	27°13'12"	29°56'07"	2111	Ca2	M	22	Av	1200	20-35	0	3	NE	2	2	36	50	21
240	27°13'12"	29°56'07"	2111	Ca2	M	22	Av	1200	20-35	0	3	NE	2	2	36	50	19
276	27°10'08"	29°59'33"	1745	Fa24	H	51	Ms	170	15-20	0	8	SE	2	3	36	60	28
351	27°02'20"	30°01'56"	1524	Ca2	H	22	Bv	1200	35-55	0	6	SE	0	2	35	75	17

4. The *Berkheya setifera*-*Harpochloa falx* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
212	26°56'54"	30°04'46"	1707	Ac39	H	72	Av	1200	15-20	0	2	SE	0	2	35	60	12
301	27°10'19"	30°00'31"	1783	Fa24	H	13	Ms	60	15-20	0	2	W	0	4	36	80	28
163	27°05'15"	30°03'28"	1890	Ea25	D	11	Ms	130	15-20	0	2	NW	0	5	36	65	20
204	26°55'08"	30°04'46"	1699	Ac39	D	31	Ms	240	35-55	0	6	SE	0	3	35	90	18
224	26°55'10"	30°01'27"	1692	Ea25	D	72	Ms	170	20-35	0	6	S	1	1	36	70	28
226	26°55'10"	30°01'27"	1692	Ea25	D	72	Ms	90	20-35	5	9	S	1	1	36	70	19
257	27°00'16"	30°03'56"	1768	Ac39	H	22	Ms	250	20-35	0	4	NW	0	2	35	80	33
300	27°10'19"	30°00'31"	1783	Fa24	H	13	Ms	270	10-15	0	2	W	0	4	36	80	25

5. The *Berkheya setifera*-*Digitaria tricholaenoides* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
335	27°12'58"	29°51'04"	1829	Fa24	M	51	Av	900	20-35	0	3	E	0	4	35	80	21
332	27°13'24"	29°51'06"	1814	Fa24	H	11	Ms	110	35-55	10	2	W	0	5	35	65	14
234	27°00'22"	29°56'36"	1631	Ca2	D	74	Ms	60	20-35	40	8	SE	2	1	36	50	26
258	27°00'16"	30°03'56"	1768	Ac39	H	22	Ms	60	10-15	2	6	W	0	2	35	80	32
242	27°12'18"	29°56'56"	1768	Ca2	M	51	Cv	700	10-15	0	7	N	3	3	35	60	27
241	27°12'18"	29°56'56"	1768	Ca2	M	51	Cv	1100	10-15	0	7	NW	3	3	35	60	25
287	27°00'24"	30°04'16"	1783	Ac39	M	12	Cv	530	15-20	0	2	NW	0	4	36	80	21
289	27°00'24"	30°04'16"	1783	Ac39	M	12	Cv	700	15-20	0	2	NW	0	4	36	80	23
288	27°00'24"	30°04'16"	1783	Ac39	M	12	Cv	650	15-20	0	2	NW	0	4	36	80	23
190	26°58'25"	30°03'59"	1745	Ca17	H	21	Bv	1200	20-35	0	2	SW	0	3	36	60	17
189	26°58'25"	30°03'59"	1745	Ca17	H	21	Bv	1000	20-35	0	3	SW	0	3	36	60	23
256	27°00'16"	30°03'56"	1768	Ac39	H	22	Ms	130	10-15	40	7	W	0	2	35	80	32
215	26°56'21"	30°04'54"	1692	Ac39	H	21	Av	1200	35-55	0	2	SE	0	3	35	60	22
334	27°12'58"	29°51'04"	1829	Fa24	M	51	Av	1200	20-35	0	3	E	0	4	35	80	23
213	26°56'54"	30°04'46"	1707	Ac39	H	72	Av	500	35-55	0	2	SW	0	2	35	60	31
175	27°01'06"	30°04'04"	1783	Ac39	M	22	Bv	1200	35-55	0	4	NE	0	3	35	75	20
237	27°13'12"	29°56'07"	2111	Ca2	M	22	Av	1200	20-35	0	3	NE	2	2	36	50	23
174	27°01'06"	30°04'04"	1783	Ac39	M	22	Bv	1100	35-55	0	6	E	0	3	35	75	21
336	27°12'58"	29°51'04"	1829	Fa24	M	51	Av	1200	20-35	0	2	E	0	4	35	80	21
194	26°59'40"	30°03'36"	1745	Ca17	H	31	Bv	1000	35-55	0	3	SE	0	3	36	85	27
172	27°01'06"	30°04'04"	1783	Ac39	M	22	Bv	1200	20-35	0	5	E	0	3	35	75	21
187	26°58'25"	30°03'59"	1745	Ca17	H	21	Bv	1200	20-35	0	2	SW	0	3	36	60	22
188	26°58'25"	30°03'59"	1745	Ca17	H	21	Bv	1200	20-35	0	2	S	0	3	36	60	23
191	26°59'40"	30°03'36"	1745	Ca17	H	31	Bv	1200	15-20	0	2	E	0	3	36	85	20
216	26°56'21"	30°04'54"	1692	Ac39	H	21	Av	500	35-55	0	2	SE	0	3	35	60	18
177	27°08'50"	30°02'13"	1722	Ea25	D	31	Ms	130	35-55	0	3	NE	0	0	36	35	26
211	26°56'54"	30°04'46"	1707	Ac39	H	72	Av	500	35-55	0	2	SW	0	2	35	60	26
337	27°12'58"	29°51'04"	1829	Fa24	M	51	Av	1200	20-35	0	2	SE	0	4	35	80	24
264	27°13'23"	29°58'48"	1768	Ca17	H	51	Sd	1200	20-35	0	3	S	0	2	35	65	21
259	27°14'11"	29°55'39"	1829	Ca2	D	51	Ms	270	10-15	0	2	NE	2	3	35	60	24
182	27°00'10"	30°03'39"	1768	Ac39	M	21	Bv	1100	20-35	0	3	SE	0	3	36	60	22
225	26°55'10"	30°01'27"	1692	Ea25	D	72	Rg	1200	35-55	0	2	N	1	1	36	70	18
221	26°55'10"	30°02'00"	1692	Ea25	D	72	Ms	270	35-55	0	2	E	0	1	36	65	18
210	26°55'36"	30°04'30"	1684	Ac39	H	72	Ar	1200	>55	0	2	SE	1	1	35	60	22
11	27°10'19"	30°04'54"	1829	Fa393	H	31	Ms	190	20-35	0	6	NE	0	3	36	60	15
8	27°12'52"	30°04'13"	1981	Fa361	H	42	Ms	270	15-20	0	15	W	2	4	36	90	19

6. The *Berkheya setifera*-*Lobelia flaccida* subsp. *flaccida* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
180	27°00'10"	30°03'39"	1768	Ac39	M	21	Bv	1100	35-55	0	2	SE	0	3	36	60	19
181	27°00'10"	30°03'39"	1768	Ac39	M	21	Bv	1100	35-55	0	2	W	0	3	36	60	15
183	27°00'10"	30°03'39"	1768	Ac39	M	21	Bv	900	35-55	0	2	SE	0	3	36	60	21
195	26°59'40"	30°03'36"	1745	Ca17	H	31	Bv	1000	20-35	0	3	E	0	3	36	85	18
245	27°13'10"	29°54'26"	1791	Ca2	H	22	Fw	1200	<10	0	3	W	2	2	36	60	24
244	27°13'10"	29°54'26"	1791	Ca2	H	22	Fw	1200	<10	0	3	W	2	2	36	60	20
295	27°00'28"	30°04'55"	1753	Ac39	M	51	Av	700	20-35	0	6	SW	0	4	35	90	26
297	27°00'28"	30°04'55"	1753	Ac39	M	51	Av	710	20-35	0	3	SW	0	4	35	90	21
296	27°00'28"	30°04'55"	1753	Ac39	M	51	Ms	200	10-15	0	6	S	0	4	35	90	33
247	27°13'55"	29°55'26"	1798	Ca2	D	51	Cv	400	20-35	0	8	W	2	3	35	50	19
294	27°00'28"	30°04'55"	1753	Ac39	M	51	Ar	410	20-35	0	4	SW	0	4	35	90	21
324	27°09'46"	30°03'27"	1814	Fa393	M	31	Ar	1100	>55	0	6	SW	2	3	35	50	18
76	27°09'57"	29°46'45"	1791	Ca2	M	51	AV	700	20-35	0	5	S	2	4	36	80	18
77	27°09'57"	29°46'45"	1791	Ca2	H	51	Av	400	35-55	0	6	S	2	4	36	80	18
196	26°59'40"	30°03'36"	1684	Ac39	H	21	Av	1200	35-55	0	2	N	0	3	35	55	20
193	26°59'40"	30°03'36"	1745	Ca17	H	31	Ms	250	35-55	0	3	E	0	3	36	85	18
176	27°00'51"	30°03'39"	1745	Ca17	H	31	Bv	1000	20-35	0	2	E	0	3	36	85	15
78	27°09'57"	29°46'45"	1524	Ca2	H	22	Bv	1200	20-35	0	3	E	0	2	35	75	19
330	27°13'26"	29°50'21"	1745	Ca17	H	31	Bv	700	20-35	0	3	SE	0	3	36	85	23
217	26°56'13"	30°04'02"	1684	Ac39	D	31	Rg	600	>55	0	11	S	0	3	35	90	19
349	27°02'20"	30°01'56"	1783	Ea25	M	51	Bv	1200	35-55	0	2	E	2	3	36	60	22
192	26°59'40"	30°03'36"	1791	Ca2	H	51	Av	550	20-35	0	6	S	2	4	36	80	20
200	26°55'13"	30°04'30"	1829	Fa24	M	51	Bv	500	20-35	0	3	SE	2	4	35	65	24
73	27°02'07"	29°53'16"	1631	Ca2	D	71	Rg	350	20-35	0	2	E	0	2	36	45	15
227	26°55'39"	30°02'13"	1692	Ac39	D	72	Av	1200	15-20	0	4	W	3	2	36	60	18
239	27°13'12"	29°56'07"	2111	Ca2	M	22	Av	1200	20-35	0	3	NE	2	2	36	50	21
338	27°07'32"	29°48'10"	1737	Ca2	H	31	Bv	550	35-55	0	10	NE	2	4	35	60	13

7. The *Berkheya setifera*-*Hermannia cristata* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
50	26°58'53"	29°46'16"	1660	Ea22	D	51	Ms	170	20-35	12	8	SW	3	3	36	30	25
52	26°58'53"	29°46'16"	1660	Ea22	D	51	Hu	750	15-20	0	6	S	3	3	36	20	21
154	27°04'58"	30°03'39"	1798	Ea25	M	42	Ms	110	35-55	0	11	E	2	4	36	60	21
139	27°02'21"	29°47'11"	1692	Ca2	D	72	Rg	750	15-20	0	2	S	2	2	36	50	16
155	27°04'58"	30°03'39"	1798	Ea25	M	42	Ms	80	20-35	0	13	E	2	4	36	60	20
157	27°04'58"	30°03'24"	1783	Ea25	M	51	Ms	250	15-20	0	9	NE	2	3	36	60	17
168	27°04'17"	30°04'00"	1768	Ea25	M	51	Ms	240	20-35	0	8	N	1	3	35	80	22
260	27°14'11"	29°55'39"	1829	Ca2	D	51	Ms	270	<10	0	3	NE	2	3	35	60	30
261	27°14'11"	29°55'39"	1829	Ca2	D	51	Cv	600	15-20	0	2	NE	2	3	35	60	33
265	27°13'23"	29°58'48"	1768	Ca17	H	51	Sd	1200	10-15	0	6	SE	0	2	35	65	24
269	27°08'24"	29°54'27"	1722	Ca2	D	21	Ms	250	20-35	0	2	N	0	2	36	70	21
272	27°14'57"	29°54'41"	1715	Fa24	H	51	Ms	150	10-15	0	4	NW	2	3	36	55	24
285	27°11'52"	29°49'24"	1776	Ca2	M	22	Ms	40	<10	10	15	W	2	3	35	45	33
290	27°00'39"	30°04'42"	1768	Ac39	H	42	Ms	260	10-15	0	10	E	2	4	36	55	28
291	27°00'39"	30°04'42"	1768	Ac39	H	42	Ms	270	20-35	0	10	E	2	4	36	55	34
292	27°00'39"	30°04'42"	1768	Ac39	H	42	Av	1200	15-20	0	10	E	2	4	36	55	23
293	27°00'39"	30°04'42"	1768	Ac39	H	42	Ms	270	<10	15	11	SE	2	4	36	55	25
313	27°08'36"	30°02'56"	1829	Fa393	D	51	Rg	1200	15-20	0	5	N	3	3	35	50	22
329	27°12'20"	29°50'06"	1859	Fa24	M	51	Ms	90	15-20	0	9	N	2	4	36	60	19
345	26°56'28"	29°46'01"	1740	Ea23	D	12	Ms	50	20-35	30	2	NE	2	2	36	60	28

8. The *Berkheya setifera*-*Taraxacum hamatiforme* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
254	26°57'59"	30°01'44"	1785	Ea25	M	31	Ms	250	20-35	0	6	E	0	3	35	96	16
327	27°11'57"	29°51'06"	1996	Fa24	M	31	Ms	190	20-35	0	10	SE	2	5	36	60	17
326	27°11'57"	29°51'06"	1996	Fa24	M	31	Hu	1200	20-35	0	5	NE	2	5	36	60	19
328	27°11'57"	29°51'06"	1996	Fa24	M	31	Hu	800	20-35	0	3	SE	2	5	36	60	15
323	27°09'46"	30°03'27"	1814	Fa393	M	31	Ms	40	20-35	50	23	SW	2	3	35	50	24
322	27°09'46"	30°03'27"	1814	Fa393	M	31	Ms	70	20-35	40	22	SW	2	3	35	50	29
325	27°09'46"	30°03'27"	1814	Fa393	M	31	Ms	270	15-20	0	6	SW	2	3	35	50	13
27	27°12'02"	30°03'55"	1951	Fa360	H	51	Ms	20	15-20	4	13	W	2	4	36	70	13
339	27°07'32"	29°48'10"	1737	Ca2	H	31	Bv	600	20-35	0	10	NE	2	4	35	60	20
283	27°11'52"	29°49'24"	1776	Ca2	M	22	Ms	55	10-15	50	9	W	2	3	35	45	31
284	27°11'52"	29°49'24"	1776	Ca2	M	22	Ms	25	<10	20	15	W	2	3	35	45	25
246	27°13'10"	29°54'26"	1791	Ca2	H	22	Fw	1200	<10	0	3	W	2	2	36	60	22
342	27°07'32"	29°48'10"	1737	Ca2	H	31	Bv	400	20-35	0	10	E	2	4	35	60	21
14	27°10'20"	30°03'13"	1844	Ca17	H	51	Gf	550	20-35	0	6	S	2	4	36	90	12
24	27°12'02"	30°03'55"	1951	Fa360	H	51	Ms	50	<10	7	15	W	2	4	36	70	16
25	27°12'02"	30°03'55"	1951	Fa360	H	51	Hu	1000	20-35	1	11	S	2	4	36	70	20
26	27°12'02"	30°03'55"	1951	Fa360	H	51	Ms	110	35-55	1	15	S	2	4	36	70	17
86	27°13'15"	30°04'34"	1882	Fa361	H	51	Ms	80	15-20	12	10	SW	3	3	36	40	17
96	27°07'57"	30°02'56"	1852	Fa393	D	31	Ms	220	15-20	0	3	S	2	5	36	50	27
159	27°02'45"	30°03'20"	1859	Ea25	H	31	Ms	220	35-55	0	2	N	0	4	22	90	29
161	27°02'45"	30°03'20"	1859	Ea25	H	31	Ms	230	20-35	0	2	N	0	4	22	90	18
162	27°05'15"	30°03'28"	1890	Ea25	D	11	Ms	110	10-15	0	2	NW	0	5	36	65	17
184	26°58'00"	30°02'27"	1737	Ac39	H	51	Gf	1200	20-35	0	5	S	0	3	23	60	26
185	26°58'00"	30°02'27"	1737	Ac39	H	51	Ms	270	20-35	0	3	S	0	3	23	60	23
197	27°08'34"	30°04'30"	1844	Fa393	M	22	Bv	940	20-35	0	3	SE	0	3	36	45	13
228	26°55'23"	30°02'55"	1722	Ac39	D	72	Bv	1200	20-35	0	2	W	0	2	35	85	11
279	27°09'29"	29°50'51"	1707	Ca2	H	21	Ms	250	20-35	0	2	E	2	2	35	60	16
280	27°09'29"	29°50'51"	1707	Ca2	H	21	Ms	270	20-35	0	2	NE	2	2	35	60	14
282	27°09'29"	29°50'51"	1707	Ca2	H	21	Ms	200	15-20	0	2	NE	2	2	35	60	15
286	27°11'52"	29°49'24"	1776	Ca2	M	22	Ms	0	<10	65	11	SW	2	3	35	45	16
302	27°12'55"	30°02'16"	1814	Ca17	H	22	Ms	250	10-15	0	3	S	0	2	36	55	17
307	27°04'07"	29°49'53"	1676	Ca2	D	22	Ms	70	20-35	40	5	SW	2	2	36	60	31
311	27°08'36"	30°02'56"	1829	Fa393	D	51	Rg	1200	20-35	0	5	N	3	3	35	50	17
312	27°08'36"	30°02'56"	1829	Fa393	D	51	Rg	1200	20-35	0	4	N	3	3	35	50	21
314	27°08'36"	30°02'56"	1829	Fa393	D	51	Rg	1200	20-35	0	5	N	3	3	35	50	22
315	27°08'36"	30°02'56"	1829	Fa393	D	51	Rg	1200	20-35	0	5	NW	3	3	35	50	30
331	27°13'24"	29°51'06"	1814	Fa24	H	11	Ms	130	35-55	0	2	N	0	5	35	65	21
333	27°13'24"	29°51'06"	1814	Fa24	H	11	Ms	110	35-55	0	2	SW	0	5	35	65	15
344	26°56'28"	29°46'01"	1740	Ea23	D	12	Ms	180	35-55	0	2	NE	2	2	36	60	21

9. The *Berkheya setifera*-*Eragrostis chloromelas* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
35	27°09'41"	30°00'31"	1814	Fa24	D	31	Ms	130	20-35	5	3	S	2	4	36	70	17
37	27°12'20"	29°52'46"	1776	Fa24	H	51	Ms	250	20-35	2	12	W	1	3	36	70	25
98	27°08'24"	30°03'56"	1838	Fa393	M	31	Ms	120	20-35	6	2	E	2	4	36	40	35
101	27°08'24"	30°03'56"	1838	Fa393	M	31	Ms	80	35-55	40	3	N	2	4	36	40	32
114	27°00'45"	29°46'40"	1646	Ca2	S	91	Ms	270	10-15	30	14	SW	2	3	36	60	24
133	27°01'28"	29°45'31"	1684	Ca2	D	51	Ms	210	10-15	0	2	S	0	2	36	75	18
138	27°02'21"	29°27'11"	1692	Ca2	D	72	Rg	750	10-15	0	3	SW	2	2	36	50	18
160	27°02'45"	30°03'20"	1859	Ea25	H	31	Ms	60	20-35	50	17	NW	0	4	22	90	24
166	27°05'15"	30°03'28"	1890	Ea25	D	11	Ms	90	15-20	0	2	SW	0	5	36	65	16

5.3.2 THE *Themeda triandra*-*Hermannia depressa* CLOSED GRASSLAND UNIT5.3.2.1 The *Hermannia depressa*-*Eragrostis plana* Closed Grassland Sub-Unit10. The *Eragrostis plana*-*Heteropogon contortus* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
46	26°56'42"	29°50'22"	1655	Ea22	D	31	Rg	800	20-35	0	-	-	0	2	36	70	7
62	26°56'43"	29°45'18"	1740	Ea23	S	31	Rg	500	20-35	0	2	E	0	4	36	50	17
66	27°00'10"	29°47'56"	1684	Ca2	D	21	Rg	450	20-35	0	2	E	0	3	36	60	18
103	26°55'16"	29°45'45"	1700	Ea23	D	31	Ms	270	10-15	0	6	SW	2	3	36	60	22
106	26°56'06"	29°46'26"	1660	Ea22	D	31	Ms	250	10-15	0	4	N	3	3	36	40	15
130	27°00'21"	29°45'28"	1661	Ea22	S	41	Ms	50	10-15	12	9	NE	2	3	36	30	23
134	27°01'28"	29°45'31"	1684	Ca2	D	51	Ms	190	15-20	0	2	S	0	2	36	75	21
136	27°01'28"	29°45'31"	1684	Ca2	D	51	Ms	270	10-15	0	6	SE	0	2	36	75	18
152	27°04'58"	30°03'39"	1798	Ea25	M	42	Ms	240	15-20	0	11	E	2	4	36	60	18
222	26°55'10"	30°02'00"	1692	Ea25	D	72	Ms	270	35-55	0	3	E	0	1	36	65	23
350	27°02'20"	30°01'56"	1524	Ca2	H	22	Bv	1200	20-35	0	4	SE	0	2	35	75	22
43	26°57'10"	29°50'21"	1660	Ea22	D	31	Ms	150	10-15	5	6	SE	2	2	36	40	15
44	26°57'10"	29°50'21"	1660	Ea22	D	31	Ms	110	15-20	30	8	SW	2	2	36	40	14
140	27°05'36"	30°01'21"	1798	Ea25	H	51	Bv	700	15-20	5	11	N	3	3	36	16	10
151	27°04'58"	30°03'39"	1798	Ea25	M	42	Ms	110	20-35	10	11	E	2	4	36	60	21
153	27°04'58"	30°03'39"	1798	Ea25	M	42	Ms	270	35-55	0	10	E	2	4	36	60	26
317	27°06'52"	30°03'43"	1768	Fa393	D	51	Bv	1200	20-35	0	6	E	3	3	36	60	19
319	27°06'52"	30°03'43"	1768	Fa393	D	51	Bv	700	35-55	0	6	E	3	3	36	60	22
343	26°56'28"	29°46'01"	1740	Ea23	D	12	Ms	100	20-35	12	3	E	2	2	36	60	28
346	26°56'28"	29°46'01"	1740	Ea23	D	12	Ms	111	35-55	0	2	NE	2	2	36	60	21
352	27°02'20"	30°01'56"	1524	Ca2	H	22	Bv	1200	20-35	0	5	E	0	2	35	75	11

11. The *Eragrostis plana*-*Psammotropha myriantha* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
131	27°00'21"	29°45'28"	1661	Ea22	S	41	Ms	30	10-15	40	9	E	2	3	36	30	28
132	27°00'21"	29°45'28"	1661	Ea22	S	41	Ms	60	10-15	40	6	E	2	3	36	30	20
4	27°12'52"	30°04'13"	1981	Fa361	H	42	Ms	120	10-15	10	19	W	2	4	36	90	21
9	27°12'52"	30°04'13"	1981	Fa361	H	42	Ms	130	20-35	10	16	W	2	4	36	90	20
5	27°12'52"	30°04'13"	1981	Fa361	H	42	Ms	180	10-15	25	18	W	2	4	36	90	24
6	27°12'52"	30°04'13"	1981	Fa361	H	42	Ms	150	10-15	15	24	S	2	4	36	90	15
7	27°12'52"	30°04'13"	1981	Fa361	H	42	Ms	270	10-15	0	19	W	2	4	36	90	17
10	27°10'19"	30°04'54"	1829	Fa393	H	31	Ms	110	35-55	3	3	NE	0	3	36	60	16
12	27°10'19"	30°04'54"	1829	Fa393	H	31	Ms	120	35-55	0	2	NE	0	3	36	60	9
17	27°07'43"	30°01'16"	1829	Fa393	D	31	Ms	80	15-20	1	4	NW	2	5	36	90	17
18	27°07'43"	30°01'16"	1829	Fa393	D	31	Ms	70	10-15	5	4	NW	2	5	36	90	18
20	27°07'43"	30°01'16"	1829	Fa393	D	31	Ms	30	20-35	45	3	NW	2	5	36	90	12
36	27°12'20"	29°52'46"	1776	Fa24	H	51	Rg	1200	20-35	0	4	S	1	3	36	70	14
87	27°14'01"	30°04'56"	1872	Fa361	H	51	Bv	1200	15-20	0	4	NW	3	3	36	50	8
88	27°14'01"	30°04'56"	1872	Fa361	H	51	Bv	900	15-20	0	4	NW	3	3	36	50	8
89	27°14'01"	30°04'56"	1872	Fa361	H	51	Bv	1150	35-55	0	3	W	3	3	36	50	8
95	27°07'57"	30°02'56"	1852	Fa393	D	31	Ms	230	20-35	0	3	S	2	5	36	50	20
102	26°55'16"	29°45'45"	1700	Ea23	D	31	Ms	200	10-15	0	3	W	2	3	36	60	15
108	26°56'06"	29°46'26"	1660	Ea22	D	31	Ms	120	10-15	0	3	N	3	3	36	40	14
111	27°01'02"	29°47'40"	1654	Ca2	D	31	Ms	200	15-20	0	5	W	2	4	36	60	19
112	27°01'02"	29°47'40"	1654	Ca2	D	31	Ms	160	15-20	0	3	W	2	4	36	60	11
113	27°00'45"	29°46'40"	1646	Ca2	S	91	Ms	270	10-15	0	3	SW	2	3	36	60	11
115	27°00'47"	29°48'09"	1669	Ca2	S	22	Rg	500	35-55	0	2	SW	0	2	36	50	10
117	27°00'47"	29°48'09"	1669	Ca2	S	22	Rg	400	35-55	0	3	SE	0	2	36	50	19
118	27°00'47"	29°48'09"	1669	Ca2	S	22	Rg	400	20-35	0	3	SW	0	2	36	50	15
129	27°00'21"	29°45'28"	1661	Ea22	S	41	Ms	60	10-15	12	6	NE	2	3	36	30	17
137	27°02'21"	29°47'11"	1692	Ca2	D	72	Rg	750	15-20	0	2	SW	2	2	36	50	12
143	27°04'55"	30°01'02"	1730	Ca2	H	21	Av	900	15-20	0	3	N	3	3	40	12	8
144	27°04'55"	30°01'02"	1730	Ca2	H	21	Ms	270	15-20	0	2	N	3	3	40	12	9
145	27°04'55"	30°01'02"	1730	Ca2	H	21	Bv	1200	15-20	0	2	N	3	3	40	12	9
146	27°04'55"	30°01'02"	1730	Ca2	H	21	Av	1000	15-20	0	2	N	3	3	40	12	9
147	27°03'37"	30°02'42"	1692	Ca2	H	21	Bv	700	15-20	0	2	E	2	3	36	50	9
150	27°03'37"	30°02'42"	1692	Ca2	H	21	Bv	630	20-35	0	2	E	2	3	36	50	11
179	27°08'50"	30°02'13"	1722	Ea25	D	31	Ms	40	35-55	45	6	NE	0	0	36	35	19
223	26°55'10"	30°02'00"	1692	Ea25	D	72	Bv	550	20-35	0	3	E	0	1	36	65	14
281	27°09'29"	29°50'51"	1707	Ca2	H	21	Ms	270	20-35	0	2	E	2	2	35	60	12
316	27°08'36"	30°02'56"	1829	Fa393	D	51	Av	1200	15-20	0	5	N	3	3	35	50	18

12. The *Eragrostis plana*-*Verbena brasiliensis* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
274	27°14'28"	29°53'42"	1715	Ca2	H	51	Cv	600	20-35	0	6	NW	2	3	36	60	16
278	27°04'55"	29°50'50"	1676	Ca2	D	22	Ms	100	10-15	0	4	SE	0	2	35	70	17
47	26°56'42"	29°54'43"	1620	Ea22	D	73	Hu	950	10-15	0	8	E	1	1	36	40	17
51	26°58'53"	29°46'16"	1660	Ea22	D	51	Hu	550	20-35	0	2	S	3	3	36	20	16
61	26°58'39"	29°54'00"	1660	Ea22	D	12	Rq	350	>55	0	2	SW	0	2	36	40	12
65	27°00'10"	29°47'56"	1684	Ca2	D	21	Ms	100	15-20	0	2	E	0	3	36	60	20
67	27°00'10"	29°47'56"	1684	Ca2	D	21	Ms	270	15-20	5	2	NE	0	3	36	60	21
83	27°00'36"	29°53'16"	1646	Ca2	D	51	Ms	130	20-35	0	2	W	2	4	35	30	16
105	26°56'06"	29°46'26"	1660	Ea22	D	31	Ms	270	10-15	0	3	N	3	3	36	40	12
107	26°56'06"	29°46'26"	1660	Ea22	D	31	Ms	250	15-20	0	3	N	3	3	36	40	15
109	27°01'02"	29°47'40"	1654	Ca2	D	31	Ms	60	10-15	1	6	SW	2	4	36	60	18
110	27°01'02"	29°47'40"	1654	Ca2	D	31	Ms	130	10-15	5	4	W	2	4	36	60	12
116	27°00'47"	29°48'09"	1669	Ca2	S	22	Rq	200	-	0	2	SW	0	2	36	50	21
148	27°03'37"	30°02'42"	1692	Ca2	H	21	Bv	750	15-20	0	2	E	2	3	36	50	15
178	27°08'50"	30°02'13"	1722	Ea25	D	31	Ms	270	35-55	0	9	S	0	0	36	35	29
218	26°55'28"	30°02'01"	1692	Ac39	D	31	Bv	1200	20-35	0	2	E	0	3	36	65	18
220	26°55'28"	30°02'01"	1692	Ac39	D	31	Bv	1200	35-55	0	3	SE	0	3	36	65	14
263	27°13'23"	29°58'48"	1768	Ca17	H	51	Sd	1200	20-35	0	4	SE	0	2	35	65	18
266	27°13'23"	29°58'48"	1768	Ca17	H	51	Sd	1200	10-15	0	6	SE	0	2	35	65	15
267	27°08'24"	29°54'27"	1722	Ca2	D	21	Av	1200	20-35	0	3	N	0	2	36	70	17
268	27°08'24"	29°54'27"	1722	Ca2	D	21	Av	1200	20-35	0	2	N	0	2	36	70	15
270	27°08'24"	29°54'27"	1722	Ca2	D	21	Ms	200	20-35	0	2	N	0	2	36	70	15
303	27°12'55"	30°02'16"	1814	Ca17	H	22	Ms	110	<10	0	2	S	0	2	36	55	14
305	27°12'55"	30°02'16"	1814	Ca17	H	22	Ms	110	10-15	0	3	S	0	2	36	55	15
341	27°07'32"	29°48'10"	1737	Ca2	H	31	Bv	650	35-55	0	10	E	2	4	35	60	25
347	27°05'49"	29°53'15"	1661	Ca2	D	22	Ms	270	20-35	0	6	W	3	3	36	70	21
348	27°05'49"	29°53'15"	1661	Ca2	D	22	Ms	250	20-35	2	5	W	3	3	36	70	17

5.3.2.2 The *Hermannia depressa*-*Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit13. The *Salvia repens* var. *transvaalensis*-*Berkheya radula* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
79	27°10'10"	29°46'44"	1768	Ea23	H	51	Rq	350	20-35	0	3	E	3	4	36	30	23
80	27°10'10"	29°46'44"	1768	Ea23	H	51	Rq	350	20-35	1	3	E	3	4	36	30	29
63	26°56'43"	29°45'10"	1740	Ea23	S	31	Ms	200	10-15	0	2	SE	0	4	36	50	16
64	26°56'43"	29°45'18"	1740	Ea23	S	31	Rq	500	10-15	0	2	SE	0	4	36	50	16
243	27°13'33"	29°55'46"	1806	Ca2	D	22	Rq	600	>55	0	2	NW	2	2	35	50	12
81	27°10'10"	29°46'44"	1768	Ea23	H	51	Rq	400	20-35	0	3	E	3	4	36	30	19
82	27°00'36"	29°53'16"	1646	Ca2	D	51	Ms	130	20-35	0	6	NW	2	4	36	30	23
32	27°09'41"	30°00'31"	1814	Fa24	D	31	Ms	180	20-35	5	2	S	2	4	36	70	22
33	27°09'41"	30°00'31"	1814	Fa24	D	31	Ms	180	35-55	0	3	S	2	4	36	70	22
34	27°09'41"	30°00'31"	1814	Fa24	D	31	Ms	70	20-35	25	3	S	2	4	36	70	24
49	26°56'42"	29°54'43"	1620	Ea22	D	73	Rq	1200	20-35	0	2	NE	1	1	36	40	11
74	27°02'07"	29°53'16"	1631	Ca2	D	71	Rq	300	20-35	0	2	E	0	2	36	45	11
75	27°02'07"	29°53'16"	1631	Ca2	D	71	Rq	300	20-35	0	2	NE	0	2	36	45	11
149	27°03'37"	30°02'42"	1692	Ca2	H	21	Bv	700	20-35	0	3	E	2	3	36	50	11

14. The *Salvia repens* var. *transvaalensis*-*Lobelia angolensis* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
167	27°04'17"	30°04'00"	1768	Ea25	M	51	Ms	270	15-20	0	14	S	1	3	35	80	19
209	26°55'36"	30°04'30"	1684	Ac39	H	72	Ar	1200	>55	0	2	SE	1	1	35	60	18
275	27°10'08"	29°59'33"	1745	Fa24	H	51	Av	1200	15-20	0	6	E	2	3	36	60	20
170	27°00'36"	30°01'43"	1692	Ca2	H	51	Rg	1050	20-35	0	6	SW	0	3	35	60	25
171	27°00'36"	30°01'43"	1692	Ca2	H	51	Rg	800	20-35	0	6	S	0	3	35	60	29
53	26°58'00"	29°54'00"	1640	Ea22	D	91	Rg	600	35-55	0	3	NW	1	1	36	40	15
58	26°58'39"	29°54'00"	1660	Ea22	D	12	Rg	500	>55	0	2	SW	0	2	36	40	23
60	26°58'39"	29°54'00"	1660	Ea22	D	12	Rg	350	>55	0	2	W	0	2	36	40	25
100	27°08'24"	30°03'56"	1838	Fa393	M	31	Ms	190	35-55	0	4	E	2	4	36	40	23
142	27°05'36"	30°01'21"	1793	Ea25	H	51	Ms	200	15-20	12	13	N	3	3	36	16	13
169	27°03'50"	30°03'42"	1776	Fa25	H	51	Ms	270	20-35	0	13	n	3	3	35	45	21
219	26°55'28"	30°02'01"	1692	Ac39	D	31	Bv	1200	15-20	0	3	SE	0	3	36	65	20
232	27°00'22"	29°56'36"	1631	Ca2	D	74	Ms	270	20-35	0	2	N	2	1	36	50	28
233	27°00'22"	29°56'36"	1631	Ca2	D	74	Ms	270	35-55	1	4	E	2	1	36	50	29
262	27°14'11"	29°55'39"	1829	Ca2	D	51	Ms	270	10-15	0	3	N	2	3	35	60	30
271	27°14'57"	29°54'41"	1715	Fa24	H	51	Ms	160	10-15	0	6	NW	2	3	36	55	34
273	27°14'57"	29°54'41"	1715	Fa24	H	51	Ms	170	10-15	0	4	NW	2	3	36	55	23
277	27°10'08"	29°59'33"	1745	Fa24	H	51	Av	1200	15-20	0	6	E	2	3	36	60	16
340	27°07'32"	29°48'10"	1737	Ca2	H	31	Bv	550	20-35	0	11	E	2	4	35	60	22

15. The *Salvia repens* var. *transvaalensis*-*Rhus dentata* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
16	27°07'58"	30°01'16"	1829	Fa393	D	42	Ms	70	20-35	20	24	W	2	4	36	80	17
91	27°00'23"	30°02'42"	1722	Ea25	H	31	Ms	100	20-35	10	28	SW	2	4	22	75	21
92	27°00'23"	30°02'42"	1722	Ea25	H	31	Ms	180	20-35	0	21	S	2	4	22	75	28
21	27°10'21"	29°58'49"	1753	Fa24	H	51	Ms	100	15-20	5	4	NE	2	1	36	75	24
94	27°00'10"	30°02'42"	1760	Ea25	H	31	Hu	770	35-55	0	2	S	2	4	36	90	15
19	27°07'43"	30°01'16"	1829	Fa393	D	31	Ms	270	20-35	0	4	NW	2	5	36	90	15
22	27°10'21"	29°58'49"	1753	Fa24	H	51	Ms	60	20-35	30	10	SW	2	1	36	75	16
23	27°10'21"	29°58'49"	1753	Fa24	H	51	Ms	180	20-35	2	3	NW	2	1	36	75	20
38	27°12'20"	29°52'46"	1776	Fa24	H	51	Ms	270	35-55	0	6	SW	1	3	36	70	15
90	27°00'23"	30°02'42"	1722	Ea25	H	31	Ms	270	20-35	0	11	S	2	4	22	75	24
93	27°00'10"	30°02'42"	1760	Ea25	H	31	Ms	220	35-55	5	11	SW	2	4	36	90	23
231	26°55'54"	30°02'26"	1722	Ac39	H	72	Bv	1200	20-35	0	2	N	2	2	35	70	15

16. The *Salvia repens* var. *transvaalensis*-*Striga bilabiata* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
141	27°05'36"	30°01'21"	1798	Ea25	H	51	Ms	190	15-20	25	13	N	3	3	36	16	16
54	26°58'00"	29°54'00"	1640	Ea22	D	91	Rg	350	35-55	0	3	NW	1	1	36	40	17
56	26°58'00"	29°54'00"	1640	Ea25	D	91	Rg	400	35-55	1	3	NW	1	1	36	40	16
55	26°58'00"	29°54'00"	1640	Ea22	D	91	Ms	140	15-20	10	6	NW	1	1	36	40	20
59	26°58'39"	29°54'00"	1660	Ea22	D	12	Rg	450	>55	0	2	S	0	2	36	40	21
135	27°01'28"	29°45'31"	1684	Ca2	D	51	Ms	80	10-15	5	6	E	0	2	36	75	19
39	2°57'46"	29°50'24"	1675	Ea22	D	22	Rg	1200	20-35	0	6	NW	1	2	36	30	19
40	2°57'46"	29°50'24"	1675	Ea22	D	22	Rg	200	15-20	5	7	W	1	2	36	30	27
41	26°57'46"	29°50'24"	1675	Ea22	D	22	Rg	100	20-35	0	5	W	1	2	36	30	18
72	26°59'43"	29°51'21"	1650	Ea22	D	22	Rg	250	>55	0	2	SE	3	2	36	52	19
42	26°57'10"	29°50'21"	1660	Ea22	D	31	Rg	100	20-35	8	8	S	2	2	36	40	12
45	26°56'42"	29°50'22"	1655	Ea22	D	31	Rg	190	35-55	0	6	NE	0	2	36	70	11
68	26°59'43"	29°51'21"	1650	Ea22	D	22	Rg	200	15-20	0	3	SE	3	2	36	52	11
69	26°59'43"	29°51'21"	1650	Ea22	D	22	Rg	400	35-55	0	2	S	3	2	36	52	19
70	26°59'43"	29°51'21"	1650	Ea22	D	22	Rg	400	35-55	9	3	S	3	2	36	52	12
71	26°59'43"	29°51'21"	1650	Ea22	D	22	Ms	190	20-35	12	3	S	3	2	36	52	21

17. The *Salvia repens* var. *transvaalensis*-*Hermannia parviflora* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
1	26°56'05"	29°48'41"	1680	Ea22	D	22	Ar	1200	>55	0	4	E	0	2	36	64	19
3	26°56'05"	29°48'41"	1680	Ea22	D	22	Ar	450	>55	0	4	NE	0	2	36	64	22
84	26°56'41"	29°55'41"	1640	Ea22	D	72	Rg	1200	>55	0	2	W	3	1	36	60	23
2	26°56'05"	29°48'41"	1680	Ea22	D	22	Ar	1000	>55	0	4	E	0	2	36	64	24
85	26°56'41"	29°55'41"	1640	Ea22	D	72	Rg	1200	>55	0	2	W	3	1	36	60	24
48	26°56'42"	29°54'43"	1620	Ea22	D	73	Hu	1200	20-35	0	2	NE	1	1	36	40	18
57	26°58'00"	29°54'00"	1640	Ea22	D	91	Rg	900	35-55	0	4	NE	1	1	36	40	17

18. The *Themeda triandra*-*Limeum viscosum* subsp. *viscosum* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB - SAMPLE RELEVÉ
121	27°00'49"	29°45'56"	1654	Ca2	S	22	Ms	130	10-15	0	3	NE	2	3	36	40	16
122	27°00'37"	29°45'24"	1667	Ea22	D	21	Wa	350	10-15	0	2	N	2	2	36	40	15
125	27°00'37"	29°45'24"	1667	Ea22	D	21	Wa	750	10-15	0	2	NW	2	2	36	40	16
126	27°00'37"	29°45'24"	1667	Ea22	D	21	Ms	270	15-20	0	3	NW	2	2	36	40	26
123	27°00'37"	29°45'24"	1667	Ea22	D	21	Gc	550	10-15	0	2	NW	2	2	36	40	16
124	27°00'37"	29°45'24"	1667	Ea22	D	21	Ms	270	10-15	0	2	NW	2	2	36	40	19
120	27°00'49"	29°45'56"	1654	Ca2	S	22	Ms	100	10-15	0	3	N	2	3	36	40	21
127	27°00'37"	29°45'24"	1667	Ea22	D	21	Rg	350	20-35	0	2	SE	2	2	36	40	14
235	27°10'45"	29°57'15"	1745	Ca2	M	72	Av	1200	35-55	0	2	SE	1	2	35	80	13
119	27°00'49"	29°45'56"	1654	Ca2	S	22	Ms	120	10-15	3	3	N	2	3	36	40	24
128	27°00'21"	29°54'28"	1661	Ea22	S	41	Ms	30	10-15	66	2	E	2	3	36	30	12
104	26°55'16"	29°45'45"	1700	Ea23	D	31	Ms	270	10-15	0	4	SW	2	3	36	60	12
304	27°12'55"	30°02'16"	1814	Ca17	H	22	Ms	50	<10	10	3	S	0	2	36	55	12

5.4 THE *Eragrostis chloromelas*-*Eragrostis plana* CLOSED GRASSLAND TYPE

5.4.1 THE *Eragrostis plana*-*Aristida bipartita* CLOSED GRASSLAND UNIT

1. The *Aristida bipartita*-*Tragus racemosus* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB - SAMPLE RELEVÉ
118	27°14'28"	29°53'42"	1715	Ca2	H	51	Ms	200	20-35	0	3	N	2	3	36	60	8
117	27°14'28"	29°53'42"	1715	Ca2	H	51	Ms	270	10-15	0	2	NW	2	3	36	60	14
145	27°00'36"	29°53'16"	1646	Ca2	D	51	Ms	110	15-20	25	2	NW	2	4	36	30	19
146	27°08'50"	30°02'13"	1722	Ea25	D	31	Ms	60	35-55	75	9	NE	0	0	36	35	15
144	26°56'42"	29°50'22"	1655	Ea22	D	31	Ms	90	15-20	1	3	NE	0	2	36	70	9
13	27°00'36"	29°53'16"	1646	Ca2	D	51	Ms	110	20-35	1	3	NW	2	4	36	30	15
119	27°04'55"	29°50'50"	1676	Ca2	D	22	Ms	250	10-15	0	2	S	0	2	35	70	12

2. The *Aristida bipartita*-*Hermannia geniculata* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
132	27°12'20"	29°50'06"	1859	Fa24	M	51	Ms	170	20-35	0	8	N	2	4	36	60	16
134	27°12'20"	29°50'06"	1859	Fa24	M	51	Ms	170	20-35	0	6	N	2	4	36	60	12
139	27°10'34"	29°46'43"	1798	Ea23	H	31	Ms	30	20-35	90	17	NE	0	4	36	50	15
140	27°10'34"	29°46'43"	1798	Ea23	H	31	Ms	30	20-35	50	5	NE	0	4	36	50	13
142	27°10'34"	29°46'43"	1798	Ea23	H	31	Ms	50	20-35	80	11	NE	0	4	36	50	13
133	27°12'20"	29°50'06"	1859	Fa24	M	51	Ms	250	15-20	0	10	N	2	4	36	60	18

5.4.2 THE *Eragrostis plana*-*Conyza podocephala* CLOSED GRASSLAND UNIT3. The *Conyza podocephala*-*Hermannia depressa* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
4	27°07'58"	30°01'16"	1829	Fa393	D	42	Ms	60	35-55	30	6	NE	2	4	36	80	15
5	27°07'58"	30°01'16"	1829	Fa393	D	42	Ms	150	35-55	0	3	N	2	4	36	80	11
87	26°57'26"	29°46'16"	1700	Ea23	S	22	Ms	270	20-35	0	3	N	0	3	35	75	18
126	27°12'55"	30°02'16"	1814	Ca17	H	22	Ms	160	20-35	0	2	S	0	2	36	55	11
17	27°13'15"	30°04'34"	1822	Fa361	H	51	Ms	180	10-15	0	9	SW	3	3	36	40	13
18	27°14'01"	30°04'56"	1872	Fa361	H	51	Av	1200	15-20	0	2	NW	3	3	36	50	9
32	27°05'34"	30°02'56"	1859	Ea25	D	12	Ms	200	20-35	0	2	N	0	5	36	25	16
33	27°05'34"	30°02'56"	1859	Ea25	D	12	Ms	100	20-35	0	6	SE	0	5	36	25	16
34	27°05'34"	30°02'56"	1859	Ea25	D	12	Ms	180	20-35	0	2	NE	0	5	36	25	15
35	27°04'55"	30°04'24"	1859	Ea25	M	31	Ms	250	15-20	0	11	E	2	5	36	50	13
63	27°08'34"	30°04'30"	1844	Fa393	M	22	Ms	270	>55	0	2	SE	0	3	36	45	10
62	27°08'34"	30°04'30"	1844	Fa393	M	22	Bv	620	20-35	0	2	S	0	3	36	45	13
55	27°00'11"	30°03'26"	1768	Ac39	M	22	Bv	1100	35-55	0	2	SW	2	3	35	50	16
131	27°11'57"	29°51'06"	1996	Fa24	M	31	Ms	60	10-15	0	5	NE	2	5	36	60	17
6	27°12'02"	30°03'55"	1951	Fa360	H	51	Ms	90	20-35	55	18	NW	2	4	36	70	16
23	27°00'10"	30°02'42"	1760	Ea25	H	31	Av	700	15-20	0	3	SE	2	4	36	90	13
130	27°11'57"	29°51'06"	1996	Fa24	M	31	Cv	600	20-35	0	6	NE	2	5	36	60	21
20	27°00'23"	30°02'42"	1722	Ea25	H	31	Ms	100	10-15	60	17	SW	2	4	22	75	29
112	27°14'19"	29°56'36"	1936	Fa24	M	42	Ms	150	10-15	25	28	SE	2	4	22	60	29
114	27°14'19"	29°56'36"	1936	Fa24	M	42	Ms	270	<10	20	31	SE	2	4	22	60	23
113	27°14'19"	29°56'36"	1936	Fa24	M	42	Ms	50	<10	15	35	SE	2	4	22	60	24
115	27°14'19"	29°56'36"	1936	Fa24	M	42	Ms	200	<10	25	33	SE	2	4	22	60	20
36	27°04'55"	30°04'24"	1859	Ea25	M	31	Ms	200	15-20	0	4	E	2	5	36	50	10
37	27°04'55"	30°04'24"	1859	Ea25	M	31	Ms	100	20-35	0	15	E	2	5	36	50	13
24	26°56'06"	29°46'26"	1660	Ea22	D	31	Ms	210	20-35	0	4	NW	3	3	36	40	13
31	27°05'36"	30°01'21"	1798	Ea25	H	51	Av	450	20-35	0	4	N	3	3	36	16	12
121	27°04'55"	29°50'50"	1676	Ca2	D	22	Ms	100	15-20	5	6	E	0	2	35	70	21
122	27°04'55"	29°50'50"	1676	Ca2	D	22	Ms	90	10-15	1	5	SE	0	2	35	70	18
22	27°00'10"	30°02'42"	1760	Ea25	H	31	Av	700	20-35	0	2	SE	2	4	36	90	16
8	27°12'20"	29°52'46"	1776	Fa24	H	51	Hu	1200	20-35	0	6	S	1	3	36	70	12
86	26°57'26"	29°46'16"	1700	Ea23	S	22	Av	1100	35-55	0	3	NW	0	3	35	75	15
88	26°57'26"	29°46'16"	1700	Ea23	S	22	Ms	270	20-35	0	3	N	0	3	35	75	22
11	26°56'43"	29°45'18"	1740	Ea23	S	31	Rg	400	20-35	0	2	SE	0	4	36	50	9
46	27°02'58"	30°04'24"	1722	Ca17	H	72	Cv	-	-	0	2	SE	3	2	35	35	7
89	26°57'26"	29°46'16"	1700	Ea23	S	22	Bv	1200	35-55	0	3	N	0	3	35	75	20
90	26°57'26"	29°46'16"	1700	Ea23	S	22	Ms	150	35-55	0	3	N	0	3	35	75	18
141	27°10'34"	29°46'43"	1798	Fa23	H	31	Hu	800	15-20	0	6	NE	0	4	36	50	14
29	27°02'21"	29°47'11"	1692	Ca2	D	72	Rg	500	20-35	0	2	S	2	2	36	50	12
116	27°14'28"	29°53'42"	1715	Ca2	H	51	Ms	180	20-35	0	5	NW	2	3	36	60	16
15	27°13'15"	30°04'34"	1882	Fa361	H	51	Bv	62	15-20	0	7	S	3	3	36	40	8
16	27°13'15"	30°04'34"	1882	Fa361	H	51	Bv	1200	35-55	0	6	SW	3	3	36	40	12
44	27°02'58"	30°04'24"	1722	Ca17	H	72	Cv	1200	20-35	0	2	SE	3	2	35	35	5
81	27°10'45"	29°57'15"	1745	Ca2	M	72	Av	1200	20-35	0	2	SE	1	2	35	80	7
120	27°04'55"	29°50'50"	1676	Ca2	D	22	Ar	600	20-35	0	3	SE	0	2	35	70	15

4. The *Conyza podocephala*-*Euphorbia striata* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
59	26°56'39"	30°03'35"	1692	Ac39	H	31	Gf	1000	20-35	0	3	E	3	3	35	50	14
105	27°13'55"	29°55'26"	1798	Ca2	D	51	Av	1200	35-55	0	3	W	2	3	35	50	11
78	26°55'54"	30°02'26"	1722	Ac39	H	72	Bv	1200	15-20	0	3	N	2	2	35	70	11
57	26°56'39"	30°03'35"	1692	Ac39	H	31	Gf	1200	20-35	0	2	SE	3	3	35	50	20
58	26°56'39"	30°03'35"	1692	Ac39	H	31	Gf	1000	15-20	0	3	E	3	3	35	50	13
102	27°13'10"	29°54'26"	1791	Ca2	H	22	Fw	1200	<10	0	4	W	2	2	36	60	17
94	27°12'18"	29°56'56"	1768	Ca2	M	51	Cv	1000	10-15	0	2	N	3	3	35	60	20
56	27°00'11"	30°03'26"	1768	Ac39	M	22	Bv	1000	20-35	0	2	SW	2	3	35	50	8
50	27°01'25"	30°04'11"	1814	Ea25	M	51	Rg	700	20-35	0	3	NE	3	3	35	65	10
99	27°13'33"	29°54'46"	1806	Ca2	D	22	Rg	1200	>55	0	3	NW	2	2	35	50	11
101	27°13'33"	29°54'46"	1806	Ca2	D	22	Rg	800	>55	0	3	N	2	2	35	50	15
43	27°02'58"	30°04'24"	1722	Ca17	H	72	Cv	1200	35-55	0	2	SE	3	2	35	35	13
48	27°01'25"	30°04'11"	1814	Ea25	M	51	Ms	240	35-55	0	4	NE	3	3	35	65	12
49	27°01'25"	30°04'11"	1814	Ea25	M	51	Rg	300	35-55	0	3	NE	3	3	35	65	11
54	27°00'11"	30°03'26"	1768	Ac39	M	22	Bv	1000	20-35	0	3	SW	2	3	35	50	5
75	26°55'39"	30°02'13"	1692	Ac39	D	72	Av	1200	20-35	0	2	NW	3	2	36	60	19
76	26°55'54"	30°02'26"	1722	Ac39	H	72	Bv	1200	20-35	0	2	N	2	2	35	70	12
96	27°13'23"	29°55'31"	1783	Ca2	D	22	Av	600	35-55	0	5	NW	2	2	35	50	4
97	27°13'23"	29°55'31"	1783	Ca2	D	22	Av	550	35-55	0	4	W	2	2	35	50	3
98	27°13'33"	29°55'46"	1806	Ca2	D	22	Pn	1200	35-55	0	3	N	2	2	35	50	11
100	27°13'33"	29°55'46"	1806	Ca2	D	22	Av	1200	35-55	0	3	NW	2	2	35	50	11
109	27°13'58"	29°55'15"	1783	Ca2	H	71	Av	1200	35-55	0	3	SW	3	1	35	95	11
45	27°02'58"	30°04'24"	1722	Ca17	H	72	Bv	1200	20-35	0	2	SE	3	2	35	35	11
65	26°55'36"	30°04'30"	1684	Ac39	H	72	Rg	1200	35-55	0	3	E	1	1	35	60	16

5. The *Conyza podocephala*-*Cymbopogon excavatus* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
21	27°00'10"	30°02'42"	1760	Ea25	H	31	Hu	800	20-35	0	4	SE	2	4	36	90	17
27	26°55'07"	29°46'49"	1630	Ea22	S	91	Ar	1000	20-35	0	4	NE	1	1	34	50	13
25	26°55'07"	29°46'49"	1630	Ea22	S	91	Ar	1000	20-35	0	4	N	1	1	34	50	18
26	26°55'07"	29°46'49"	1630	Ea22	S	91	Ar	1000	20-35	0	6	NE	1	1	34	50	15
14	26°56'41"	29°55'41"	1640	Ea22	D	72	Ar	1200	>55	0	2	NW	3	1	36	60	12
1	27°08'52"	29°59'32"	1692	Fa24	D	22	Rg	800	>55	0	3	N	2	1	24	50	7
2	27°08'52"	29°59'32"	1692	Fa24	D	22	Rg	500	>55	0	2	NW	2	1	24	50	9
3	27°08'52"	29°59'32"	1692	Fa24	D	22	Rg	400	>55	0	3	NW	2	1	24	50	7
19	27°00'23"	30°02'42"	1722	Ea25	H	31	Ms	270	20-35	0	9	W	2	4	22	75	27
30	27°02'21"	29°47'11"	1692	Ca2	D	72	Ms	100	10-15	0	2	N	2	2	36	50	15
47	27°00'36"	30°01'43"	1692	Ca2	H	51	Rg	650	20-35	0	8	SW	0	3	35	60	17

5.4.3 THE *Eragrostis plana*-*Paspalum dilatatum* CLOSED GRASSLAND UNIT6. The *Paspalum dilatatum*-*Senecio erubescens* var. *crepidifolius* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
80	27°00'22"	29°56'36"	1631	Ca2	D	74	Rg	1200	35-55	0	3	NW	2	1	36	50	22
79	27°00'22"	29°56'36"	1631	Ca2	D	74	Rg	1200	35-55	0	3	NW	2	1	36	50	18
143	27°05'49"	29°53'15"	1661	Ca2	D	22	Av	550	15-20	0	11	W	3	3	36	70	23
127	27°04'07"	29°49'53"	1676	Ca2	D	22	Rg	900	20-35	1	2	NE	2	2	36	60	24
128	27°04'07"	29°49'53"	1676	Ca2	D	22	Rg	650	20-35	0	2	NE	2	2	36	60	18
42	27°03'50"	30°03'42"	1776	Ea25	H	51	Ms	270	20-35	0	10	W	3	3	35	45	15
12	27°02'07"	29°53'16"	1631	Ca2	D	71	Rg	600	20-35	0	2	E	0	2	36	45	12
41	27°03'50"	30°03'42"	1776	Ea25	H	51	Ms	270	20-35	0	6	W	3	3	35	45	20
9	26°56'42"	29°54'43"	1620	Ea22	D	73	Hu	1200	15-20	0	5	NE	1	1	36	40	13
10	26°56'42"	29°54'43"	1620	Ea22	D	73	Rg	1200	20-35	0	2	E	1	1	36	40	12
74	26°55'39"	30°02'13"	1692	Ac39	D	72	Rg	1200	35-55	0	2	SE	3	2	36	60	13

7. The *Paspalum dilatatum*-*Berkheya speciosa* subsp. *lanceolata* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
67	26°56'54"	30°04'46"	1707	Ac39	H	72	Av	1150	35-55	0	2	S	0	2	35	60	22
68	26°56'54"	30°04'46"	1707	Ac39	H	72	Av	600	35-55	0	2	SE	0	2	35	60	13
77	26°55'54"	30°02'26"	1722	Ac39	H	72	Bv	1200	15-20	0	2	NW	2	2	35	70	14
107	27°13'58"	29°55'15"	1783	Ca2	H	71	Rg	1200	>55	0	2	W	3	1	35	95	8
124	27°04'55"	29°50'50"	1676	Ca2	D	22	Ms	200	15-20	0	3	SE	0	2	35	70	16
123	27°04'55"	29°50'50"	1676	Ca2	D	22	Ms	90	10-15	2	14	SE	0	2	35	70	16
104	27°13'55"	29°55'26"	1798	Ca2	D	51	Av	1200	35-55	0	4	W	2	3	35	50	7
106	27°13'55"	29°55'26"	1798	Ca2	D	51	Av	550	20-35	0	5	W	2	3	35	50	8
108	27°13'58"	29°55'15"	1783	Ca2	H	71	Pn	1200	35-55	0	2	SW	3	1	35	95	11
110	27°13'58"	29°55'15"	1783	Ca2	H	71	Rg	1200	>55	0	2	SW	3	1	35	95	5

8. The *Paspalum dilatatum*-*Arundinella nepalensis* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
7	27°12'20"	29°52'46"	1776	Fa24	H	51	Ms	170	20-35	50	4	SE	1	3	36	70	18
64	26°55'36"	30°04'30"	1684	Ac39	H	72	Ar	1200	>55	0	2	SE	1	1	35	60	13
125	27°11'52"	29°49'24"	1776	Ca2	M	22	Ar	500	35-55	0	3	E	2	3	35	45	7
40	27°04'17"	30°04'00"	1768	Ea25	M	51	Ar	1200	20-35	0	9	SW	1	3	35	80	20
38	27°04'17"	30°04'00"	1768	Ea25	M	51	Ar	1200	35-55	0	9	SW	1	3	35	80	15
39	27°04'17"	30°04'00"	1768	Ea25	M	51	Ar	1200	35-55	0	9	SW	1	3	35	80	13
111	27°00'16"	30°03'56"	1768	Ac39	H	22	Rg	1200	35-55	0	2	NW	0	2	35	80	11
129	27°09'46"	30°03'27"	1814	Fa393	M	31	Ar	1200	>55	0	2	NE	2	3	35	50	9
135	27°13'26"	29°50'21"	1829	Fa24	M	51	Rg	1200	20-35	0	3	SE	2	4	35	65	12
137	27°13'26"	29°50'21"	1829	Fa24	M	51	Bv	850	20-35	0	3	SE	2	4	35	65	17
136	27°13'26"	29°50'21"	1829	Fa24	M	51	Rg	700	20-35	0	4	SE	2	4	35	65	11
138	27°13'26"	29°50'21"	1829	Fa24	M	51	Bv	650	20-35	0	4	SE	2	4	35	65	12
69	26°56'21"	30°04'54"	1692	Ac39	H	21	Av	500	35-55	0	2	SE	0	3	35	60	18
72	26°55'10"	30°01'27"	1692	Ea25	D	72	Rg	1200	35-55	0	2	S	1	1	36	70	19
20	27°00'45"	29°46'40"	1646	Ca2	S	91	Ms	100	10-15	0	3	SW	2	3	36	60	6

9. The *Paspalum dilatatum*-*Hyparrhenia anamesa* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
60	26°50'00"	30°02'27"	1737	Ac39	H	51	Bv	1200	15-20	0	3	S	0	3	35	60	15
61	26°58'00"	30°02'27"	1737	Ac39	H	51	Ms	270	20-35	0	6	S	0	3	35	60	20
66	26°55'36"	30°04'30"	1684	Ac39	H	72	Rg	1200	35-55	0	10	E	1	1	35	60	15
73	26°55'39"	30°02'13"	1692	Ac39	D	72	Rg	1200	35-55	0	3	W	3	2	36	60	15

10. The *Paspalum dilatatum*-*Eleusine coracana* subsp. *africana* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
91	27°12'18"	29°56'56"	1768	Ca2	M	51	Cv	1200	10-15	0	6	NW	3	3	35	60	18
92	27°12'18"	29°56'56"	1768	Ca2	M	51	Cv	600	10-15	0	3	N	3	3	35	60	19
93	27°12'18"	29°56'56"	1768	Ca2	M	51	Cv	1200	10-15	0	6	NW	3	3	35	60	22
83	27°08'52"	29°56'09"	1722	Ca2	H	72	Av	1200	35-55	0	2	NW	0	2	36	60	12
84	27°08'52"	29°56'09"	1722	Ca2	H	72	Av	1200	35-55	0	2	NW	0	2	36	60	12
85	27°08'52"	29°56'09"	1722	Ca2	H	72	Av	1200	20-35	0	2	NW	0	2	36	60	12
82	27°08'52"	29°56'09"	1722	Ca2	H	72	Av	1200	35-55	0	2	NW	0	2	36	60	5
51	27°00'51"	30°03'39"	1783	Ea25	M	51	Bv	1200	20-35	0	2	E	2	3	36	60	7
52	27°00'51"	30°03'39"	1783	Ea25	M	51	Bv	1000	20-35	0	3	E	2	3	36	60	7

11. The *Eragrostis plana*-*Nidorella anomala* Closed Grassland Variant

RELEVÉ NUMBER	LATITUDE (S)	LONGITUDE (N)	ALTITUDE (m)	LAND TYPE	GEOLOGY	GEOMORPHOLOGY	SOIL FORM	SOIL DEPTH (mm)	% CLAY CONTENT OF THE A HORIZON	% ROCK COVER	SLOPE (°)	ASPECT	EROSION	EXPOSURE	VEGETATION FORMATION	% CANOPY COVER	SPECIES/SUB-SAMPLE RELEVÉ
70	26°56'13"	30°04'02"	1684	Ac39	H	21	Av	1200	35-55	0	2	N	0	3	35	55	17
71	26°56'13"	30°04'02"	1684	Ac39	H	21	Av	1200	35-55	0	3	N	0	3	35	55	14
103	27°13'55"	29°55'26"	1798	Ca2	D	51	Cv	500	35-55	0	7	W	2	3	35	50	12
53	27°00'51"	30°03'39"	1783	Ea25	M	51	Bv	1000	35-55	0	4	E	2	3	36	60	10
95	27°13'23"	29°55'31"	1783	Ca2	D	22	Av	1200	35-55	0	4	NW	2	2	35	50	4

APPENDIX 3

The results of the statistical analysis of the habitat data for the *Tristachya leucothrix-Themedra triandra* Closed Grassland Type and the *Eragrostis chloromelas-Eragrostis plana* Closed Grassland Types, and the lower syntaxa thereof (see Chapter 7).

TABLE 1 Results of the statistical analysis (T-tests) of the habitat data for the *Tristachya leucothrix-Themeda triandra* Closed Grassland Type (A) and the *Eragrostis chloromelas-Eragrostis plana* Closed Grassland Type (B).

HABITAT FACTOR	COMMUNITY TYPE		S	v	T
	A (n=352)	B (n=146)			
Mean altitude (m)	1754	1757	-	496	-0,30
Mean rainfall (mm)	736	744	99,0%	496	-2,42
Mean %rock cover	4	4	-	496	-0,49
Rock cover $\geq 10\%$	27	46	99,5%	55	-3,15
Mean slope	5	4	-	495	1,51
Slope $\geq 10^\circ$	14	18	97,5%	63	-2,35
Soil depths (mm):					
Mispah soils	168	163	-	221	0,38
Vertic soils	668	954	99,9%	94	-3,42
Restricted soils ¹	982	1011	-	135	-0,58
Free soils ²	877	994	-	40	-1,36
Mean %canopy cover	61	58	-	296	1,64

S: Level of statistical significance

v: Degrees of freedom

T: Result of T-test

¹Soils with restricted drainage

²Freely drained soils

TABLE 2 Results of the statistical analysis (Chi-squared tests) of the habitat data for the *Tristachya leucothrix-Themeda triandra* Closed Grassland Type and the *Eragrostis chloromelas-Eragrostis plana* Closed Grassland Type.

HABITAT FACTOR	S	v	Chi-squared
Geomorphology	99,9%	7	48,43
Slopes only	99,9%	4	23,36
Flats only	99,9%	2	24,90
Geology	-	3	5,98
Soil types	99,0%	3	13,83
%Clay content	95,0%	5	11,90
Erosion	99,0%	3	11,42
Aspect	99,0%	7	24,13
Meso- & xeroclinal slopes	95,0%	1	4,34
Grazing	-	3	1,54
Fire	95,0%	1	4,12
Exposure	-	5	6,40

S: Level of statistical significance

v: Degrees of freedom

Chi-squared: Result of Chi-squared test

TABLE 3 Results of the statistical analysis (T-tests) of the habitat data for the *Themeda triandra-Berkheya setifera* Closed Grassland Unit (A) and the *Themeda triandra-Hermannia depressa* Closed Grassland Unit (B).

HABITAT FACTOR	COMMUNITY TYPE		S	v	T
	A (n=352)	B (n=146)			
Mean altitude (m)	1787	1721	99,9%	337	6,75
Mean rainfall (mm)	748	726	99,9%	337	6,41
Mean %rock cover	3	3	-	337	-0,33
Rock cover $\geq 10\%$	29	21	-	38	1,49
Mean slope	5	5	-	337	-0,23
Slope $\geq 10^\circ$	13	15	-	46	-1,61
Soil depths (mm):					
Mispah soils	165	172	-	165	-0,52
Vertic soils	926	577	99,5%	56	3,42
Restricted soils ¹	984	1003	-	88	-0,31
Free soils ²	894	814	-	22	0,58
Mean %canopy cover	67	55	99,9%	337	6,46

S: Level of statistical significance

v: Degrees of freedom

T: Result of T-test

¹Soils with restricted drainage

²Freely drained soils

TABLE 4 Results of the statistical analysis (Chi-squared tests) of the habitat data for the *Themeda triandra-Berkheya setifera* Closed Grassland Unit and the *Themeda triandra-Hermannia depressa* Closed Grassland Unit.

HABITAT FACTOR	S	v	Chi-squared
Geomorphology	95,0%	7	15,02
Slopes only	95,0%	4	11,29
Flats only	-	2	3,03
Geology	99,9%	3	62,37
Soil types	99,9%	3	29,28
%Clay content	99,9%	5	25,80
Erosion	99,9%	3	22,57
Aspect	-	7	6,77
Meso- & xeroclinical slopes	-	1	0,27
Grazing	95,0%	3	9,09
Fire	-	1	0,91
Exposure	99,0%	5	19,78

S: Level of statistical significance

v: Degrees of freedom

Chi-squared: Result of Chi-squared test

TABLE 5 Results of the statistical analysis (T-tests) of the habitat data for the *Hermannia depressa-Eragrostis plana* Closed Grassland Sub-Unit (A) and the *Hermannia depressa-Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit (B).

HABITAT FACTOR	COMMUNITY TYPE		S	v	T
	A (n=352)	B (n=146)			
Mean altitude (m)	1731	1709	-	151	1,60
Mean rainfall (mm)	725	728	-	151	-0,49
Mean %rock cover	4	3	-	151	0,83
Rock cover $\geq 10\%$	24	18	-	19	0,99
Mean slope	5	6	-	150	-0,50
Slope $\geq 10^\circ$	15	15	-	19	-0,18
Soil depths (mm):					
Mispah soils	165	184	-	75	-1,02
Vertic soils	555	584	-	40	-0,22
Restricted soils ¹	1001	1008	-	27	-0,05
Free soils ²	700	985	-	3	-1,24
Mean %canopy cover	56	54	-	151	0,40

S: Level of statistical significance

v: Degrees of freedom

T: Result of T-test

¹Soils with restricted drainage

²Freely drained soils

TABLE 6 Results of the statistical analysis (Chi-squared tests) of the habitat data for the *Hermannia depressa-Eragrostis plana* Closed Grassland Sub-Unit and the *Hermannia depressa-Salvia repens* var. *transvaalensis* Closed Grassland Sub-Unit.

HABITAT FACTOR	S	v	Chi-squared
Geomorphology	99,9%	7	26,99
Slopes only	99,0%	4	13,96
Flats only	99,0%	2	12,96
Geology	-	3	4,17
Soil types	99,9%	3	25,85
%Clay content	99,9%	5	21,26
Erosion	99,0%	3	13,18
Aspect	-	7	<0,01
Meso- & xeroclinal slopes	-	1	<0,01
Grazing	-	3	4,14
Fire	-	1	3,39
Exposure	99,9%	5	20,87

S: Level of statistical significance

v: Degrees of freedom

Chi-squared: Result of Chi-squared test

TABLE 7 Results of the statistical analysis (T-tests) of the habitat data for the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (A) and the *Eragrostis plana-Conyza podocephala* Closed Grassland Unit (B).

HABITAT FACTOR	COMMUNITY TYPE		S	v	T
	A (n=352)	B (n=146)			
Mean altitude (m)	1760	1760	-	201	0
Mean rainfall (mm)	742	741	-	201	0,16
Mean %rock cover	5	2	-	201	1,56
Rock cover $\geq 10\%$	46	33	-	17	1,17
Mean slope	6	5	-	201	0,29
Slope $\geq 10^\circ$	19	20	-	22	0,29
Soil depths (mm):					
Mispah soils	162	171	-	73	-0,49
Vertic soils	857	884	-	46	-0,32
Restricted soils ¹	990	989	-	50	-0,02
Free soils ²	1033	1033	-	22	0,02
Mean %canopy cover	56	58	-	201	-0,90

S: Level of statistical significance

v: Degrees of freedom

T: Result of T-test

¹Soils with restricted drainage

²Freely drained soils

TABLE 8 Results of the statistical analysis (Chi-squared tests) of the habitat data for the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit and the *Eragrostis plana-Conyza podocephala* Closed Grassland Unit.

HABITAT FACTOR	S	v	Chi-squared
Geomorphology	99,0%	6	17,48
Slopes only	99,0%	4	16,19
Flats only	-	1	0,14
Geology	-	3	0,20
Soil types	-	3	2,32
%Clay content	-	5	0,90
Erosion	-	3	0,40
Aspect	-	7	2,33
Meso- & xeroclinal slopes	-	1	0,80
Grazing	-	3	0,01
Fire	-	1	1,95
Exposure	-	5	3,20

S: Level of statistical significance

v: Degrees of freedom

Chi-squared: Result of Chi-squared test

TABLE 9 Results of the statistical analysis (T-tests) of the habitat data for the *Eragrostis plana-Conyza podocephala* Closed Grassland Unit (A) and the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (B).

HABITAT FACTOR	COMMUNITY TYPE		S	v	T
	A (n=352)	B (n=146)			
Mean altitude (m)	1760	1733	95,0%	147	1,90
Mean rainfall (mm)	741	745	-	147	-0,64
Mean %rock cover	2	1	-	147	0,86
Rock cover $\geq 10\%$	33	50	-	7	-
Mean slope	5	4	-	147	1,31
Slope $\geq 10^\circ$	20	11	95,0%	13	1,83
Soil depths (mm):					
Mispah soils	171	196	-	37	-0,78
Vertic soils	884	1074	97,5%	44	-2,38
Restricted soils ¹	989	979	-	44	0,11
Free soils ²	1033	1050	-	14	-0,12
Mean %canopy cover	58	61	-	147	-1,38

S: Level of statistical significance

v: Degrees of freedom

T: Result of T-test

¹Soils with restricted drainage

²Freely drained soils

TABLE 10 Results of the statistical analysis (Chi-squared tests) of the habitat data for the *Eragrostis plana-Conyza podocephala* Closed Grassland Unit and the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit.

HABITAT FACTOR	S	v	Chi-squared
Geomorphology	99,9%	7	26,98
Slopes only	99,9%	4	20,53
Flats only	-	2	4,46
Geology	-	3	4,08
Soil types	95,0%	3	8,24
%Clay content	-	5	4,72
Erosion	-	3	4,54
Aspect	-	7	7,65
Meso- & xeroclinal slopes	-	1	0,86
Grazing	-	3	2,30
Fire	-	1	0,01
Exposure	-	4	5,95

S: Level of statistical significance

v: Degrees of freedom

Chi-squared: Result of Chi-squared test

TABLE 11 Results of the statistical analysis (T-tests) of the habitat data for the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit (A) and the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit (B).

HABITAT FACTOR	COMMUNITY TYPE		S	v	T
	A (n=352)	B (n=146)			
Mean altitude (m)	1760	1733	95,0%	150	1,91
Mean rainfall (mm)	742	745	-	150	-0,49
Mean %rock cover	5	1	95,0%	150	1,71
Rock cover $\geq 10\%$	46	50	-	12	-
Mean slope	6	4	-	150	1,58
Slope $\geq 10^\circ$	19	11	-	15	1,61
Soil depths (mm):					
Mispah soils	162	196	-	48	-1,03
Vertic soils	857	1074	99,0%	42	-2,70
Restricted soils ¹	990	979	-	38	0,12
Free soils ²	1033	1050	-	14	-0,12
Mean %canopy cover	56	58	97,5%	150	-2,30

S: Level of statistical significance

v: Degrees of freedom

T: Result of T-test

¹Soils with restricted drainage

²Freely drained soils

TABLE 12 Results of the statistical analysis (Chi-squared tests) of the habitat data for the *Eragrostis plana-Aristida bipartita* Closed Grassland Unit and the *Eragrostis plana-Paspalum dilatatum* Closed Grassland Unit.

HABITAT FACTOR	S	v	Chi-squared
Geomorphology	99,9%	7	29,98
Slopes only	99,9%	4	18,99
Flats only	95,0%	2	8,97
Geology	-	3	3,48
Soil types	99,0%	3	14,63
%Clay content	-	5	6,84
Erosion	-	3	4,84
Aspect	-	7	12,77
Meso- & xeroclinal slopes	-	1	2,75
Grazing	-	3	2,09
Fire	-	1	1,16
Exposure	-	5	10,15

S: Level of statistical significance

v: Degrees of freedom

Chi-squared: Result of Chi-squared test

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