BEZUIDENHOUT, HUGO

SYNTAXONOMY AND SYNECOLOGY OF WESTERN TRANSVAAL GRASSLANDS

PhD **UP** **1994**

Syntaxonomy and synecology of western Transvaal grasslands

by

HUGO BEZUIDENHOUT

Submitted in partial fulfilment of the requirements for the degree

PHILOSOPHIAE DOCTOR (BOTANY)

in the Faculty of Science
(Department of Botany)

University of Pretoria
Pretoria

December 1993

Promoter: Prof Dr G.J. Bredenkamp
Co-promoter: Prof Dr G.K. Theron

I dedicate this dissertation to Thea and Kobus.

ABSTRACT

Syntaxonomy and synecology of western Transvaal grasslands

by

HUGO BEZUIDENHOUT

Promoter: Prof Dr G.J. Bredenkamp
Co-promoter: Prof Dr G.K. Theron

Department of Botany
University of Pretoria

PHILOSOPHIAE DOCTOR (BOTANY)

The western Transvaal grassland is presently under great threat because of the ever increasing population as well as the exploitation of the natural resources. The vegetation, as one of these resources, was relatively unknown and the need for a phytosociological investigation was urgent. A phytosociological research programme on the plant communities of the western Transvaal grassland, was initiated in conjunction with a more comprehensive Grassland Biome Project which aims at a synecological and syntaxonomical synthesis of the Biome in southern Africa. The main purpose of this study was to identify, classify, describe and determine the location of the grassland plant communities and other vegetation types within the western Transvaal grasslands. A new procedure was used to compile a synecological and syntaxonomical synthesis of the vegetation of the western Transvaal grasslands. By using land types as first stratification it presented an easily interpretable vegetation-cum-habitat classification and thus much needed information on the vegetation ecology of the study area. This should be used for future land-use planning, management, utilization, research and conservation of the natural resources. The synthesis of the western Transvaal grasslands make a contribution towards the compilation of the synthesis of the Grassland Biome of southern Africa.

CONTENTS

CHAPTER 1

INTRODUCTION

PAGE

1.1 Introduction

Knowledge of the vegetation and soil of a country provides the basic foundation which supports the agricultural, industrial, commercial and cultural pillars of human society. The vegetation and soil are interdependent in so far that the destruction of one leads to the loss of the other. Since the settlement of Europeans on this subcontinent three centuries ago, the exploitation of the natural vegetation has resulted in its general deterioration and in the loss of soil (Louw 1951). However, it is not all to be blamed on the land users, but also on the unpredictable weather, the erratic distribution of rainfall and sometimes untimely frosts (Weather Bureau 1986).

Man and animals are dependent on the natural resources and the need to maximize the optimal use for these resources will definitely increase with the growth of the human population. The population of South Africa was approximately 28.4 million in 1988 and it is expected to increase with 2.3 % per year. Therefore, the population could double before the end of the century (De Waal 1988, Myburgh 1993). Great care should be taken to optimize the use of natural resources but on the other hand, not destroy it. Optimal use of natural resources can not be taken care of without adequate knowledge of the ecosystems involved (Edwards 1972). Different ecosystems reacts differently to certain management practises (Bredenkamp & Theron 1976) and therefore, in order to formulate a management policy, where proper land use is emphasized, the classification of the vegetation is essential (Van Rooyen *et al.* 1981).

Since the 1974 AETFAT Congress (Werger & Edwards 1976), vegetation studies in South Africa have increased in the fynbos and woodland (savanna) vegetation, but the vegetational resources of the grassland, forests and Karoo still lack baseline information such as phytosociological studies (Scheepers 1983). Mentis and Huntley (1982) also stated the necessity of research in the Grassland Biome (Rutherford & Westfall 1986), and therefore a phytosociological research programme on the synthesis of the vegetation of the

Grassland Biome has commenced in 1983/1984. Examples of these studies which have been concluded are Bezuidenhout (1988), Bloem (1988), Turner (1989), Kooij (1990), Breytenbach (1991), Du Preez (1991), Matthews (1991), Smit (1992), Coetzee (1993), Eckhardt (1993), Fuls (1993) and Myburgh (1993).

The importance of the Highveld Region is underlined by the fact that although only 12 % (11.5 million hectares) of the total area of the Republic of South Africa (RSA) falls in this Region, it produces one third of the total agricultural yield of the RSA. Approximately 50 % of ploughed land in the RSA occur in the Region (Department of Agriculture and Water Supply 1987). The Region also produces approximately 24 % of the total value of South Africa's animal products (Anon 1987). The western Transvaal Grassland Biome (2.7 million hectares) is situated in the north-western part of the Highveld Region. Apart from the above-mentioned factors, the stability and state of the vegetation of the western Transvaal grassland is also negatively influenced by the industrial and mining activities (Bezuidenhout 1988). A deficit in wood, has lead the farmers to plant exotic tree species such as *Acacia mearnsii*, *Pinus* species and *Eucalyptus* species. The tree *Acacia mearnsii* is an alien invader (Henderson *et al.* 1987) which competes with the natural woodland.

At present the conservation status of the western Transvaal is very poor and only 0.33 % of the 2.7 million hectares is presently under conservation. Sound ecologically founded conservation planning is urgently needed for the region (Siegfried 1989). The classification, description and determination of the location of the different vegetation units should form a basis for all conservation planning in the region.

In 1988, when this study commenced, relatively little was known about the vegetation of the western Transvaal grassland. Although smaller local studies, such as those of Louw (1951), Morris (1973), Van Wyk (1983) and Bezuidenhout (1988) existed but the only broad and most noted classification of the vegetation was that of Acocks (1953) which has been reprinted twice since then (Acocks 1975 &

1988). The existing classifications are not sufficient to permit land use, utilization, conservation and management planning at an acceptable level or scale. A more detailed identification, description and determination of the localities of the grassland and other vegetation types within the western Transvaal Grassland Biome are needed (Scheepers 1983).

Several Braun-Blanquet type surveys have been conducted in southern Africa. Many of these were however semi-detailed local classifications, for example Nature Reserves (Bredenkamp 1975, Coetzee 1974, Van Rooyen 1984), and formal syntaxonomy has wisely been avoided, as detailed local classifications could lead to the identification of a prolific number of different community types (Mueller-Dombois & Ellenberg 1974, Coetzee 1983). Mueller-Dombois & Ellenberg (1974) consider it useful to maintain an unsystematic status for vegetation communities where the emphasis is on intensive local vegetation studies.

However, a hierarchical, formal classification and syntaxonomy becomes desirable where the emphasis lies on a vegetation synthesis at a more extensive geographical scale (Coetzee 1983). A basis for formal syntaxonomical studies in southern Africa is that of Werger (1973), Van Der Meulen (1979), Coetzee (1983) and du Preez (1991). The present study aims at a synthesis of the grassland communities in the entire western Transvaal grassland, thus, it was decided to include a formal syntaxonomy where appropriate, in accordance with the Code of Phytosociological Nomenclature (Barkman *et al.* 1986).

Relevant phytosociological data of the western Transvaal Grassland Biome have been collected by Morris (1973), Van Wyk (1983), Bezuidenhout *et al.* (1988), Bredenkamp *et al.* (1989), Bredenkamp & Bezuidenhout (1990), Bezuidenhout & Bredenkamp (1990, 1991a, 1991b, 1991c), Bredenkamp *et al.* (*in prep.*), Bezuidenhout *et al.* (1993, *in press.*, *submitted*(a), *submitted*(b), *in prep.*(b), *in prep.*(c)). These data sets and resulting classifications provide the basis for a phytosociological and syntaxonomical synthesis of the western Transvaal grassland (Bezuidenhout *et al.* *in prep.*(a)).

Thus, the objectives of this study are:

(1) To identify, classify, describe and determine the location of the grassland plant communities and other vegetation types within the western Transvaal Grassland Biome.

(2) To compile a comprehensive synecological and syntaxonomical synthesis, in line with the Grassland Biome Project (Scheepers 1987), of the vegetation of the western Transvaal grassland.

The dissertation consists of articles, which have been published, or manuscripts, which have been submitted for publication, in various journals. In each of these contributions an account of the introduction, study area, methods, results, conclusions and references for that particular study are presented. Chapters on a comprehensive account of the study area, methods, conclusions and a list of references are also included. Some style anomaly and tedious repetition do occur between the different chapters but it can be ascribed to the difference in the layout and style of the various scientific journals. Page numbering is successive according to pages containing text, tables and figures. In each chapter the tables and figures are numbered as an entity except in the case of published articles which retain their original numbering. Each article or manuscript should be treated as an entity in itself.

Many wheel point data sets are available from many parts of the country, especially from the Grassland Biome area (Bredenkamp *et al*. 1991) and although no wheel point data are used in this study, the possible application of wheel point data in phytosociological classifications were tested. This report forms part of the Methods and Developments (Chapter 3). A procedure for the effective classification of large phytosociological data sets, and the combination of many data sets from various parts of the South African grasslands, is presented as a new development in Chapter 3.

Phytosociological data of the Lichtenburg area in the western Transvaal Grassland Biome have been collected by Morris (1973) but were not classified by Braun-Blanquet procedures. Thus, in order to include Morris' Lichtenburg data in the synthesis of the western Transvaal grassland, the data were reclassified by means of Braun-Blanquet procedures (Bezuidenhout *et al*. *in prep*.(b), *in prep*.(c)).

Parts of the Mooi River Catchment Area, a small area within the boundary of the western Transvaal grassland, was previously conducted for a M.Sc. thesis at the Potchefstroom University for CHE (Bezuidenhout 1988). Certain data sets from this study are included in the present study, as this data proved to be relevant for the phytosociological synthesis of the western Transvaal Grassland Biome. These data sets were reworked, extended and published, and results are included in Chapter 5.

1.2 References

ACOCKS, J.P.H. 1953. Veld Types of South Africa. 1st edn. *Mem. bot. Surv. S. Afr.* 28: 1 - 192.

ACOCKS, J.P.H. 1975. Veld Types of South Africa. 2nd edn. *Mem. bot. Surv. S. Afr.* 40: 1 - 128.

ACOCKS, J.P.H. 1988. Veld Types of South Africa. 3rd edn. *Mem. bot. Surv. S. Afr.* 57: 1 - 146.

ANON. 1987. Agriculture in South Africa. 2nd edn. Chris van Rensburg, Johannesburg.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of Phytosociological Nomenclature, 2nd edn. *Vegetatio* 67: 145 - 195.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* 18: 387 - 403.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991a. Plantegroeiklassifikasie van die A-landtipe van die Mooirivieropvanggebied, Transvaal. *S. Afr. Tydskr. Natuurwet. en Tegnol.* 10: 4 - 11.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991b. Die plantgemeenskappe van die Ba-landtipe in die Mooirivieropvanggebied, Transvaal. *S. Afr. Tydskr. Natuurwet. en Tegnol.* 10: 85 - 92.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991c. The vegetation of the Bc land type in the western Transvaal Grassland, South Africa. *Phytocoenologia* 19: 497 - 518.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydskr. Natuurwet. en Tegnol.* 7: 4 - 9.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. 1993. The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa. *S. Afr. J. Bot.* 59: 319 - 331.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *in press*. Syntaxonomy of the vegetation of the Fb land type in the western Transvaal Grassland, South Africa. *S. Afr. J. Bot.*

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted*(a). The vegetation syntaxa of the Ba land type in the western Transvaal Grassland, South Africa. *S. Afr. J. Bot.*

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted*(b). The vegetation of the western Transvaal dolomitic and chert grassland, South Africa. *S. Afr. J. Bot.*

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *in prep.*(a). Phytosociological Classes of the western Transvaal grassland, South Africa.

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep.*(b). A Braun-Blanquet reclassification of the *Cymbopogon-Themeda* Grassland in the Lichtenburg area, south-western Transvaal.

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep.*(c). A Braun-Blanquet reclassification of the Bankenveld grassland in the Lichtenburg area, south-western Transvaal.

BLOEM, K.J. 1988. 'n Plantsosiologiese studie van die Verlorenvaleinatuurreservaat, Transvaal. M.Sc. thesis, University of Pretoria, Pretoria.

BREDENKAMP, G.J. 1975. 'n Plantsosiologiese studie van die Suikerbosrand-natuurreservaat. M.Sc. thesis, University of Pretoria, Pretoria.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. 1990. The vegetation of the Faan Meintjes Nature Reserve, Transvaal. *S. Afr. J. Bot.* 56: 54 - 64.

BREDENKAMP, G.J., BEZUIDENHOUT, H., BOSCH, O.J.H. & JANSE VAN RENSBURG, F.P. 1991. A comparison of vegetation classifications from wheel point and total floristic data sets from a South African grassland. *Bot. Bull. Academia Sinica* 32: 187 - 195.

BREDENKAMP, G.J., BEZUIDENHOUT, H., NAUDE, C., JOUBERT, H. *in prep.* The vegetation of the Boskop Dam Nature Reserve, Potchefstroom.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom - Fochville - Parys area. *S. Afr. J. Bot.* 55: 199 - 206.

BREDENKAMP, G.J. & THERON, G.K. 1976. Vegetation units for management of the grasslands of the Suikerbosrand Nature Reserve. *S. Afr. J. Wild. Res.* 6: 113 - 122.

BREYTENBACH, P.J.J. 1991. Die fitososiologie van die Villiers-Grootvlei-omgewing. M.Sc. thesis, University of Pretoria, Pretoria.

COETZEE, B.J. 1974. A phytosociological classification of the vegetation of the Jack Scott Nature Reserve. *Bothalia* 11: 329 - 347.

COETZEE, B.J. 1983. Phytosociology, vegetation structure and landscapes of the Central District, Kruger National Park. *Dissertationes Botanicae* 69: 1 - 456.

COETZEE, J.P. 1993. Phytosociology of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area. M.Sc. thesis, University of Pretoria, Pretoria.

DEPARTMENT OF AGRICULTURE AND WATER SUPPLY. 1987. Landbou-ontwikkelingsprogram: Hoëveldstreek 1986. Directorate Agricultural Information, Government Printer, Pretoria.

DE WAAL, A. 1988. Tick Tick Tick .... *Publico* 8: 4 - 5.

DU PREEZ, P.J. 1991. A syntaxonomical and synecological study of the vegetation of the southern and eastern Orange Free State and related areas with special reference to Korannaberg. D.Sc. dissertation, University of the Orange Free State, Bloemfontein.

ECKHARDT, H.C. 1993. A synecological study of the vegetation of the north-eastern Orange Free State. M.Sc. thesis, University of Pretoria, Pretoria.

EDWARDS, D. 1972. Botanical survey and agriculture. *Proc. Grassl. Soc. sth. Afr.* 7: 15 - 19.

FULS, E.R. 1993. Vegetation ecology of the northern Orange Free State. Ph.D. dissertation, University of Pretoria, Pretoria.

HENDERSON, M., FOURIE, D.M.C., WELLS, M.J., HENDERSON, L. 1987. Declared weeds and alien invader plants in South Africa. Department of Agriculture and Water Supply. Government Printer, Pretoria.

KOOIJ, M.S. 1990. A phytosociological study of the north-western Orange Free State. M.Sc. thesis, University of Pretoria, Pretoria.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. bot. Surv. S. Afr.* 24: 1 - 105.

MATTHEWS, W.S. 1991. Phytosociology of the north-eastern Mountain sourveld. M.Sc. thesis, University of Pretoria, Pretoria.

MENTIS, M.T. & HUNTLEY, B.T. 1982. A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog. Rep.* 62: 1 - 29.

MORRIS, J.W. 1973. Automatic classification and ecological profiles of south-western Transvaal Highveld grassland. Ph.D. dissertation, University of Natal, Durban.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and Methods of vegetation Ecology. New York: Wiley.

MYBURGH, W.J. 1993. Die fitososiologie van die suurgrasveld in die Suidoos-Transvaalse Hoëveld. M.Sc. thesis, University of Pretoria, Pretoria.

RUTHERFORD, M.C. & WESTFALL, R.H. 1986. Biomes of Southern Africa - an objective categorization. *Mem. bot. Surv. S. Afr.* 54: 1 - 97.

SCHEEPERS, J.C. 1983. Progress with vegetation studies in South Africa. *Bothalia* 14: 683 - 690.

SCHEEPERS, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on the classification and mapping. *S. Afr. Ecosys. Prog. Occ. Rep. Series* 16: 1 - 31.

SIEGFRIED, W.R. 1989. Preservation of species in southern African nature reserves. *In* B.J. Huntley (ed.) Biotic diversity in southern Africa: Concepts and conservation. Oxford University Press, Cape Town.

SMIT, C.M. 1992. Phytosociology of the Newcastle-Memel-Chelmsford Dam area. M.Sc. thesis, University of Pretoria, Pretoria.

TURNER, B.J. 1989. A phytosociological study of the south-eastern Transvaal Highveld grasslands. M.Sc. thesis, University of Pretoria, Pretoria.

VAN DER MEULEN, F. 1979. Plant sociology of the western Transvaal Bushveld, South Africa: A syntaxonomic and synecological study. *Dissertationes Botanicae* 49: 1 - 192.

VAN ROOYEN, N. 1984. 'n Fenologiese studie van die plantegroei van die Roodeplaatdam-natuurreservaat. D.Sc. dissertation, University of Pretoria, Pretoria.

VAN ROOYEN, N., THERON, G.K. & GROBBELAAR, N. 1981. A floristic description and structural analysis of the plant communities of the Punda Milia-Pafuri-Wambiya area in the Kruger National Park, Republic of South Africa. 1. The hygrophilous communities. *Jl S. Afr. Bot.* 47: 213 - 246.

VAN WYK, S. 1983. 'n Plantekologiese studie van die Abe Bialey-natuurreservaat. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

WEATHER BUREAU. 1986. Climate of South Africa. Climate statistics up to 1984. *Weather Bureau Report* 40: 1 - 474.

WERGER, M.J.A. 1973. Phytosociology of the Upper Orange River Valley, South Africa. Ph.D. dissertation, University of Nijmegen, Nijmegen.

WERGER, M.J.A. & EDWARDS, D. 1976. Progress with vegetation studies in southern Africa. *Boissiera* 24: 625 - 632.

CHAPTER 2

STUDY AREA - PHYSICAL ENVIRONMENT

PAGE

2.1 Study area

The study area represents the north western part of the Highveld Region and is situated in the north western corner of the Grassland Biome (Figure 1). The study area is bounded by latitudes 25° 45′ and 27° 15′ south and longitudes 24° 45′ and 27° 45′ east. The core of the study area is represented by the 1 : 250 000 West-Rand map (Land Type Series 1979b). Parts of the Rustenburg, Vryburg and Christiana maps (1 : 250 000) are also included in this study area. Relatively big towns situated in the study area are Randfontein, Potchefstroom, Ventersdorp, Klerksdorp, Lichtenburg, Delareyville and Vryburg. The study area covers approximately 2.7 million hectares of which a large part has been ploughed, mainly for maize cultivation (Land Type Survey Staff 1984). Natural vegetation is mostly confined to shallow, rocky, non-arable soils. Unfortunately, this natural vegetation is often overgrazed by cattle and sheep.

2.2 Land types

According to the Land Type Survey Staff (1984) the definition of a land type is as follows: "a land type denotes an area that can be shown at 1 : 250 000 scale and that displays a marked degree of uniformity with respect to terrain form, soil pattern and climate". Broad soil patterns were chosen at the beginning of the land type survey for the purpose of constructing a common legend for the land type maps (Land Type Survey Staff 1984). This legend gives the user the immediate knowledge as to what soil forms can be expected in which area. Therefore land types give the researcher the three significant abiotic factors which are closely related to vegetation patterns.

Other researchers (*inter alia* Bredenkamp & Theron 1978, 1980; Bezuidenhout *et al.* 1988) have established that geology, soil and climate are important abiotic factors which correlate well with vegetation communities. Therefore the land type plays an important role in the first stratification of the study area. The stratification of the area into land types and the compilation of a separate plant sociological table for each land type, result in the successful identification of ecologically sound plant communities (Bezuidenhout 1988). The Land Type Survey Staff

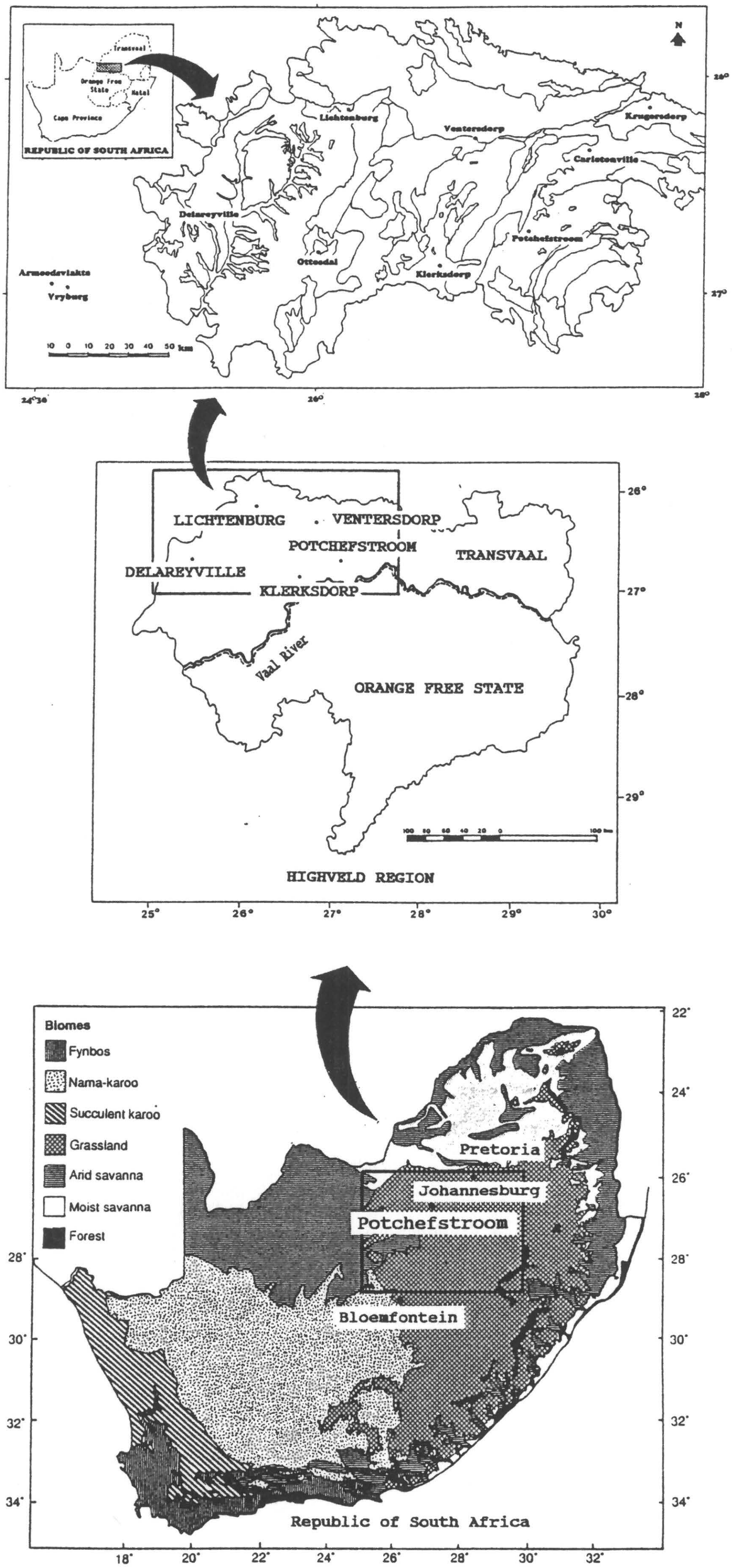


Figure 1: The location of the study area in relation to the Highveld Region and the Grassland Biome of South Africa.

(1984) separates the different land types with characters A, B, C etc. Each of these characters can be subdivided, whereafter each subdivision is named with a small character i.e. a, b, c etc. Sometimes the same land type can occur more than once on the same map or even on more than one map. In such an instance, a number is allocated to indicate that the specific land type is e.g. the thirty-ninth of the A land type. However, if the same land type occurs on more than one map it is distinguished by using yet again a character (a,b,c etc.) for example Fa14a. For the purpose of this study, only the first two characters (Fa) are used. Within each of these land types, the dominant soil profile was described and analysed according to Land Type Survey Staff (1984).

2.3 Soils

Soil forms and series as well as technical terms used are according to MacVicar *et al.*(1977). Soils in the study area are heterogeneous and vary from sandy to clayey, due to the great variation in parent material.

2.3.1 A land type

Characteristic of this map unit is yellow and red apedal soils without water tables and which are freely drained. In the Ab land type the yellow soils occupy less than 10 % of the area whilst dystrophic and/or mesotrophic soils occupy a larger area than high base status red-yellow apedal soils. Soils of the Ae land type differ from the Ab land type in that it is deeper than 300 mm and no dunes are present. However, both of these units have red apedal soils. The dominant soil form is Hutton (90% of the land type) and less than 6 % of the soils of the A land type are Glenrosa- and Mispah soil forms (Land Type Survey Staff 1984).

2.3.2 B land type

This unit has a plinthic catena but the upland duplex and margalitic soils are rare. A large part of the study area is covered with B land type soils (Figure 2). Plintic soils cover more than 10 % whilst upland duplex and margalitic soils are absent or occupy less than 10 % of the area. The following information can

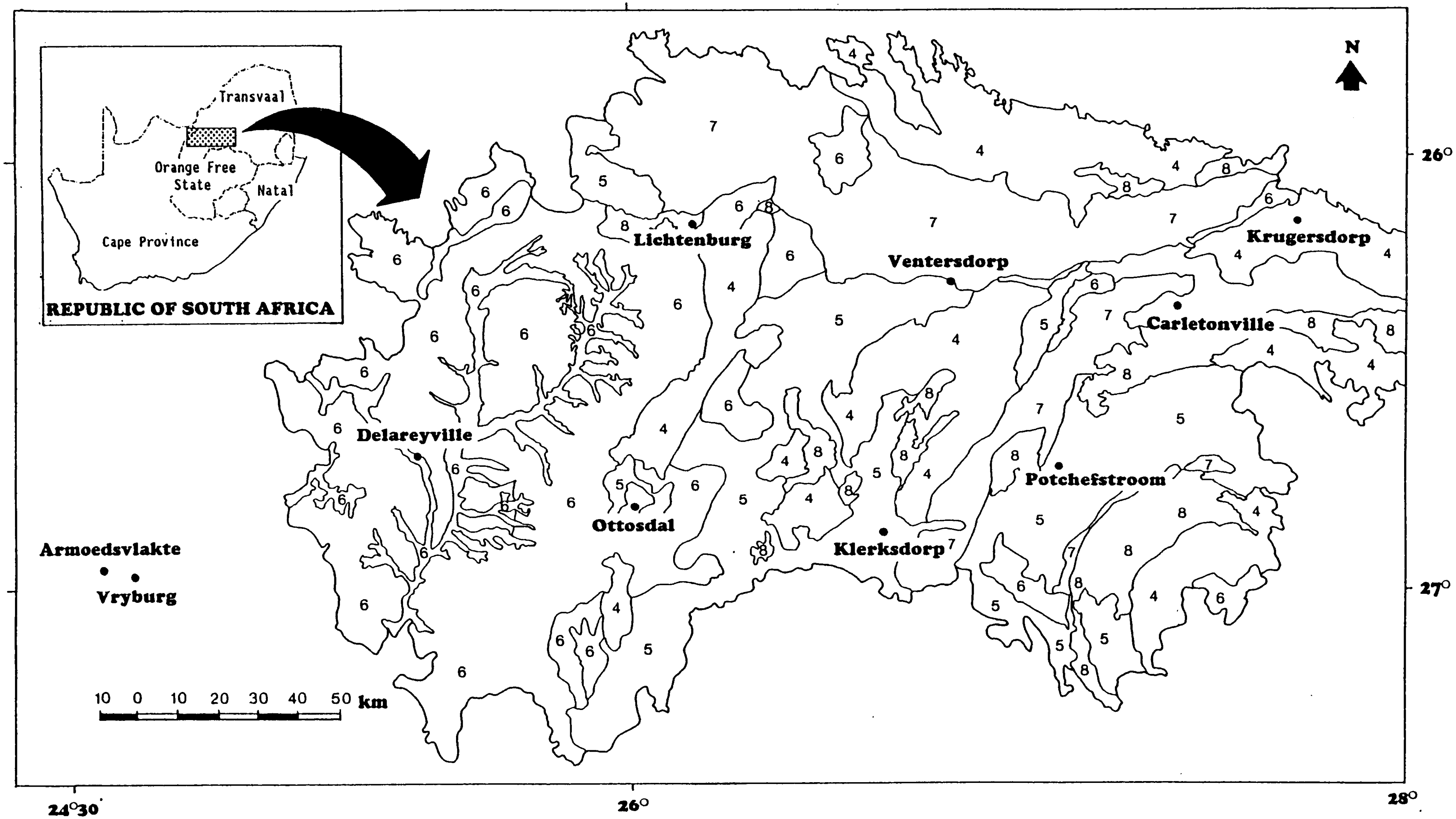


Figure 2: The distribution of the different land types in the western Transvaal grassland, South Africa ((4) Ba land type, (5) Bc land type, (6) Bd and Ea land types, (7) Fa land type and (8) Fb land type)(Adapted from Land Type Series 1979a & b).

serve to distinguish between the Ba, Bc and Bd land types. Soils of the Ba land type, are red and/or yellow apedal, dystrophic and/or mesotrophic predominate over red and/or yellow apedal soils that are eutrophic, and in which red soils occupy more than a third of the area. The dominant soil form is Hutton (30 % of the Ba land type) with a variety of other soil forms present in the land type. The same rule, with appropriate adaptations applies to units Bc (eutrophic, red soils widespread) and Bd (eutrophic, red soils not widespread) (Land Type Survey Staff 1984). In the Bc land type both Hutton and Mispah soil forms are dominant (21 % of the land type) while in the Bd land type the yellow soils such as Avalon and/or Pinedene (23 % of the land type) and sometimes the Clovelly soil form are dominant in this land type.

2.3.3 E land type

This unit indicates land with high base status, dark coloured and/or red soils, usually clayey, associated with basic parent materials. More than a half of the E land type is covered by soil forms with vertic, melanic and red structured diagnostic horizons. The dominant soil form is the Rensburg form (60 % of the land type) with the subdominant Inhoek soil form in this land type (Land Type Survey Staff 1984).

The E land type soils has dark and/or red coloured soils associated with a clayey texture. This map unit is also associated with land with a high base status on basic parent materials.

2.3.4 F land type

This group forming the F land type is intended to accommodate pedologically young landscapes that are not predominantly alluvial or aeolian and in which the dominant soil forming processes have been rock weathering, the formation of orthic topsoil horizons and, generally, clay illuviation, typically giving rise to lithocutanic horizons. The soil forms which epitomise these processes are Glenrosa and Mispah. Fa land type refers to land in which lime in the soil is not encountered regularly in any part of the landscape. The dominant soil forms are Glenrosa and Mispah (50 % of the land type) while the Hutton soil form (39 % of the land type) is also present. Fb land type indicates land where lime occurs regularly (in small quantities) in one or more valley bottom soils. The dominant soil forms are Glenrosa (25 % of the land type) and Mispah (24 % of the land type) with rocks (20 % of the land type) also prominent in this land type (Land Type Survey Staff 1984).

2.4 Geology

The relatively heterogeneous geology are represented by the Witwatersrand and Ventersdorp Supergroups and the Transvaal Sequence with individual isolated old Archaic granites and Karoo Sequence. The lithostratigraphy of the study area is according to the handbook published by the Geological Survey (SACS 1980). A geology map for the 2626 West-Rand is available but the 2624 Vryburg map was not available at the time of preparing this report (Geological Survey 1986). Essentially, the following geological systems are represented in the western Transvaal.

2.4.1 Archaic granite

This is the oldest rock type in the study area but only small isolated outcrops are present. In the well known centre of the Vredefort Dome near Parys and also in the south-western areas from Ventersdorp to Hartebeesfontein as well as south-west from Coligny to Ottosdal, small outcrops of the archaic granite can be found (Nel 1935; Geological Survey 1986).

2.4.2 Witwatersrand Supergroup

The foldings and faultings of this Supergroup have developed over a long time. According to Nel (1935) the Witwatersrand Supergroup contains gold-bearing conglomerate. This Supergroup is a thick succession of shales, quartzite, silica-rich ironstone and conglomerate which usually leed to an undulating landscape. Near Randfontein the Witwatersrand Supergroup occurs in the study area as well as in the Vredefort Dome where it forms the outer/external layer. North of Klerksdorp an outcrop of this Supergroup occurs which stretches from the north-west towards Ventersdorp. Isolated outcrops appear at Hartebeesfontein and Ottosdal (Geological Survey 1986). The Witwatersrand Supergroup comprises a succession of arenaceous and argillaceous sediments with virtually no calcareous rocks (SACS 1980). The Fb land type correlates well with the Witwatersrand Supergroup (Land Type Survey Staff 1984).

2.4.3 Ventersdorp Supergroup

The Ventersdorp Supergroup is strongly correlated with the distribution of the Witwatersrand Supergroup. Both the Klipriviersberg- and Platberg Groups occur in the study area. The Ventersdorp Supergroup varies considerably in thickness as it comprises successions of andesitic lava, conglomerates and quartzite sediments (Viljoen 1987). In the central and western parts of the study area it is sometimes exposed as hills. Occasionally this Supergroup is overlain by younger aeolian sands and limestone (Truswell 1977). The Ba land type is mostly confined to this Supergroup (Land Type Survey Staff 1984).

2.4.4 Transvaal Sequence

The Transvaal Sequence fills an east-west elongated basin in the south-central part of Transvaal and includes the corresponding succession in the Potchefstroom synclinorium. Three groups based on lithological differences have been established (SACS 1980).

2.4.4.1 The Wolkberg Group

The Black Reef Quartzite Formation consists of quartzite, with lenses of grit and conglomerate, and shale. This formation separates the Chuniespoort Group and stretches in an east-westerly line. It has no influence on the vegetation distribution and is a relatively thin layer that outcrops in the centre of the study area (Geological Survey 1986).

2.4.4.2 The Chuniespoort Group

Dolomite and chert of the Chuniespoort Group (Malmani Subgroup) are the main rock types which underly the north-eastern part of the study area and stretches in an east-westerly direction. East of Ventersdorp it splits, with one leg extending in a south-westerly direction passing north of Potchefstroom and continuing to the south-west to Stilfontein and Orkney. The other leg continues in an east-westerly direction just north of Lichtenburg where it turns to the north-west. A small outcrop of this Group is present on the outer layer of the Vredefort Dome (Geological Survey 1986). This Group is strongly related to the Fa land type (Land Type Survey Staff 1984).

According to Von Backström *et al.* (1953) the dolomite, which is also called "Olifantklip", has mostly a fine-grained texture, a blue-grey colour and a wrinkled black weathered surface. When exposed to water it dissolves, resulting in the formation of sinkholes. The chert however is much more resistant to weathering and depending on the chert content the dolomite may dissolve or not (Molengraaff 1904). If it does dissolve it forms large underground water reservoirs (Barker 1985). The flat or slightly undulating plains of the dolomite are dissected by prominent chert ridges. Old sinkholes have been filled up with aeolian sand (Harmse 1967).

2.4.4.3 The Pretoria Group

The Pretoria Group overlies the Chuniespoort Group on the northern parts of the study area while extending from the Chuniespoort Group to the same Chuniespoort Group on the outer layer of the Vredefort Dome in the south-eastern parts (Geological Survey 1986). The Timeball Hill, Hekpoort, Daspoort, Silverton, Magaliesberg en Strubenskop Formations from the Pretoria Group are situated in the study area. The Pretoria Group consists mainly of quartzite, shales and prominent volcanic elements in the Hekpoort Andesite Formation and diabaas sills (SACS 1980). The Bc land type associates well with the Pretoria Group (Land Type Survey Staff 1984).

2.4.5 The Karoo Sequence and recent deposits

The Karoo Sequence (Ecca Group), consisting of Ecca sandstone and -shale, rarely occurs in the study area. This Sequence is mostly confined to the south-eastern parts of the study area (Truswell 1977). The Ecca sandstone and -shale are soft and weather easily. Aeolian sands overlying the existing rock could be found in the western parts of the study area (Du Toit 1954). On the economic side alluvium along the rivers and their tributaries could be diamond-bearing, which is proven by ruins and debris of old diamond diggings along the Harts- and Mooi Rivers (Von Backström *et al.* 1953).

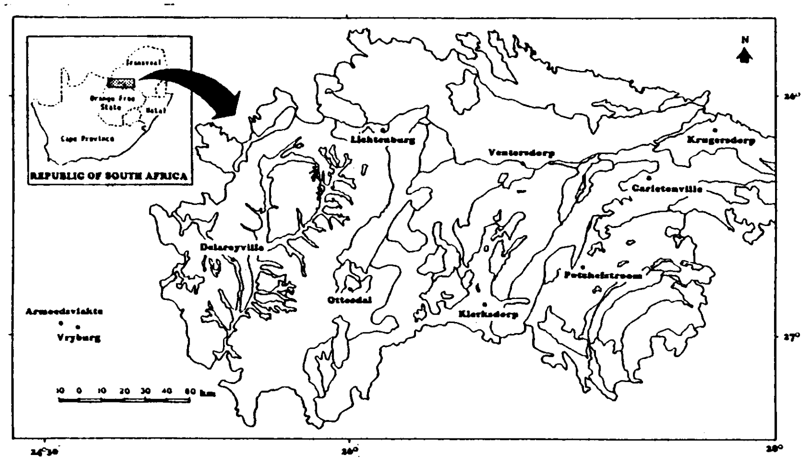
2.5 Physiography

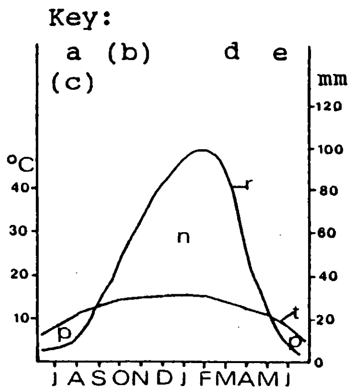
According to Kruger (1983) the study area forms a part of the Central Interior Plain and the landscape varies from a flat to undulating plain. In the eastern and central parts of the study area the undulating landscape sometimes get dissected by quartzite and chert ridges and occasionally lava hills of the Ventersdorp Supergroup. In the western parts, the relatively flat landscape are interrupted by lava hills and occasionally chert and quartzite ridges. The Vredefort Dome in the south-southeastern part of the study area is dissected by ridges as well as the Vaal River. The north-eastern parts of the study area differs in altitude from 1 371 m up to 1 670 m above sea-level, while the south-western parts differ between 1 200 m and 1 500 m above sea-level.

To the west of the study area large pans, for example Barberspan and Leeuwpan, are prominent characteristics. Apart from the Vaal River which partially forms the southern border of the study area, the Mooi- and Harts Rivers, as well as Skoon- and Bamboesspruits also form a part of the drainage of the study area (Land Type Series 1979a; Land Type Series 1979b).

2.6 Climate

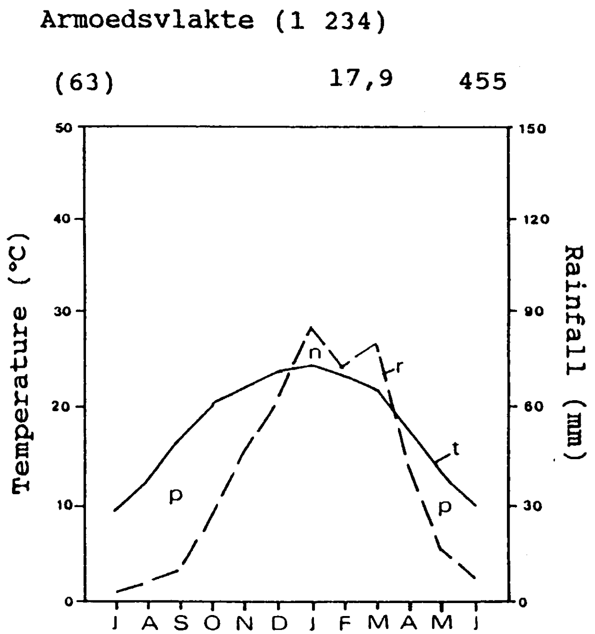
Climate plays an important role in the land- and soil-forming processes (Strahler 1975). It also has a major influence on the distribution of vegetation (Acocks 1988). According to Schulze (Weather Bureau 1965) South Africa can be divided into 15 climatic zones. The study area is classified into the Highveld area (H-area) with a precarious, warm, temperate to semi-dry climate in a summer rainfall region. Marked climatic contrasts between summer and winter are common in the area with extremes like droughts, flooding, hail, rare snow and frost regularly occurring (Weather Bureau 1965).

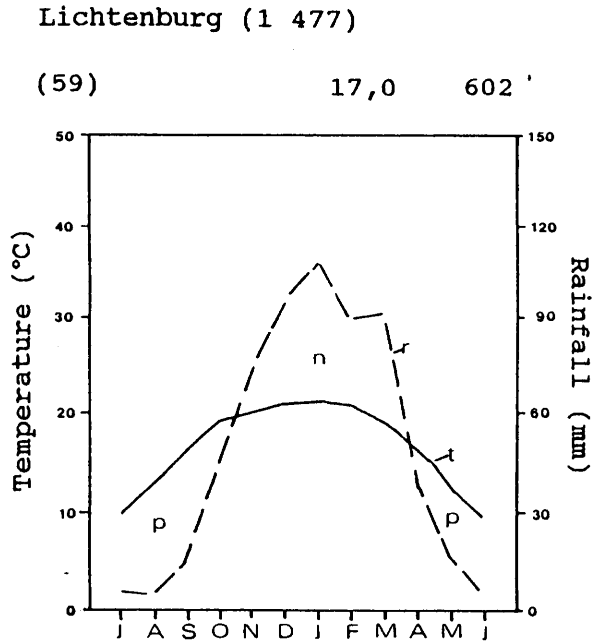




Key:

a - name of town
(b) - altitude
(c) - period with data
d - mean annual temperature (°C)
e - mean annual rainfall (mm)
p - dry period
n - wet period
r - mean monthly rainfall (mm)
t - mean monthly temperature (°C)





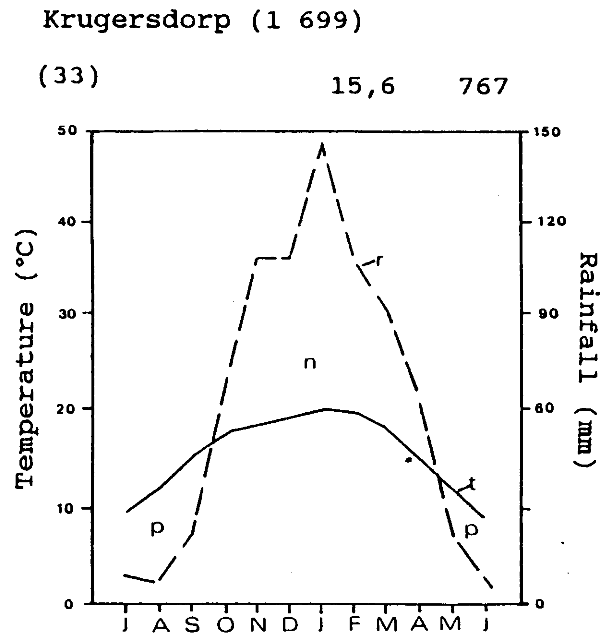


Figure 3: Climate diagrams for selected towns in the study area.

Soil moisture is derived from precipitation mainly in the form of rainfall, mist (and fog), dew, hail and snow (Deall *et al.* 1989). The rainfall is unpredictable and varies from an average of 450 mm per year in the west to 770 mm per year in the east of the study area (Figure 3). This considerable difference in rainfall occurs from east to west over the study area while there is not such a marked contrast in the south-northerly direction (Department of Agriculture and Water Supply 1987). Approximately 80 % of the annual rainfall occurs during October to March (mainly as thunderstorms in the afternoon). Rain during winter months is exceptional. Frost can occur as early as 20 April whilst the latest frosts of the season has been recorded as late as 30 September. Annual frost period can therefore vary between 6 till 71 days (Department of Agriculture and Water Supply 1987).

Topography has a definite influence on the temperature of the study area, especially along the rivers (Barker 1985). From August to January the mean daily maximum temperature can increase to an average of 32,1 °C in January. In winter the coldest month is July with the mean daily minimum of -2,2 °C (Department of Agriculture and Water Supply 1987). Although there is no big temperature difference between the western and eastern parts of the study area, the western parts tend to be warmer and drier than the central and eastern parts of the study area (Figure 3)(Weather Bureau 1986).

According to Barker (1985) the prevailing wind for the most of the year is a north-northwest to north-easterly wind. The wind that provides the rain is an easterly wind coming from the Indian Ocean. August and September are the windiest months while very little wind blows during June and July (Weather Bureau 1960).

2.7 Conclusion

A basic environmental display of the study area is necessary for a phytosociological classification. The weathering of the different rocks(geology), together with the amount of rainfall, lead to a diversity in topographical positions, soil texture, soil depth and percentage stones or rocks on the soil surface. These attributes are largely responsible for determining plant communities distributions in the western Transvaal (cf.

Bezuidenhout *et al. in prep.*).

Acknowledgement

Mrs. D. Bezuidenhout is thanked for assistance in the preparation of the manuscript. Mrs. J. Schaap assist with the figures.

2.8 References

ACOCKS, J.P.H. 1988. Veld types of South Africa. 3rd. edn. *Mem. bot. Surv. S. Afr.* 57: 1 - 146.

BARKER, C.H. 1985. 'n Geomorfologiese studie van die Mooirivieropvanggebied. M.Sc. thesis, Potchefstroom Univ. for C.H.E., Potchefstroom.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom Univ. for C.H.E., Potchefstroom.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel, noordwes van Parys. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 7: 4 - 9.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *in prep.* Phytosociological Classes of the western Transvaal grassland, South Africa.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve I. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 - 329.

BREDENKAMP, G.J. & THERON, G.K. 1980. A synecological account of the Suikerbosrand Nature Reserve II. The phytosociology of the Ventersdorp geological system. *Bothalia* 13: 199 - 216.

DEALL, G.B., SCHEEPERS, J.C. & SCHUTZ, C.J. 1989. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 1. Physical environment. *Bothalia* 19 : 53 - 67.

DEPARTMENT OF AGRICULTURE AND WATER SUPPLY. 1987. Landbou-ontwikkelingsprogram: Hoëveldstreek 1986. Government Printer, Pretoria.

DU TOIT, A.C. 1954. The geology of South Africa. 3rd edn. Oliver & Boyd, Edinburgh.

EDWARDS, D. 1979. The role of plant ecology in the development of South Africa. *Bothalia* 12: 748 - 751.

GEOLOGICAL SURVEY 1986. Geological map, 1:250 000, 2626 West Rand. Government Printer, Pretoria.

HARMSE, H.J. VON M. 1967. Soil genesis in the Highveld Region, South Africa. D.Sc. dissertation, University of Utrecht, Utrecht.

KRUGER, G.P. 1983. Terrain morphological map of southern Africa. Soil and Irrigation Research Institute, Department of Agriculture. Government Printer, Pretoria.

LAND TYPE SERIES. 1979a. 2526 Rustenburg. Prepared by the Soil and Irrigation Research Institute, Pretoria. 1 : 250 000. Government Printer, Pretoria.

LAND TYPE SERIES. 1979b. 2626 West-Rand. Prepared by the Soil and Irrigation Research Institute, Pretoria. 1 : 250 000. Government Printer, Pretoria.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. agric. nat. resour. S. Afr.* 4: 1 - 441.

MACVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H. & HARMSE, H.J.VON M. 1977. Soil classification - A binomial system for South Africa. Department Agricultural-technical services, Pretoria.

MOLENGRAAFF, G.A.F. 1904. Geology of the Transvaal. Essen & Perkins, Johannesburg.

NEL, L.T. 1935. The geology of the Klerksdorp-Ventersdorp area. Geological Survey. Government Printer. Pretoria.

SACS. 1980. South African Committee for Stratigraphy. Stratigraphy of South Africa. Part 1 (comp. L.E. Kent). Lithostratigraphy of Republic of South Africa, South West Africa/Namibia, and the Republics of Botswana, Transkei and Venda. Dept. Mineral and Energy Affairs, Pretoria.

STRAHLER, A.N. 1975. Physical geography. 4th edn. John Wiley and Sons, New York.

TRUSWELL, J.F. 1977. Geological Evolution of South Africa. Purnell, Cape Town.

VILJOEN, J.N.J. 1987. 'n Pedologiese ondersoek van grond geassosieer met gesteentes van die Supergroep Ventersdorp in die Wes-Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

VON BACKSTRöM, J.W., SCHUMANN, F.W., LE ROUX, H.D., KENT, L.E. & DU TOIT, A.L. 1953. The geology of the area around Lichtenburg. Geological Survey. Government Printer, Pretoria.

WEATHER BUREAU 1960. Climate of South Africa. Part 6, Surface winds. *WB* 26. Government Printer, Pretoria.

WEATHER BUREAU 1965. Climate of South Africa. Part 8, General survey. *WB* 28. Government Printer, Pretoria.

WEATHER BUREAU 1986. Climate of South Africa, climate statistics up to 1984. *WB* 40. Government Printer, Pretoria.

CHAPTER 3

METHODS

AND

DEVELOPMENTS

3.1 Methods

This dissertation comprises of research reports from different areas within the entire study area and some of them with different research purposes. Consequently the specific method which was used for the specific area or research purpose is presented in each of the different contributions (Chapters). However, the general methods applied in this study is described here.

3.1.1 Approach

The methods used for this study were, to a certain extent, determined by the scale (1 : 250 000) and also the availability of natural vegetation in this predominantly exploited area. The main objective for this study was to identify, classify, describe and determine the location of the grassland plant communities and other vegetation types within the western Transvaal Grassland Biome. In order to create an ecological classification, the Zürich-Montpellier method was used (Braun-Blanquet 1932 and Werger 1973). Amongst others this Braun-Blanquet method was also successfully used in the Grassland Biome by Turner (1989), Kooij (1990), Du Preez (1991), Breytenbach (1991), Matthews (1991), Coetzee (1993), Eckhardt (1993), Myburgh (1993) and Fuls (1993). Werger (1973) stated that this method satisfies the three basic essential requirements of a vegetation ecology study namely: (i) it is scientifically sound, (ii) it fulfils the necessity of classification at an appropriate level and (iii) it is the most efficient and versatile amongst comparable approaches.

During the summer of 1985 a reconnaissance survey of the entire study area preceded the in depth study. Unknown plant species were collected for identification at either the Herbarium of the Department of Botany (Potchefstroom University for Christian Higher Education) or the National Herbarium of the National Botanical Institute in Pretoria. During the summer months (beginning of January to the end of April) of 1986 - 1989 plant surveys were carried out.

3.1.2 Distribution, number and size of sample plots

Land types were used as a first stratification unit in the investigation of the western Transvaal vegetation, and subsequently the terrain types were used for a finer stratification. Amongst others this stratification procedure was also used amongst others by Kooij (1990), Coetzee (1993) and Eckhardt (1993). The term land type is used in a land-use classification system describing a homogeneous terrain with regard to soil pattern and climate while a terrain unit is any part of the land surface with homogeneous form and slope (Land Type Survey Staff 1984). Presently the land types and terrain units are used for farm planning and management (Department of Agriculture and Water Supply 1987). In the phytosociological study of the Mooi River Catchment area, this procedure and the compilation of separate plant sociological tables for each land type have resulted in the successful identification of ecologically sound plant communities (Bezuidenhout 1988).

The sample plots were randomly allocated to the land types and terrain units *pro-rata* on an area size basis. The exact position of the sample plots were subjectively positioned in such a way that it adequately represented the vegetation concerned. Although the subjective approach is often criticised, this strategy ensured that a representative sample of the variation is obtained, which is also statistically acceptable (Werger 1973). This strategy is important where the number of samples is strictly limited (Morris 1973), as was the case in this study area. According to Bredenkamp (1982) the number of sample plots are determined by many factors. However, the final result should be a reflection of the total variation of the vegetation (Bredenkamp 1982). A total of 622 sample plots were used in the different land types, Faan Meintjes Nature Reserve and the Vredefort Dome. The relatively low number of sample plots are ascribed to the fact that 97.3 % of the land is available for cultivation. The normally square plot size was fixed on 16 m^2 for the grassland vegetation and 100 m^2 for the woody vegetation (Bredenkamp & Theron 1978 and Van Wyk 1983).

3.1.3 Sampling method

The widely used, for South Africa, Braun-Blanquet sampling method was applied (Bredenkamp 1982). This was done in order to make data as well as results of this study comparable to other studies in the region and especially in the Grassland Biome.

(i) Floristic analysis

All plant species present in the sample plot were recorded and a cover-abundance value was estimated for each of these species according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974).

r - one or few individuals (rare) with less than 1 % cover of total sample plot area;
\+ - occasional and less than 1 % of total sample plot area;
1 - abundant and with very low cover, or less abundant but with higher cover, 1 - 5 % cover of total sample plot area;
2 - abundant with > 5 - 25 % cover of total sample plot area, irrespective of the number of individuals;
3 - > 25 % - 50 % cover of total sample plot area, irrespective of the number of individuals;
4 - > 50 % - 75 % cover of total sample plot area, irrespective of the number of individuals;
5 - > 75 % cover of total sample plot area, irrespective of the number of individuals.

Taxa names conform to those of Gibbs Russell *et al*. (1985, 1987) and to Arnold & De Wet (1993).

(ii) Physiognomical analysis

Height and canopy cover for the tree, shrub and herbaceous layers were additionally recorded in each sample plot, and average values were calculated for each plant community. Grasses and other forbs, sedges and herbs are included in the herbaceous layer.

(iii) Habitat analysis

According to Daubenmire (1968) as well as Gauch (1982) the distribution of the plant communities are closely related to environmental conditions. Therefore it is inevitable that certain environmental information, such as rock type (geology), terrain type (topographical position) and soil type as well as soil depth and an estimation of rockiness of the soil surface are noted.

(a) Geology

The rock type that occurs in the sample plots was, as far as possible, identified but in the case of no outcrops in the nearby vicinity, the geological map (Geological Survey 1986) and various descriptions of the geology (Du Toit 1954, Nel 1935, SACS 1980 & Viljoen 1987) were used.

(b) Topographical position

The topographical positions, adapted from the Land Type Survey Staff (1984), were distinguished in each of the separate land types. For a more detailed description of the topographical positions as well as a sketch of these positions, refer to the different contributions in chapters four and five.

(c) Soil

The soil nomenclature follows the classification of MacVicar *et al.* (1977). By using a soil auger the soil depth as well as soil type were determined. The clay content was determined by the "feel-ribbon method" (Foth *et al.* 1978) and was expressed as a percentage.

(d) Estimation of rockiness of the soil surface

An estimation of the rockiness of the soil surface was expressed in percentage rocks or stones covering the total sample plot.

(e) General observations

Other observations which were noted include the extent of erosion, utilization and management practices.

3.1.4 Data processing

Although the Braun-Blanquet method is one of the most significant tools in the study of vegetation, certain new aids in this study were designed for more efficient and objective ways of classifying data sets.

The TWINSPAN classification algorithm (Hill 1979a) was used as a first analysis for the floristic data. Refinement of the TWINSPAN classification was then done by applying Braun-Blanquet procedures. This speeds up the whole classification procedure resulting in a more objective and reliable table. An article on this subject is presented in this chapter under developments (3.2.1) (Bredenkamp *et al.* 1991). These procedures were successfully used by various researchers such as Kooij (1990), Du Preez (1991), Matthews (1991) and Fuls (1993).

Efficient handling of very large data sets were problematic and a new procedure was developed. This procedure is also discussed in this chapter in the form of a manuscript (3.2.2) (Bredenkamp & Bezuidenhout *in prep.*).

An ordination technique, DECORANA (Hill 1979b), was applied to most of the floristic data to illustrate floristic relationships between plant communities to detect possible gradients in and between communities and to detect possible habitat gradients associated with vegetation gradients.

3.1.5 Nomenclature

Where new syntaxa are described and formal syntaxonomy is applied to the classification, it is in accordance to the Code of Phytosociological Nomenclature (Barkman *et al.* 1986).

3.1.6 **References**

ARNOLD, T.H. & DE WET, B.C. 1993. Plants of southern Africa: names and distribution. *Mem. bot. Surv. S. Afr.* 62: 1 - 825.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of Phytosociological Nomenclature, 2nd edn. *Vegetatio* 67: 145 - 195.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BRAUN-BLANQUET, J. 1932. Plant sociology. Transl. by Fuller, G.D. & Conard, H.S. McGraw-Hill, New York.

BREDENKAMP, G.J. 1982. A plant ecological study of the Manyeleti Game Reserve. D.Sc. dissertation, University of Pretoria, Pretoria.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. *in prep.* A proposed procedure for the analysis of large data sets in the classification of South African Grasslands.

BREDENKAMP, G.J., BEZUIDENHOUT, H., BOSCH, O.J.H. & JANSE VAN RENSBURG, F.P. 1991. A comparison of vegetation classification from wheel point and total floristic data sets from a South African grassland. *Bot. Bull. Academia Sinica* 32: 187 - 195.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve I. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 - 329.

BREYTENBACH, P.J.J. 1991. Die fitososiologie van die Villiers-Grootvlei-omgewing. M.Sc. thesis, University of Pretoria, Pretoria.

COETZEE, J.P. 1993. Phytosociology of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area. M.Sc. thesis, University of Pretoria, Pretoria.

DAUBENMIRE, R. 1968. Plant Communities. A textbook of plant synecology. Harper & Row, New York.

DEPARTMENT OF AGRICULTURE AND WATER SUPPLY. 1987. Landbou-ontwikkelingsprogram: Hoëveldstreek 1986. Directorate Agricultural Information, Government Printer, Pretoria.

DU PREEZ, P.J. 1991. A syntaxonomical and synecological study of the vegetation of the southern and eastern Orange Free State and related areas with special reference to Korannaberg. D.Sc. dissertation. University of the Orange Free State, Bloemfontein.

DU TOIT, A.C. 1954. The geology of South Africa. Oliver & Boyd, Edinburgh.

ECKHARDT, H.C. 1993. A synecological study of the vegetation of the north-eastern Orange Free State. M.Sc. thesis. University of Pretoria, Pretoria.

FOTH, H.D., WITHEE, L.V., JACOBS, H.S. & THIEN, S.J. 1978. Laboratory manual for introductory: SOIL SCIENCE. 4th edn. WM.C.Brown Company Publishers, Dubuque, Iowa.

FULS, E.R. 1993. Vegetation ecology of the northern Orange Free State. Ph.D. dissertation, University of Pretoria, Pretoria.

GAUCH, H.G. 1982. Multivariate analysis in community ecology. Cambridge University Press, New York.

GEOLOGICAL SURVEY. 1986. Geological map, 1:250 000, 2626 West Rand. Government Printer, Pretoria.

GIBBS RUSSELL, G.E., REID, C., VAN ROOY, J. & SMOOK, L. 1985. List of species of southern African plants. 2nd edn. Part 1. *Mem. bot. Surv. S. Afr.* 51: 1 - 152.

GIBBS RUSSELL, G.E., WELMAN, W.G., RETIEF, E., IMMELMAN, K.L., GERMISHUIZEN, G., PIENAAR, B.J., VAN WYK, M. & NICHOLAS, A. 1987. List of species of southern African plants. 2nd edn. Part 2. *Mem. bot. Surv. S. Afr.* 56: 1 - 270.

HILL, M.O. 1979a. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

HILL, M.O. 1979b. DECORANA - A Fortran program for detrended correspondence analysis and reciprocal averaging. Cornell University, New York.

KOOIJ, M.S. 1990. A phytosociological study of the north-western Orange Free State. M.Sc. thesis, University of Pretoria, Pretoria.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. agric. nat. Resour. S. Afr.* 4: 1 - 441.

MACVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H. & HARMSE, H.J. VON M. 1977. Soil classification - A binomial system for South Africa. Department of Agriculture and Technical Services, Pretoria.

MATTHEWS, W.S. 1991. Phytosociology of the north-eastern Mountain sourveld. M.Sc. thesis, University of Pretoria, Pretoria.

MORRIS, J.W. 1973. Automatic classification and ecological profiles of south-western Transvaal Highveld grassland. Ph.D. dissertation, University of Natal, Durban.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

MYBURGH, W.J. 1993. Die fitososiologie van die suurgrasveld in die Suidoos-Transvaalse Hoëveld. M.Sc. thesis, University of Pretoria, Pretoria.

NEL, L.T. 1935. The geology of the Klerksdorp-Ventersdorp area. Geological Survey. Government Printer, Pretoria.

SACS. 1980. Stratigraphy of South Africa. Part 1 (comp. L.E. Kent). Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia, and the Republics of Botswana, Transkei and Venda. Dept. Mineral and Energy Affairs, Pretoria.

TURNER, B.J. 1989. A phytosociological study of the south-eastern Transvaal Highveld grasslands. M.Sc. thesis, University of Pretoria, Pretoria.

VAN WYK, S. 1983. 'n Plantekologiese studie van die Abe Bialey-natuurreservaat. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

VILJOEN, J.N.J. 1987. 'n Pedologiese ondersoek van grond geassosieer met gesteentes van die Supergroep Ventersdorp in die Wes-Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

WERGER, M.J.A. 1973. Phytosociology of the Upper Orange River Valley, South Africa. Ph.D. dissertation, University of Nijmegen, Nijmegen.

3.2 Developments

3.2.1 A comparison of vegetation classifications from wheel point and total floristic data sets from a South African grassland.

Page

* Published: *Botanical Bulletin of Academia Sinica* 32: 187 - 195.

Bot. Bull. Academia Sinica (1991) **32:** 187-195

A comparison of vegetation classifications from wheel point and total floristic data sets from a South African grassland

G. J. Bredenkamp[1,*], H. Bezuidenhout[2], O. J. H. Bosch[3] and F. P. Janse van Rensburg[4]

[1]*Department of Botany, University of Pretoria, Pretoria, 0002, South Africa*
[2]*Grassland Research Centre, Private Bag X05, Lynn East, 0039, South Africa*
[3]*Department of Botany, Potchefstroom University for CHE, Potchefstroom, 2520, South Africa*
[4]*Department of Agriculture (Highveld Region), Private Bag X804, Potchefstroom, 2520, South Africa*

(*Received September 19, 1990; Accepted April 10, 1991*)

Abstract. Vegetation classes obtained from Two-way Indicator Species Analysis (TWINSPAN) and Braun-Blanquet Analysis of a semi-quantitative, total floristic data set and a quantitative wheel point data set on grass species only, from the same sample plots, are compared. The Braun-Blanquet classification of the total floristic data set is considered as the norm to which all other classifications are compared. The Braun-Blanquet classification of wheel point data corresponded 67.53% to the basic classification. The TWINSPAN classifications of the total floristic data set and the wheel point data set corresponded 79.22% and 54.55% respectively, to the basic classification. Chi-square tests indicate that all the classifications are significantly correlated to the basic Braun-Blanquet classification.

Key words: Braun-Blanquet technique; Classification; Comparison; Total floristic composition; TWINSPAN; Wheel point data.

Introduction

For many years agricultural researchers in South Africa have used wheel point data (Tidmarsh and Havenga, 1955) to classify and describe vegetation or to determine grazing potential (Danckwerts, 1982; Bosch and Janse van Rensburg, 1987; Fourie *et al.*, 1987). Many wheel point data sets are therefore available from many parts of the country, especially from the grassland biome area.

Recently a vegetation classification and mapping programme was initiated within the Southern African grassland biome (Mentis and Huntley, 1982; Bezuidenhout, 1988; Bredenkamp *et al.*, 1989). Accepting the necessity for classification in the grassland biome, Scheepers (1987) emphasized that the reconciliation of various approaches should be actively investigated to maximize the usefulness of the past work with the Braun-Blanquet technique presently used for vegetation classifications in South Africa. If wheel point data can be applied successfully in this classification exercise, the inclusion of this information in a Braun-Blanquet type data base, or classification system, could prevent wasting expensive manpower and time in duplicating field surveys where data already exist. It is expected that, in a particular data set, relevês lacking certain species, would be classified in different classes than those representing total floristic composition. This implies that wheel point data *per se* cannot be included in a Braun-Blanquet type data base. However, if classifications based on wheel point data could be reconciled with general classifications derived from total floristic composition, this information could be very useful in the classification, description and mapping of the grassland biome. To test this possible reconciliation, the results obtained from a Braun-Blanquet (Westhoff and

*Corresponding author: Prof. G. J. Bredenkamp, Department of Botany, University of Pretoria, 0002, Pretoria, South Africa.

Van der Maarel, 1978) and TWINSPAN (Hill, 1979) classification of quantitative wheel point data on grass species only, and semi-quantitative total floristic data from exactly the same sample plots, were compared. Taxa names and taxon author names used in this report conform to those of Gibbs-Russell (1984).

Study Area

The Faan Meintjes Reserve was chosen for this investigation. The reason for this was that two independent surveys were conducted simultaneously in the Reserve on the same sample plots. The wheel point survey formed part of an extensive investigation of the ecological status of grass species and benchmarks in the Highveld Region (Bosch *et al.*, 1987). A Braun-Blanquet type survey on exactly the same (and additional) sample plots was conducted to classify and describe the vegetation of the Reserve (Bredenkamp and Bezuidenhout, 1990).

The Reserve which covers an area of approximately 930 ha is situated 15 km northeast of the town Klerksdorp, in the western Transvaal, South Africa. According to the Acocks (1988) classification the vegetation of the Reserve represents *Cymbopogon-Themeda*-veld (Veld Type 48). However typical Bankenveld vegetation (Veld Type 61) may also be found on the Reserve (Bredenkamp and Bezuidenhout, 1990).

A description of the climate, geology, topography and soils of the study area is given in detail by Bosch (1985) and Bredenkamp and Bezuidenhout (1990).

Materials and Methods

Bredenkamp and Bezuidenhout (1990) used 108 stratified random, 900 m^2 (30×30 m), sample plots to classify and describe the vegetation of the Reserve by means of the Braun-Blanquet approach. The study area was stratified on 1 : 10 000 scale aerial photographs into relatively homogeneous physiographic - physiognomic units. Total floristic composition was noted, and the cover abundance of each species was estimated on basis of the Domin-Krajina scale (Mueller-Dombois and Ellenberg, 1974).

Table 1. *A list of the plant communities of the Faan Meintjes Nature Reserve (Bredenkamp and Bezuidenhout, 1990), with the communities referred to in this text*

No. in this text	Plant communities
	1. *Rhus magalismontanum-Aristida vestita* Shrubland
1	1.1. *Loudetia simplex-Aristida vestita* Shrubland
	1.2. *Dombeya rotundifolia-Aristida vestita* Shrubland
	2. *Protasparagus suaveolens-Grewia flava* Woodland
	2.1. *Grewia flava-Acacia caffra* Woodland
2	2.2. *Grewia flava-Acacia karroo* Woodland
	3. *Brachiaria serrata-Triraphis andropogonoides* Grassland
3	3.1. *Triraphis andropogonoides-Tristachya leucothrix* Grassland
4	3.2. *Triraphis andropogonoides-Schizachyrium sanguineum* Grassland
5	3.3. *Triraphis andropogonoides-Elionurus muticus* Grassland
	4. *Setaria flabellata-Cymbopogon plurinodis* Grassland
6	4.1. Typical Variant
7	4.2. *Pentzia globosa* Variant
	5. *Setaria sphacelata-Eragrostis plana* Bottomland
8	5.1. *Eragrostis plana-Andropogon appendiculatis* Bottomland
9	5.2. *Eragrostis plana-Eragrostis curvula* Bottomland

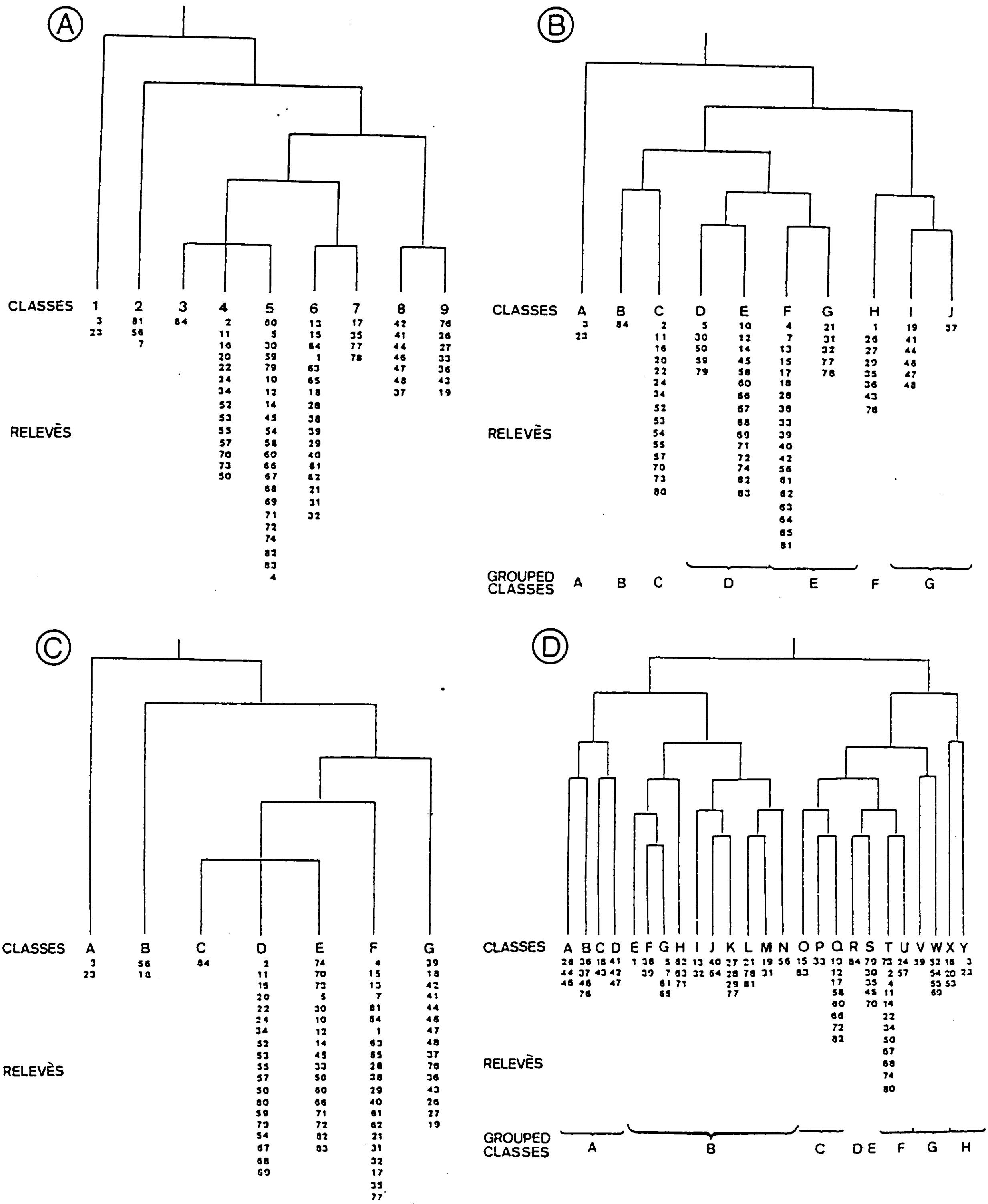


Fig. 1. Classification of 77 relevès by. A: Braun-Blanquet analysis of total floristic data; B: TWINSPAN of total floristic data; C: Braun-Blanquet analysis of wheel point data; D: TWINSPAN of wheel point data.

The wheel point apparatus has an axle with a spoked wheel, mostly about 1 m in diameter, that run on its spokes, that is a wheel without a rim. One of the spokes has a sharp point. The sharpened spoke is used as the point where the point-survey is being made. By pushing the wheel through vegetation sistematic point sampling is conducted. In South African grassland vegetation this method is used extensively to collect quantitative data of the grass species, mainly to determine the condition of the grass sward in relation to grazing potential, and to monitor change in the grass species composition.

In seventy seven of the 108 sample plots Bosch and Janse van Rensburg (1987) conducted 200 point nearest plant wheel point surveys to collect quantitative floristic data on the grass species only.

These 77 sample plots were used to compare classifications derived from quantitative wheel point data and semi-quantitative total floristic data.

The 77 sample plots represent nine of the plant communities identified by Bredenkamp and Bezuidenhout (1990). Conventional Braun-Blanquet procedures were followed, however table re-arrangements were done by computer. A dendrogram (Fig. 1A) was constructed from the hierarchical classification derived from the phytosociological table. A list of these communities is given in Table 1. As the Braun-Blanquet approach is presently the standardized technique for vegetation classification in South Africa (Bredenkamp, 1975), the Braun-Blanquet classification of the 77 sample plots was considered as the norm, to which all the other classifications were compared.

TWINSPAN (Hill, 1979) and standard Braun-Blanquet procedures (Braun-Blanquet, 1964; Werger, 1974; Westhoff and Van der Maarel, 1978), which both produce hierarchical classifications, were applied to both data sets. Tabular comparisons were made between the basic Braun-Blanquet classification of total floristic data and:

* the TWINSPAN classification of total floristic data,
* the Braun-Blanquet classification of wheel point data and
* the TWINSPAN classification of wheel point data.

Statistical correlation between classifications was calculated using the chi-square test as described by Bailey (1974) and applied by Morris (1973), Bredenkamp (1982) and Bezuidenhout (1988). Significance of the chi-square tests is according to the statistical tables of Fisher and Yates (1963).

Table 2. *A comparison between the Braun-Blanquet (BB) and TWINSPAN classifications of total floristic data*

		TWINSPAN							
		A	B	C	D	E	F	G	Tot
	1	2							2
	2					3			3
	3		1						1
	4			13	1				14
BB	5			2	19	1			22
	6					15	2		17
	7					3	1		4
	8					1		6	7
	9					1	5	1	7
	Tot	2	1	15	20	24	8	7	77

X^2=360.92
X^2=84.037 at p=0.001 with 48 degrees of freedom

Results

TWINSPAN Classification of the Total Floristic Data Set

Application of the TWINSPAN algorithm to the total floristic data set resulted in 10 classes at the fifth and final division (Fig. 1B). The seven classes (A-G, Fig. 1B) obtained at the fourth division level correspond well to the basic Braun-Blanquet classification. A comparison between the two classifications (Table 2) shows:

- 61 of the relevès (79.22%) were classified in accordance with the Braun-Blanquet classification,
- the two classifications are significantly correlated at 48 degrees of freedom ($X^2=360.92$ $X^2=84.037$ at p=0.001) and
- if the obtained X^2 value is expressed as a percentage of the X^2 value of a perfect correlation, the two classifications correspond 58.59%.

Classes A, B, C, D, F and G coincide well with Communities 1, 3, 4, 5, 9 and 8 respectively. Communities 2, 6 and 7, are grouped in Class E, and not distinguished at the fifth division of the TWINSPAN classification.

Braun-Blanquet Analysis of Wheel Point Data

The Braun-Blanquet analyses of wheel point data resulted in identification of 7 final classes (A-G in Fig. 1C). Comparison between this classification and the basic classification indicates the following (Table 3):

- 52 of the 77 relevès (67.53%) were classified in accordance with the Braun-Blanquet classification.
- The chi-square test shows that the two classification are significantly correlated at 48 degrees of freedom ($X^2=317.80$ $X^2=84.037$ at p=0.001).
- If the obtained X^2 value is expressed as a percentage of X^2 value of a perfect correlation, the two classifications correspond 51.59%.

Communities 2, 6 and 7 of the basic classification are grouped in class F, and Communities 8 and 9 in class G. Class B cannot be assigned with confidence to any of the recognised communities, but probably represents Community 2.

TWINSPAN Classification of Wheel Point Data

The TWINSPAN of wheel point data resulted in 25 final classes. By grouping related classes on various levels in the hierarchical classification, the classes were reduced to 8 (Fig. 1D). This grouping was done subjectively with the ecological interpretability of the

Table 3. *A comparison between the Braun-Blanquet classifications of total floristic data (BB) and wheel point data (BBWP)*

	BBWP								
		A	B	C	D	E	F	G	Tot
	1	2							2
	2		1				2		3
	3			1					1
	4				12	2			14
BB	5				7	14	1		22
	6						15	2	17
	7		1				3		4
	8							7	7
	9					1		6	7
	Tot	2	2	1	19	17	21	15	77

X^2=317.80
X^2=84.037 at p=0.001 with 48 degrees of freedom

Table 4. *A comparison between the Braun-Blanquet classification of total floristic composition (BB) and TWINSPAN of wheel point data*

BB \ TWINSPAN	A	B	C	D	E	F	G	H	T
1								2	2
2		3							
3				1					1
4					1	8	2	3	14
5		2	8		3	6	3		22
6	1	15	1						17
7		2	1		1				4
8	7								7
9	4	2	1						7
Tot	12	24	11	1	5	14	5	5	77

X^2=238.24
X^2=94.461 at p=0.001 with 56 degrees of freedom

groups as a guideline.

Comparison between this classification and the basic classification indicates the following (Table 4):

* 42 of the 77 relevês (54.55%) were classified in accordance with the Braun-Blanquet classification,
* The two classifications are significantly correlated at 56 degrees of freedom ($X^2=238.24$ $X^2=94.461$ at $p=0.001$) and
* If, however, the obtained X^2 value is expressed as a percentage of the X^2 value of a perfect correlation, the two classifications correspond 38.68%, which is relatively low.

In accordance with the Braun-Blanquet classification of wheel point data, the TWINSPAN algorithm also classified most relevês of Communities 2, 6 and 7 of the basic classification in a single class (Class B). Relevês from Communities 4 and 5 were classified into Classes E, F and G. Class H represents Communities 1 and 4 and Class A represents Communities 8 and 9.

Discussion

The Braun-Blanquet analysis of wheel point data and the TWINSPAN of total floristic composition as well as of wheel point data generally grouped most relevês of Communities 2, 6 and 7 in a single class. Community 7 however clearly represents a degraded phase of Community 6, and is presently floristically and ecologically so different from Community 6 that it should be identified and managed as a separate unit (Bredenkamp and Bezuidenhout, 1990). The differentiating species of the degraded community, *Pentzia globosa* and *Felicia muricata* were not included in the wheel point data set (grass species only), which explains why the two communities were not distinguished by the Braun-Blanquet analysis of wheel point data.

In spite of the quantitative nature of wheel point data, TWINSPAN did not clearly identify the degraded phase. Even if these two karroid species were included in the wheel point survey, their relatively low abundance and cover would probably not influence the TWINSPAN classification significantly.

The TWINSPAN of total floristic composition likewise did not distinguish between these two communities, probably due to the relative insignificance of the two diagnostic species within the total floristic data set. In this case ecologically significant species were therefore not adequately emphasized in the TWINSPAN algorithm.

Community 2 (the *Grewia flava-Acacia karroo* Woodland, Bredenkamp and Bezuidenhout, 1990) is an easy recognisable woodland, dominated by *Acacia karroo* and characterized by many diagnostic species. Floristically this woodland is distinguished from Communities 6 and 7 (grasslands), by the presence of the woody or semi-woody *Acacia karroo, Protasparagus suaveolens, P. laricinus, Grewia flava,* and *Teucrium trifidum* and also the grass species *Sporobolus fimbriatus*. Also of diagnostic importance is the absence of 13 grassland associated herbaceous species, including two grass species namely *Cymbopogon excavatus* and *Trichoneura grandiglumis*. Bredenkamp and Bezuidenhout (1990) distinguished two forms of the *Grewia flava-Acacia karroo* Woodland namely the typical form and a form representing *Acacia karroo* invasion into adjacent, previously overutilized, grassland communities (see also Bredenkamp *et al*., 1989). Here the abovementioned grassland associated species are usually still present. Relevès representing this Woodland and which were included in the present comparative study, had all been compiled at sample plots in the *Acacia karroo* invaded grassland. TWINSPAN therefore classified these relevès together with relevès from the grassland communities, due to the presence of the many grassland associated species. Furthermore, as wheel point data lack the woody and not grassy herbaceous species, the inclusion of this Woodland in a single class together with grassland Communities 6 and 7 is not surprising.

Neither the Braun-Blanquet analysis nor the TWINSPAN of wheel point data distinguished between Communities 8 and 9, but grouped them into a single class. Application of both techniques to the total floristic data set however, resulted in the recognition of the two communities. Both hierarchical classifications also indicate that due to floristic relationships, the two communities may be grouped into a single higher vegetation unit.

The distribution of relevès from Communities 4 and 5 into classes E, F and G, and the grouping of relevès from Communities 1 and 4 into class H by the TWINSPAN of wheel point data (Table 4) cannot be explained ecologically.

Conclusion

It was repeatedly shown (cf. Bredenkamp, 1982) that in South African vegetation, the Braun-Blanquet analysis of total floristic composition mostly results in ecologically interpretable vegetation classes, which may be classified in an ecologically sound hierarchical system. This was also the case in the Faan Meintjes Nature Reserve (Bredenkamp and Bezuidenhout, 1990). Vegetation management classes may be selected on any appropriate level in the hierarchical system (see also Bredenkamp and Theron, 1976).

Due to the corresponding results obtained from TWINSPAN and Braun-Blanquet analyses on total floristic data sets, TWINSPAN may be useful as an extremely good first approximation to create basic classifications which may be refined by the application of Braun-Blanquet procedures. In this way a nearly final, objective classification can be obtained quickly, whilst the option to reclassify certain relevès on basis of the Braun-Blaquet criterion of diagnostic species, into ecologically more interpretable classes, remains open.

It is clear that wheel point data cannot be treated together with total floristic data in a single classification, as relevès containing only part of the total floristic composition may be classified in totally seperate classes. However wheel point data may be used for classification of vegetation and may be reconciliated with basic Braun-Blanquet classifications. Classes obtained from classifications based on wheel point data may often represent higher vegetation units in a hierarchical classification system.

It is concluded that Braun-Blanquet analysis of wheel point data produces ecologically more interpretable results, and its results correspond more closely to the basic Braun-Blanquet classification, than a TWINSPAN classification on similar data. The quantitative data obtained from wheel point surveys are however considered more useful for the determination of vegetation gradients, the study of vegetation dynamics and veld condition assessment, than for vegetation classification.

Careful analysis of classifications obtained from different types of data, by experienced vegetation scientists well acqainted with the vegetation and general ecology of the particular area, may lead to successful reconciliation of these classifications.

Acknowledgements. This research was funded by the Foundation for Research Development, Republic of South Africa. Part of this research was conducted while all authors were employed by the Potchefstroom University for CHE.

Literature Cited

Acocks, J. P. H. 1988. Veld types of South Africa. Mem. Bot. Surv. S. Afr. **57**: 1-146.

Bailey, N. T. F. 1974. Statistical Methods in Biology. Lion Library, London.

Bezuidenhout, H. 1988. A Plant Sociological Study of the Mooi River Catchment Area, Transvaal. M. Sc. Thesis, Potchefstroom University for CHE.

Bosch, O. J. H. 1985. The Pasture of the Faan Meintjes Nature Reserve: An Ecological Study. Klerksdorp Record, Klerksdorp.

Bosch, O. J. H., F. P. Janse van Rensburg, and S. Du T. Truter. 1987. Identification and selection of benchmark sites on litholitic soils of the western grassland biome of South Africa. J. Grass. Soc. South. Afr. **4(2)**: 59-62.

Bosch, O. J. H. and F. P. Janse van Rensburg. 1987. Ecological status of species on grazing gradients on shallow soils of the western grassland biome in South Africa. J. Grassl. Soc. South. Afr. **4(4)**: 143-147.

Braun-Blanquet, J. 1964. Pflanzensociologie. 3rd edition. Springer, Vienna.

Bredenkamp, G. J. 1975. A Plant Sociological Study of the Suikerbosrand Nature Reserve. M. Sc. Thesis, University of Pretoria.

Bredenkamp, G. J. 1982. A Plant Ecological Study of the Manyeleti Game Reserve. D. Sc. Thesis, University of Pretoria.

Bredenkamp, G. J. and H. Bezuidenhout. 1990. The vegetation of the Faan Meintjes Nature Reserve. S. Afr. J. Bot. **56(1)**: 54-64.

Bredenkamp, G. J., A. F. Joubert, and H. Bezuidenhout. 1989. A reconnaisance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area. S. Afr. J. Bot. **55(2)**: 199-206.

Bredenkamp, G. J. and G. K. Theron. 1976. Vegetation units for management of the grasslands of the Suikerbosrand Nature Reserve. S. Afr. J. Wild. Res. **6(2)**: 113-122.

Danckwerts, J. 1982. Veld condition assessment in the eastern Cape region. Dohne Agric. **5**: 9-14.

Fisher, R. A. and F. Yates. 1963. Statistical Tables for Biological, Agricultural and Medicine Research. Longmans, London.

Fourie, J. H., N. J. De Wet, and J. J. Page. 1987. Veldtoestand en neiging in Kalahari-Duineveld onder 'n ekstensiewe veeboer derystelsel. (English summary). J. Grassl. Soc. South. Afr. **4 (2)**: 48-54.

Gibbs-Russell, E. G. 1984. List of species of southern African plants. Mem. Bot. Surv. S. Afr. **48**: 1-144.

Hill, M. O. 1979. TWINSPAN-a Fortran program for arranging multivariate data in an ordered twoway table by classication of the individuals and attributes. Cornell University, New York.

Mentis, M. T. and B. J. Huntley. 1982. A description of the grassland biome project. South African National Scientific Programmes Report 62. CSIR, Pretoria.

Morris, J. W. 1973. Automatic Classification and Ecological Profiles of South-Western Transvaal Highveld Grassland. D. Phil Thesis, University of Natal.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. Wiley, New York.

Scheepers, J. C. 1987. Grassland biome project: Proceedings of the workshop on classification and mapping. Ecosystem Programmes Occasional Report Series 16. CSIR, Pretoria.

Tidmarsh, C. E. M. and C. M. Havenga. 1955. The wheel point method of survey and measurement of semi-open grasslands and Karoo vegetation in South Africa. Mem. Bot. Surv. S. Afr. **29**: 1-14.

Werger, M. J. A. 1974. On concepts and techniques applied in the Zurich-Montpellier methos of vegetation survey. Bothalia **11**: 309-323.

Westhoff, V. and E. Van der Maarel. 1978. The Braun-Blanquet approach. *In* R. H. Whittaker (ed.), Classification of Plant Communities. Junk, London, pp. 287-399.

以 wheel point 及植物組成種類之資料組比較南非某草地之植被分類

G. J. Bredenkamp[1], H. Bezuidenhout[2], O. J. H. Bosch[3] and F. P. Janse van Rensburg[4]

[1]Department of Botany, University of Pretoria, Pretoria, 0002, South Africa
[2]Grassland Research Centre, Private Bag X05, Lynn East, 0039, South Africa
[3]Department of Botany, Potchefstroom University for CHE, Potchefstroom, 2520, South Africa
[4]Department of Agriculture (Highveld Region), Private Bag X804, Potchefstroom, 2520, South Africa

本篇論文係針對相同的樣區，分別採用「雙相指標種分析」，以及半定量的植物組成種類的資料組和僅就禾本科植物的定量 wheel point 資料組做「Braun-Blanquet 分析」。根據該兩種方法比較植被的分類狀況。若將植物組成種類的資料組採「Braun-Blanquet 法」加以分析，並以所獲得的該項結果當做基準值，則 wheel point 資料組以「Braun-Blanquet 法」所得的數值爲該基準值的 67.53%；至於若是採用「雙相指標種分析」，則植物組成種類的資料組和 wheel point 資料組所獲的結果分別爲基準值的 79.22%及 54.55%。Chi-squane 測驗顯示上述所有的分類法皆與基準的「Braun-Blanquet」分類法有顯著的相關性。

3.2.2 A proposed procedure for the analysis of large phytosociological data sets in the classification of south African grasslands.

Page

* To be *submitted* in: *Vegetatio*

A proposed procedure for the analysis of large phytosociological data sets in the classification of South African grasslands

G.J. Bredenkamp & H. Bezuidenhout

Department of Botany, University of Pretoria, Pretoria 0002, Republic of South Africa.

Key words: Classification, grassland, large data set, new procedures, South Africa.

Abstract

A procedure for the effective classification of large phytosociological data sets, and the combination of many data sets from various parts of the South African grasslands, is demonstrated. The procedure suggests a region by region or project by project treatment of the data. The analyses are performed step by step to effectively bring together all relevés of similar or related plant communities. The first step involves a separate numerical classification of each subset (region), and subsequent refinement by Braun-Blanquet procedures. The resulting plant communities are summarized in a single synoptic table, by calculating a synoptic value for each species in each community. In the second step all communities in the synoptic table are classified by numerical analysis, to bring related communities from different regions / studies together in a single cluster. After refinement of these clusters by Braun-Blanquet procedures, broad vegetation types are identified. As a third step phytosociological tables are compiled for each identified broad vegetation type, and a comprehensive abstract hierarchy constructed.

Introduction

Although the results of a number of research projects in southern African grassland vegetation have been published since the turn of the century, very few of these offer comparable results and reconciliation is virtually impossible (Scheepers 1987). Since the introduction of the Braun-Blanquet method to South Africa (Werger 1973) and the decision to standardise on this method for the analysis and description of South African vegetation, several Braun-Blanquet type surveys have been completed within grasslands or related vegetation (eg. Bredenkamp & Theron 1978 & 1980, Coetzee 1974 & 1975, Van Wyk & Bredenkamp 1986, Behr & Bredenkamp 1988, Bredenkamp *et al.* 1989, Kooij *et al.* 1990). Unfortunately most of these studies were confined to relatively small areas, for example nature reserves or other limited regions. For this reason formal fixing of syntaxonomical ranks and names has been avoided (Bredenkamp *et al.* 1989), as information from a wider area is desirable to ensure correct ranking and naming of syntaxa (Tüxen 1970, Werger *et al.* 1972). The fragmentary information and the lack of a comprehensive formal hierarchical syntaxonomical system for South African vegetation in general, and the grasslands in particular, have led to the description and naming of many plant communities, without considering other studies or earlier names for possibly similar syntaxa. After the initiation of the South African Grassland Biome Project (Mentis & Huntley 1982) the urgent need for and necessity of an ecologically sound, comprehensive classification, description and mapping of South African grasslands was expressed (Scheepers 1987).

Due to the lack of data, especially from more extensive areas, the necessity of fieldwork as well as the incorporation of all existing compatible data was emphasized (Scheepers 1987). Consequently a phytosociological research program was encouraged by the foundation of a Vegetation Classification and Mapping Working Group under the auspices of the Grassland Biome Project (Scheepers 1987). Within this Working Group the Ecology Groups of the University of Pretoria, National Botanical Institute (Dept. of Agricultural Development) and Potchefstroom University for Christian Higher Education initiated various phytosociological projects. The many relevés compiled in these studies facilitated the opportunity for a comprehensive formal syntaxonomical and synecological synthesis of the grasslands concerned. The questions were how to treat the large data set now available for grassland vegetation, and how should the total information now available be used to the best benefit of the envisaged formal syntaxonomical hierarchy. Although the grassland gives the impression of being floristically, and even ecologically relatively homogeneous, this is not the case. The data represent many different plant communities and encompass an ecologically heterogeneous area.

A number of clustering programs can treat very large data sets eg. CLUSLA (Louppen & Van der Maarel 1979), TWINSPAN (Hill 1979) and COMPCLUS (Gauch 1979). Furthermore, very large data sets have been treated together, using TABORD (Van der Maarel *et al.* 1978) or PHYTOPAK (Huntley *et al.* 1981).

In our comprehensive study an attempt was made to consolidate data of related plant communities from various previous studies and to incorporate the relevant data generated in current surveys.

The goals of this study were to:

* develop a procedure to process large data sets, which include relevés, and communities, from previous studies as well as newly compiled relevés,

* create a suitable data-base to manage all relevant data sets efficiently,

* combine relevés representative of **the same or related plant communities**, but compiled by various workers in various projects, which may include various geographical regions, in a single phytosociological table or synoptic table, and

* develop an efficient computer program to accomplish all necessary procedures accurately and efficiently.

However many problems were experienced regarding the treatment of this large data set (see also Van der Maarel, *et al.* 1987):

* It is difficult or virtually impossible to handle phytosociological tables of this dimension by standard Braun-Blanquet procedures, especially where character species are absent and syntaxa are characterised by differential taxa or specific combinations of species or species groups.

* The identification and definition of certain ecologically interpretable communities may be difficult, as specific species combinations may be obscured in the large, heterogeneous data set.

* The objective demarcation of the data into various subsets, by using numerical classification methods was also ineffective, mainly due to the heterogeneity of the data and also the presence of a large number of species with very limited occurrences in the total data set. This leads to difficulty in choosing various options in many of the multivariate clustering methods (Van der Maarel, *et al.* 1987).

* The particular algorithm used in many multivariate methods may result in unrealistic major divisions.

Van der Maarel *et al.* (1987) questioned the desirability and effectivity (see also Van der Maarel 1982) of simultaneous treatment of large heterogeneous data sets and discussed the various problems, concerning both methodology and ecology, of such treatments. Stratification of the data seems to be a realistic solution. A region by region treatment of geographically heterogeneous data is also preferred by Orlóci & Stanek (1979) and Jensén & Van der Maarel (1980).

Recently, a two-step procedure was found to be effective in the treatment of large data sets (Van der Maarel *et al.* 1987). By combining ideas on this two-step vegetation analysis method and ideas on the refinement of numerical classifications by Braun-Blanquet procedures (Bezuidenhout *et al.* 1988; Behr & Bredenkamp 1988), a procedure was developed for the treatment of large phytosociological data sets from South African grasslands.

This report aims to give an outline of the proposed procedures. The principles of the procedure were tested in a pilot study and the results of this study are presented.

Methods

Data collection

The data set includes 820 relevés with > 1 000 species, representing many different vegetation types and encompasses an ecologically heterogeneous area, covering approximately 22 000 km² in the north-western part of the grassland biome of South Africa (Figure 1).

Data were obtained from four previous studies and four current studies. The data were stratified by region in the following way (Figure 1):

Previous studies:

Data set 1, from the Witwatersrand Geological Super Group (quartzite mountains), Heidelberg area (Bredenkamp & Theron 1978);

Data set 2 from the Venterdorp Geological Super Group (lavas), Heidelberg area (Bredenkamp & Theron 1980);

Data set 3 from the Jack Scott Nature Reserve, Magaliesburg area (Coetzee 1974);

Data set 4 from the plains in the Potchefstroom-Fochville-Parys area (Bredenkamp *et al.* 1989);

Current studies:

Data set 5 from the Dolomitic region, in the Potchefstroom-Ventersdorp-Randfontein area (Bezuidenhout & Bredenkamp 1990);

Data set 6 from the quartzite hills and ridges in the Potchefstroom area (Bezuidenhout & Bredenkamp, new survey);

Data set 7 from the Roodepoort area (Bredenkamp & Bezuidenhout, new survey);

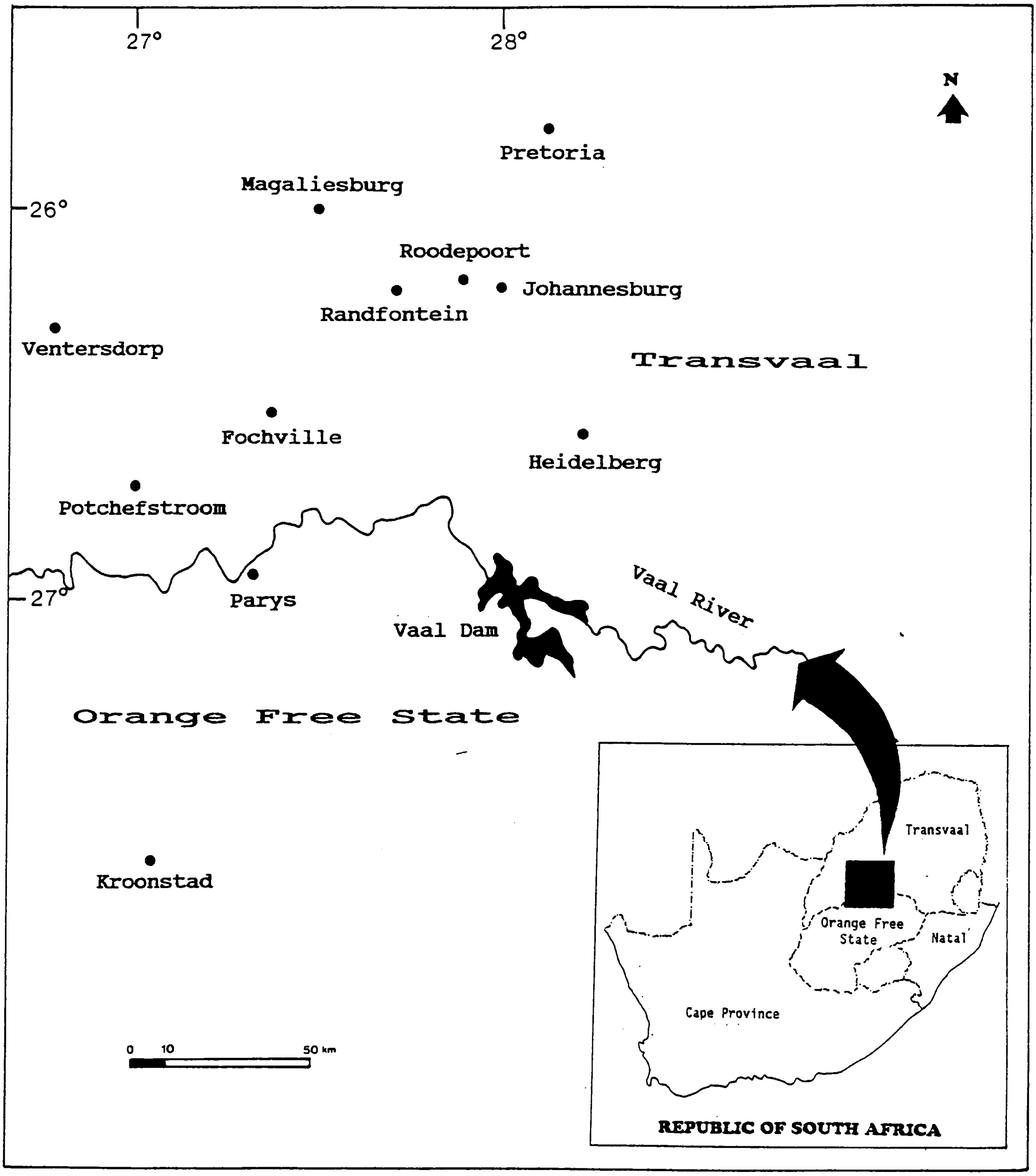


Figure 1: The location of the study area.

Data set 8 from the extensive bottomland areas in the Kroonstad area (Kooij *et al*., new survey).

Relevé data include total floristic composition with Braun-Blanquet type cover/abundance values (Westhoff & Van der Maarel 1978). Habitat data at least include geology, topography, soil type, soil depth, and rockiness of the soil surface while other soil properties may also be available in certain studies. Climatic data from the regions represented by the relevés are also available.

Data analysis

An elaboration of a recently proposed two-step procedure (Van der Maarel *et al*. 1987), was applied in this study. The procedure includes three steps and is as follows:

Step 1.

a. Stratify the entire data set either by area or project, or if possible, by vegetation type. This stratification enables a region by region treatment of possibly geographical heterogeneous material.

b. Subject each subset to any suitable numerical classification. This analysis should result in a number fairly homogeneous clusters, representing a first approximation of possible community types. In our case we applied TWINSPAN (Hill 1979), as it was found that this algorithm results in a fair first approximation of the vegetation types and produces a fairly ordered two-way table (Bezuidenhout *et al*. 1988, Behr & Bredenkamp 1988, Bredenkamp *et al*. 1989).

c. Interpret the clusters obtained ecologically.

d. Refine, if necessary, by application of Braun-Blanquet procedures to establish ecologically interpretable plant communities.

e. Construct a synoptic relevé (composite sample) for each community, in each subset, using constancy/frequency classes with 20 % intervals, resulting in constancy/frequency values of 1 to 5 for the species. In this way each community is summarised to a single column in a synoptic table. The synoptic cover abundance value proposed by Van der Maarel *et al.* (1987) was not used in this study, but can easily be incorporated.

Step 2.

a. Re-enter each community, identified from all subsets, as a synoptic relevé in a new **synoptic data set** and reclassify using the suitable numerical classification technique (TWINSPAN). Here we have the option to ignore all constancy/frequency values of < 20 %.

b. Refine the resulting classification, if necessary, by using Braun-Blanquet procedures. In this way all similar or related plant communities are brought together in a single cluster.

c. Identify from these clusters in the re-organised synoptic table the major relevant vegetation types probably representing higher syntaxa, for example classes.

Step 3.

a. Construct different phytosociological tables to include all original relevés of a particular higher syntaxon.

b. Compile a hierarchical classification.

c. Identify and describe the relevant syntaxa.

Results and discussion

The results of the procedure are shown in Figure 2. In the separate numerical analyses (TWINSPAN) of the eight subsets (Step 1) a total of 89 and 184 clusters were obtained at the fourth and sixth levels of division respectively. Refinement by Braun-Blanquet procedures produced a total of 98 plant communities. By applying Step 2, the TWINSPAN revealed 28 clusters (synclusters)

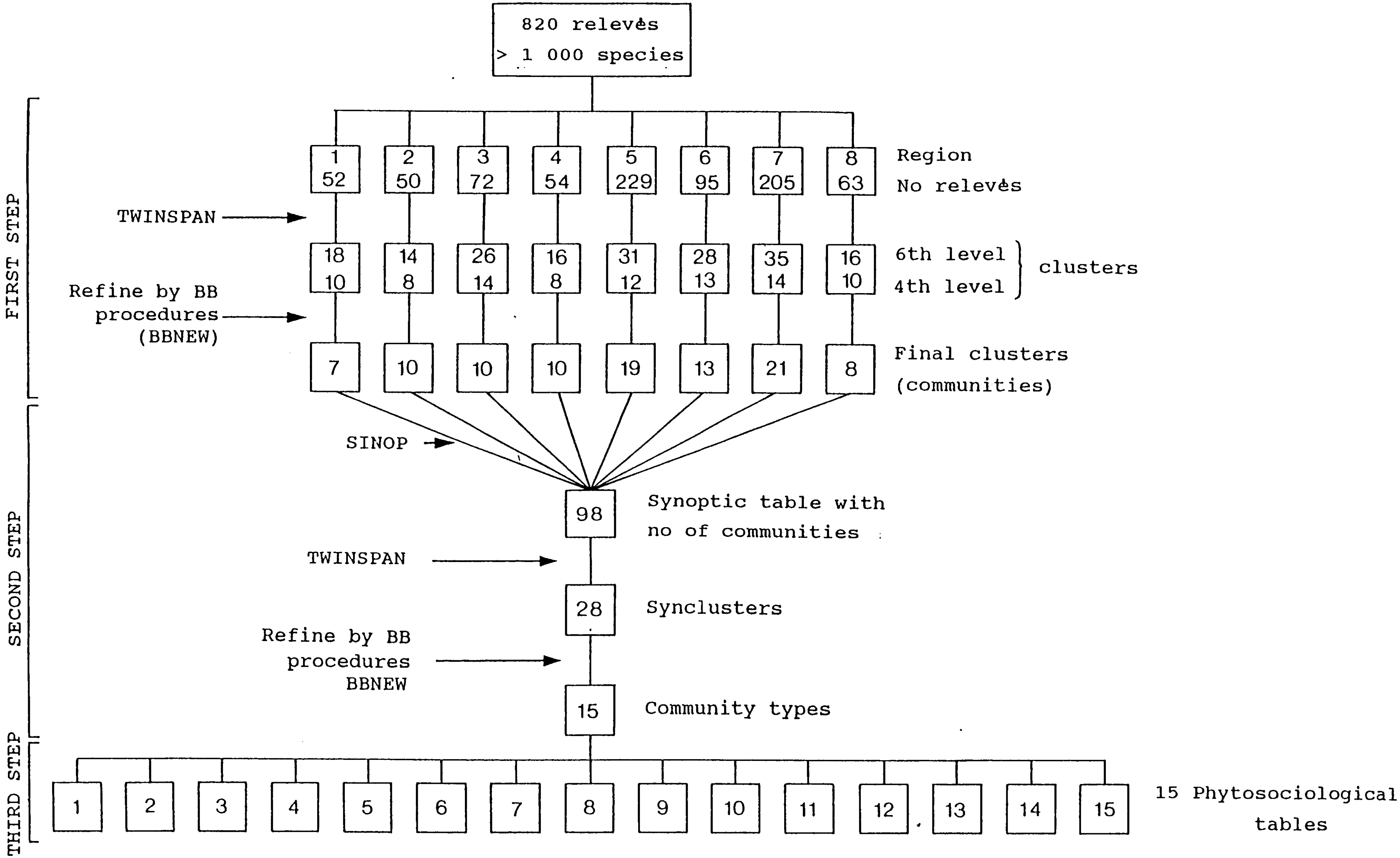


Figure 2: Diagram showing the three step procedure and some results.

which were reduced to 15 community types in the refinement using Braun-Blanquet procedures. The results of Step 3, that is the construction of 15 separate phytosociological tables, each containing relevés from one or more regions or surveys, and the description of the syntaxa, are not reported on in this paper.

The figures given in Table 1 indicate that six of the community types contain relevés from only one region, where-as the remaining nine community types contain relevés from 2 - 5 different regions.

By using the above procedure all related relevés, and related communities, from different regions, compiled during different surveys by different workers, are effectively brought together in a single phytosociological table. Simultaneously the classification of the synoptic data set provides the basis for a comprehensive hierarchical classification of all the syntaxa identified during the study.

Another advantage is that data from new regions can easily be added to the analysis, thus enabling the compilation of a comprehensive data base of relevés and distinguished syntaxa, of the area concerned.

Acknowledgement

The Foundation for Research Development, Council for Scientific and Industrial Research gave substantial financial support. Proff. S. Pignatti and E. van der Maarel are thanked for their valuable comments.

References

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanical Garden. *S. Afr. J. Bot.* 54: 525 - 533.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* 18: 387 - 403.

Table 1: The regions in each of the distinguished community types.

Community type number	Region number	Total number/regions
1	1, 8	2
2	8	1
3	8	1
4	1, 3	2
5	1, 2, 3, 4, 6	5
6	2	1
7	2, 3	2
8	7	1
9	6, 7	2
10	4, 5	2
11	3, 7	2
12	7	1
13	4, 6, 7	3
14	6	1
15	4, 6	2

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydskr. Natuurwet. & Tegnol*. 7: 4 - 9.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area. *S. Afr. J. Bot*. 55: 199 -206.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve 1. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 - 529.

BREDENKAMP, G.J. & THERON, G.K. 1980. A synecological account of the Suikerbosrand Nature Reserve 2. The phytosociology of the Ventersdorp geological system. *Bothalia* 13: 199 - 216.

COETZEE, B.J. 1974. A phytosociological classification of the vegetation of the Jack Scott Nature Reserve. *Bothalia* 11: 329 - 347.

COETZEE, B.J. 1975. A phytosociological classification of the Rustenburg Nature Reserve. *Bothalia* 11: 561 - 580.

GAUCH, H.G. 1979. COMPCLUS: A fortran program for rapid initial clustering of large data sets. Cornell University, Ithaca, New York.

HILL, M.O. 1979. TWINSPAN: A fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, Ithaca, New York.

HUNTLEY, B., HUNTLEY, J.P. & BIRKS, H.J.B. 1981. PHYTOPAK: A suite of computer programs designed for the handling and analysis of phytosociological data. *Vegetatio* 45: 85 - 95.

JENSéN, S. & VAN DER MAAREL, E. 1980. Numerical approaches to lake classification with special reference to macrophyte communities. *Vegetatio* 42: 117 - 128.

KOOIJ, M.S., BREDENKAMP, G.J. & THERON, G.K. 1990. Classification of the vegetation of the B land type in the north-western Orange Free State. *S. Afr. J. Bot.* 56: 309 - 318.

LOUPPEN, M.J.W. & VAN DER MAAREL, E. 1979. CLUSCLA: A computer program for the clustering of large phytosociological data sets. *Vegetatio* 40: 107 - 114.

MENTIS, M.T. & HUNTLEY, B.J. 1982. A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog.* 62: 1 - 29.

ORLóCI, L. & STANEK, W. 1979. Vegetation survey of the Alaska highway, Yukon territory: Types and gradients. *Vegetatio* 41: 1 - 56.

SCHEEPERS, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on classification and mapping. *S. Afr. Ecosys. Prog. Occ. Rep. Series* 16: 1 - 31.

TŰXEN, R. 1970. Pflanzensoziologie als synthetische Wissenschaft. *Meded. Bot. Tuinen Belmonte Arboretum Landbouwhogischool Wageningen* 12: 141 - 159.

VAN DER MAAREL, E. 1982. On the manipulation and editing of phytosociological and ecological data. *Vegetatio* 50: 71 - 76.

VAN DER MAAREL, E., ESPEJEL, I. & MORENO-CASASOLA, P. 1987. Two-step vegetation analysis based on very large data sets. *Vegetatio* 68: 139 - 143.

VAN DER MAAREL, E., JANSEN, J.G.M. & LOUPPEN, J.M.W. 1978. TABORD: A program for structuring phytosociological tables. *Vegetatio* 38: 143 - 156.

VAN WYK, S. & BREDENKAMP, G.J. 1986. A Braun-Blanquet classification of the Abe Bailey Nature Reserve. *S. Afr. J. Bot.* 52: 321 - 331.

WERGER, M.J.A. 1973. Phytosociology of the upper Orange River Valley: A syntaxonomical and synecological study. D.Sc. thesis, University of Nijmegen, Nijmegen.

WERGER, M.J.A., KRUGER, F.J. & TAYLOR, H.C. 1972. A phytosociological study of the Cape fynbos and other vegetation at Jonkershoek, Stellenbosch. *Bothalia* 10: 599 - 614.

WESTHOFF, V. & VAN DER MAAREL, E. 1978. The Braun-Blanquet approach. *In*: R.H. Whittaker (ed.), Classification of plant communities. Dr. W Junk, The Hague.

CHAPTER 4

PLANT COMMUNITIES OF THE WESTERN TRANSVAAL GRASSLAND

PAGE

4.1 Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys.

Page

* Published: *S.A. Tydskrif vir Natuurwetenskap en Tegnologie* 7(1): 4 - 9.

 ISSN 0254-3486 = *S.A. Tydskrif vir Natuurwetenskap en Tegnologie* 7, no. 1 1988

Navorsings- en Oorsigartikels

Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys

H. Bezuidenhout en G.J. Bredenkamp*
Departement Plantkunde, PU vir CHO, Potchefstroom 2520
J.H. Elsenbroek
Geologiese Opname, Pretoria

UITTREKSEL
Die invloed van alkaligraniet en aangrensende gesteentes op die verspreiding van plantspesies en plantgemeenskappe is ondersoek. Die plantgemeenskappe van die studiegebied is suksesvol onderskei deur die toepassing van die TWINSPAN-numeriese klassifikasietegniek en daaropvolgende verfyning deur die Braun-Blanquet-tegniek. Ses plantgemeenskappe is geïdentifiseer en elk is met 'n spesifieke habitat gekorreleer. Die resultate toon duidelik dat sowel gesteentes as aspek (noord- en suidfronthellings) 'n bepalende invloed op die verspreiding van die plantgemeenskappe het. Groepe spesies wat as betroubare indikators vir die spesifieke habitatte kan dien, is ook geïdentifiseer.

ABSTRACT
The vegetation of the alkali granite and bordering quartzite in the Vredefort Dome north-west of Parys

An investigation was made to determine the influence of alkali granite and bordering rocks on the distribution of plant species and plant communities. Six plant communities were successfully distinguished in the study area by using the TWINSPAN numerical classification technique, followed by refinement using the Braun-Blanquet technique. The plant communities could easily be correlated with specific habitat types. The results show that rock type as well as aspect (north and south facing slopes) influence the distribution of plant communities strongly. Groups of species which are reliable indicators for specific habitat conditions were also identified.

INLEIDING

In 'n omvattende geologiese ondersoek na die alkaligraniete in die Vredefortkoepel,[1] is opgemerk dat die plantegroei wat op die alkaligraniet aangetref word, aansienlik van die aangrensende plantegroeitipes verskil. Breedweg word die plantegroei van hierdie gebied as Bankenveld geklassifiseer.[2] Ander ondersoeke elders in die Bankenveld toon die invloed van die verskillende geologiese gesteentes op die verspreiding van plantgemeenskappe duidelik aan.[3-6] Ook in die Vredefortdistrik is die verband tussen gesteente en plantegroei aangetoon, maar geen melding word van die plantgemeenskappe op alkaligraniet gemaak nie. In hierdie ondersoek is gepoog om die invloed van alkaligraniet en aangrensende gesteentes op die verspreiding van plantspesies en plantgemeenskappe aan te toon.

Aspek, dit is die rigting waarin hellings front, het in die Bankenveld 'n sterk invloed op die verspreiding van plantegroei.[3-5 en 7] Aangesien die alkaligraniet teen sowel die noord- as suidfronthelling van die kwartsiet dagsoom, is aspek ook in hierdie ondersoek in aanmerking geneem.

* Outeur aan wie korrespondensie gerig kan word.

GEOLOGIE VAN DIE STUDIEGEBIED

Die ligging van die studiegebied en die verspreiding van die alkaligraniet en aangrensende gesteentes word in figuur 1 aangedui.

Die relatief jong alkaligraniet het in die sedimente van die Wesrandgroep van die Witwatersrandsupergroep ingedring. Die Wesrandgroep bestaan uit die Hospital Hill-, Goewerment- en Jeppestownsubgroepe. Twee plutone van alkaligraniet word hier aangetref. Die Baviaan Kranzpluton het in die Goewermentsubgroep-sedimente ingedring, terwyl die Schurwedraaipluton in die Jeppestownsubgroepsedimente ingedring het. Laasgenoemde pluton is op 'n strekkingsverskuiwing wat die Jeppestownsubgroep dupliseer, geleë. Sowel die Jeppestown- as Goewermentsubgroepe bestaan hoofsaaklik uit kwartsiet en skalieformasies. Die kwartsiet is meer weerstandbiedend as die alkaligraniet en bepaal dus die topografie van die gebied. Alkaligraniet bestaan hoofsaaklik uit die minerale kwarts, mikroklien, albiet, egerien, arfvedsoniet-riebeckiet en biotiet. Die ruwe, klipperige rante is 'n gevolg van verskille in weerstandbiedendheid van die onderskeie gesteentes sowel as die plooiings en verskuiwings wat hier voorkom.

Alluvium en kolluviale puin word aan die voet van die rante en op die kontaksones tussen alkaligraniet en kwartsiet aangetref (figuur 2). Uit figure 1 en 2 is dit duidelik dat die alkaligraniet òf deur kwartsiet van die Jeppestown- of Goewermentsubgroepe òf deur alluvium en puin begrens word.

METODES

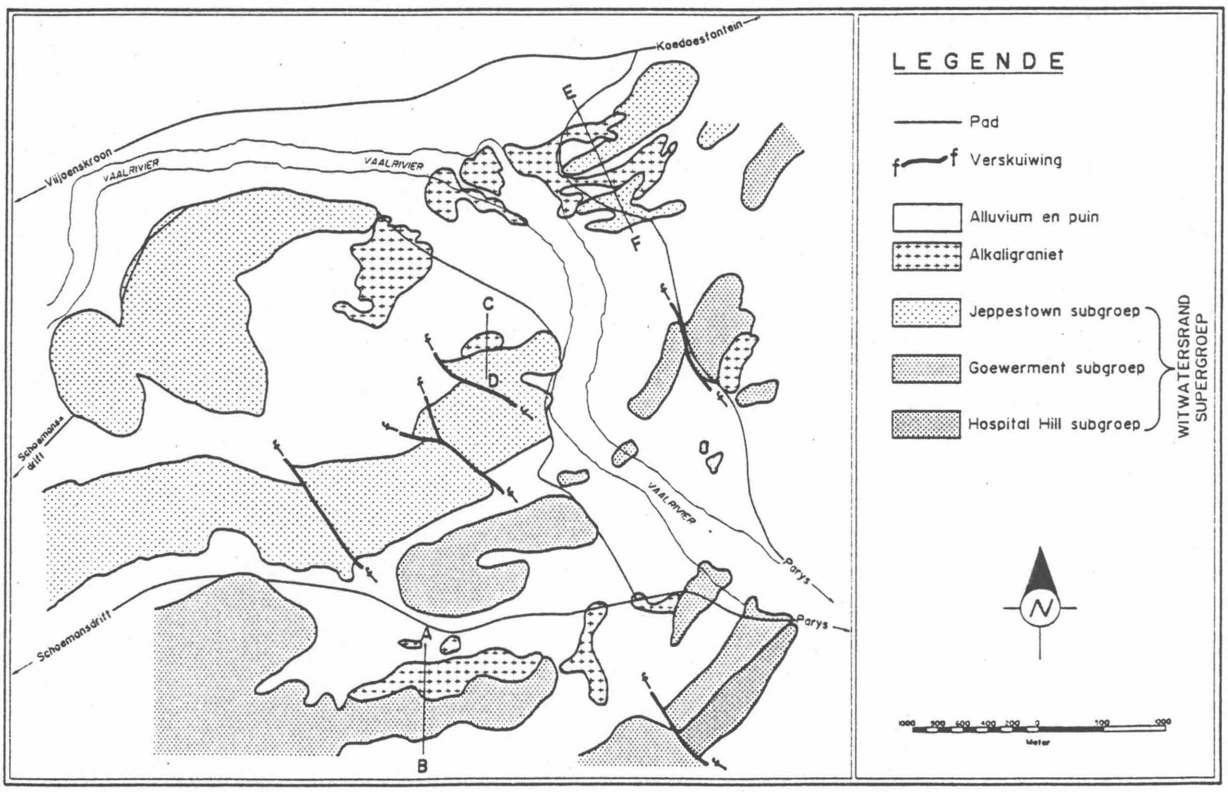
Plantegroei-opnames is volgens die Braun-Blanquet-tegniek[8] in 22 monsterpersele uitgevoer. Die persele is op drie lokaliteite waar die alkaligraniet dagsoom, uitgeplaas. Profiele A-B, C-D en E-F (figuur 1) toon die ligging van die lokaliteite. Monsterpersele van 220 m² is op alkaligraniet en op aangrensende kwartsiet, alluvium of puin, teen sowel noord- as suidfronthellings geplaas. In elke perseel is 'n volledige floristiese opname gemaak. Bedekkingswaardes is vir elke plantspesie wat in die perseel aangetref is, volgens die Braun-Blanquet-bedekkingskaal,[8] aangeteken. Verder is die algemene hoogte en kroonbedekking van die boom-, struik- en kruidstratum ook aangeteken. Die habitatopname sluit tipe gesteente, aspek, persentasie klipperigheid van die grondoppervlakte en ook grondtipe in.

In 'n poging om sinvolle, ekologies verantwoorde plantgemeenskappe te onderskei, is die floristiese datastel aan 'n Tweerigting-spesie-indikator-analise (TWINSPAN)[9] onderwerp. Die resultaat is deur die toepassing van die Braun-Blanquet-tegniek verfyn en die finale resultaat van die klassifikasie word as 'n fitososiologiese tabel (tabel 1) aangebied. Die plantgemeenskappe wat onderskei is, is hierna aan die hand van die beskikbare habitatdata ekologies geïnterpreteer. Die gemiddelde hoogte en gemiddelde kroonbedekking van die boom-, struik- en kruidstratum van elke plantgemeenskap is bereken en die resultate word in tabel 2 weergegee.

RESULTAAT

Die ontleding van die floristiese data het tot die identifikasie van die volgende ses plantgemeenskappe gelei:

1. Die *Nuxia congesta-Rhus magalismontanum*-savanne hoog op teen suidfronthellings op kwartsiet;
2. die *Nuxia congesta-Combretum molle*-savanne hoog op teen noordfronthellings op kwartsiet;
3. die *Acacia caffra-Enneapogon scoparius*-savanne op kwartsietpuin, teen noordfronthellings;
4. die *Diospyros lycioides-Sporobolus fimbriatus*-savanne teen suidfronthellings op alkaligraniet;



FIGUUR 1: 'n Vereenvoudigde geologiese kaart van die alkaligraniet en aangrensende gesteentes, noordwes van Parys.

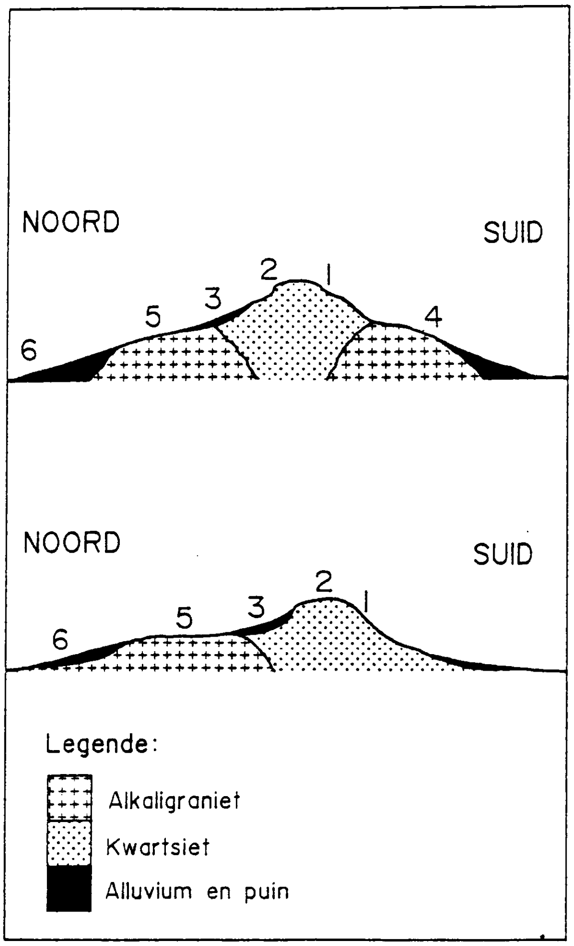
TABEL 1
'n Fitososiologiese tabel van die alkaligraniet en aangrensende gesteentes

SPESIES	333 888 723	33344 89922 91312	333 898 805	444 221 569	4444 2222 0387	3334 8892 4624
SPESIEGROEP 1						
NUXIA CONGESTA	2 1 1	+ R + 1 +			+	
BULBOSTYLIS BURCHELLII	+ +	+ + +				
SPESIEGROEP 2						
RHUS MAGALISMONTANUM	+ 1 +	1		+		
HELICHRYSUM KRAUSSII	+ 1					
BECIUM OBOVATUM	+ +					
ZORNIA GLOCHIDIATA	+ +					
COMMELINA BENGHALENSIS	+ +					
TEPHROSIA SEMIGLABRA	+ +		+			
INDIGOFERA COMOSA	+ +	+				+
LOUDETIA SIMPLEX	1 +					+
PROTEA CAFFRA	+					
SPESIEGROEP 3						
ZANTHOZYLUM CAPENSIS	+ +	+	+ + +			+
MELHANIA PROSTRATA			+ + +			+
ENNEAPOGON SCOPARIUS			+ 1			
SPESIEGROEP 4						
CHEILANTHES HIRTA	+ +			+ + +		
CONYZA PODOCEPHALA				+ + +		
ASCLEPIAS DECIPIENS	+			+ +		+
SPOROBOLUS FIMBRIATUS				+ 1	+	
GNIDIA CAPITATA				1 +	+	+
SPESIEGROEP 5						
COMBRETUM MOLLE	+ 3	2 2 + 3 3	1 + 3	1	2	+
ACACIA CAFFRA	2 R	R + R	2 2 1	+	2 1 1	3
PAVETTA ZEYHERI	+ + +	+ + +	+	+ +	+ +	+
TAPIPHYLLUM PARVIFOLIUM	+ + 1	1 +	+	+ + 1		+
TEPHROSIA BURCHELLII	+	+ + +	+ +		+	+
VANGUERIA INFAUSTA	+ +	+ +		+ +	R +	
BRACHYLAENA ROTUNDATA	+	+ + +	+ 1	1	+	
SETARIA LINDENBERGIANA	2	2 1	+	+	+ 2	
MAYTENUS TENUISPINA	+ +	1 1 R			1	+
SPESIEGROEP 6						
DICOMA GERRADII					+	+ + + +
CORCHORUS ASPLENIFOLIUS						+ + + +
CHASCANUM HEDERACEUM						+ + + +
ACACIA KARROO		1		+		2 1 2
ZIZIPHUS ZEYHERIANA						+ + +
HERMANNIA DEPRESSA						+ + +
TRACHYPOGON SPICATUS			+			+ + 1
BRACHIARIA SERRATA				+	+	+ + +
CHAMAESYCE SP.						+ +
CLEMATIS BRACHIATA						+ +
CRABBEA ANGUSTIFOLIA						+ +
CYANOTIS SPESIOSA						+ +
DIOSPYROS WHYTEANA						+ +
INDIGOFERA FILIPES						+ +
SUTERA ATROPURPUREA						+ +
VERNONIA OLIGOCEPHALA						+ +
SPESIEGROEP 7						
PROTASPARAGUS SUAVEOLENS			+ +		+ + +	+ R +
SETARIA FLABELLATA				+	+ + 1	+ + 1
SPESIEGROEP 8						
ELIONURUS MUTICUS	+	+	+	+ 2	+ + +	1 + +
FELICIA MURICATA				+ +	+	+ 1 + +
CELTIS AFRICANA		+		+	+ + +	+ +
HETEROPOGON CONTORTUS	+			+	1 + +	+
CYNODON DACTYLON				+ +	+ +	1 +
RUELLIA PATULA				+	+ +	+ +
MARISCUS INDECORUS		+ +		+	+ +	+
DIOSPYROS LYCIOIDES				1 1 +	+ +	+
RHUS PYRIODES				+ + 1	+ +	
SPESIEGROEP 9						
SIDA DREGEI	+	+	+ +	+ +		+ + + +
ARISTIDA CONGESTA			+ 2	+	+ +	+ + + +
TEUCRIUM TRIFIDUM			+ +		+ +	+ + +
ARISTIDA CANESCENS			1	+ 1	+	+ +
CYPERUS SP.			+	+		+ +
SPESIEGROEP 10						
ZIZIPHUS MUCRONATA		+ + +	+ +	1 1 +	2 1 + 2	+ 1 + 3
PAPPEA CAPENSIS		+ + + +	+ 2 1	+	+ + +	+ +
EHRETIA RIGIDA		+ +	+ +	+	+ 1 +	+ + +
SPESIEGROEP 11						
PELLAEA CALOMELANOS	+ + +	+ + +	+ + +	+ +	+ + +	+ +
RHYNCHELYTRUM REPENS	+ 1	+ + +	+ +	+ + +	+ 1 +	+ + +
THEMEDA TRIANDRA	1 1	+	+	+ + +	+ + + +	+ 1 1 +
RHUS LEPTODICTYA	+ +	+ + + + R	+ 1		+ + +	2 +
DOMBEYA ROTUNDIFOLIA	+ +	+ 1 +	1 + 1	1	+ +	+ +
COMMELINA AFRICANA	+ +	+ +	+	+ + +	+ +	+ + +
SOLANUM CAPENSIS	+ +	1 R +	+ +	+	+	+ +
ERAGROSTIS CURVULA	1 2 2	+		+ 2 +	+	1 + 2
EUCLEA CRISPA	+	+		+ 1	+ +	+ 1
GREWIA FLAVA	+	+	+ +		1 +	+ +
MAYTENUS HETEROPHYLLA	1	+ +	+	+	+ +	+
HIBISCUS TRIONUM		+		+	+	+ +
LEPIDIUM BONARIENSIS.		+	+	+	+	+
PHYLLANTHUS PARVULUS	+	+		+	+ +	

ALGEMENE SPESIES MET 'n FREKWENSIE VAN MINDER AS VYF IS NIE IN DIE TABEL INGESLUIT NIE.

5. die *Acacia caffra-Ziziphus mucronata*-savanne teen noordfronthellings op alkaligraniet en
6. die *Acacia karroo-Ziziphus mucronata*-savanne op alluvium.

Die ligging van die ses plantgemeenskappe in die landskap, met hulle geassosieerde habitat (gesteente en aspek), word in figuur 2 aangedui.



FIGUUR 2: Deursnitprofiele langs A–B en C–D (bo) en E–F (onder) soos aangedui op figuur 1. Die ligging van die ses plantgemeenskappe word aangedui deur 1–6.

BESPREKING

1. Die *Nuxia congesta-Rhus magalismontanum*-savanne

Hierdie savanne, wat met kwartsiet geassosieer is, word uitsluitlik hoog op teen suidfronthellings aangetref. Uitgestrekte kwartsietriwwe is hier blootgestel en rots en klippe bedek tot 90% van die grondoppervlakte. Die spesies van spesiegroep 2 (tabel 1) is hoofsaaklik tot hierdie habitat beperk en kan dus binne die studiegebied as indikators van die betrokke habitat beskou word. Die boomstratum is gemiddeld 3,1 m hoog, met 'n kroonbedekking van gemiddeld 20,3% (tabel 2). Die opvallendste boomspesies is *Protea caffra, Acacia caffra, Combretum molle* en *Rhus leptodictya.*

Die struikstratum wat gemiddeld 1,7 m hoog is, bedek gemiddeld 23,3%. Prominente struike sluit *Nuxia congesta, Pavetta zeyheri, Tapiphyllum parvifolium, Vangueria infausta, Maytenus tenuispina,* en die dwergstruike *Rhus magalismontanum, Indigofera comosa* en *Helichrysum kraussii* in.

TABEL 2
Die gemiddelde hoogte (H) en gemiddelde kroonbedekking (K) van die boom-, struik- en kruidstratums van die ses plantgemeenskappe wat onderskei is

Stratum	boom		struik		kruid	
Gemeenskap*	H (m)	K %	H (m)	K %	H (m)	K %
1	3,1	20,3	1,7	23,3	0,76	36,6
2	4,7	15,0	1,6	11,8	0,69	16,6
3	4,5	27,5	1,5	17,5	0,65	17,5
4	4,4	9,0	1,6	8,3	0,66	45,0
5	5,25	16,2	2,5	12,5	0,60	47,5
6	5,5	16,6	1,65	7,25	0,70	45,0

* Kyk by teks vir name van plantgemeenskappe

Die kruidstratum is gemiddeld 0,76 m hoog en besit 'n kroonbedekking van gemiddeld 36,6%.

Die prominente grasspesies sluit *Eragrostis curvula, Loudetia simplex, Setaria lindenbergiana, Themeda triandra* en *Rhynchelytrum repens* in. Ander opvallende kruide is *Commelina benghalensis, C. africana, Tephrosia semiglabra* en die xerofitiese varing *Pellaea calomelanos.*

2. Die *Nuxia congesta-Combretum molle*-savanne

Hierdie plantgemeenskap, wat met kwartsiet geassosieer is, is tot die warm, droë, klipperige en rotsagtige noordfronthellings beperk. Kwartsietriwwe en rotse bedek 91% van die grondoppervlakte. Geen spesiegroep (tabel 1) is slegs tot hierdie plantgemeenskap beperk nie, maar die gemeenskap kan maklik aan die gesamentlike teenwoordigheid van spesiegroep 1, 5 en 10 geïdentifiseer word.

Die boomstratum is gemiddeld 4,7 m hoog met 'n gemiddelde kroonbedekking van 15,0%. Die dominante boom is *Combretum molle,* terwyl *Acacia caffra, Pappea capensis, Ziziphus mucronata, Rhus leptodictya* en *Dombeya rotundifolia* dikwels opvallend teenwoordig is.

Die struikstratum is nie sterk ontwikkel nie en bedek gemiddeld slegs 11,8%. Die gemiddelde hoogte is 1,6 m. Die opvallendste struike sluit *Nuxia congesta, Pavetta zeyheri, Tapiphyllum parvifolium, Vangueria infausta, Maytenus heterophylla* en *Ehretia rigida* in.

Op hierdie droë en klipperige habitat is die kruidstratum swak ontwikkel, met 'n gemiddelde hoogte van 0,69 m en 'n kroonbedekking van slegs 16,6%. Geharde grassoorte soos *Setaria lindenbergiana, Aristida congesta, Rhynchelytrum repens* en *Enneapogon pretoriensis* is lokaal dominant. Ander kruide word slegs sporadies aangetref, maar *Selaginella dregei* is opvallend teenwoordig.

3. Die *Acacia caffra-Enneapogon scoparius*-savanne

Hierdie plantgemeenskap is tot die kwartsietpuin teen die noordfronthellings beperk. Die puin bestaan uit los kwartsietrotsblokke en klippe wat 90% van die grondoppervlakte bedek. Die plantegroei word deur die spesies van spesiegroep 3 (tabel 1) gekarakteriseer en hierdie spesies kan weens hulle beperkte verspreiding in die studiegebied as indikators in hierdie habitat beskou word. Die boomstratum is sterk ontwikkel met 'n gemiddelde hoogte van 4,5 m en 'n gemiddelde kroonbedekking van 27,5%. Prominente bome is *Acacia caffra*, *Combretum molle* en *Pappea capensis*, terwyl *Brachylaena rotundata*, *Ziziphus mucronata*, *Rhus leptodictya*, *Dombeya rotundifolia* ook aangetref word.

Die struikstratum is gemiddeld 1,5 m hoog en besit 'n kroonbedekking van 17,5%. Die opvallendste struike is *Zanthoxylum capense*, *Ehretia rigida* en *Grewia flava*.

Soos in die *Nuxia congesta-Combretum molle*-savanne is die kruidstratum hier ook swak ontwikkel, met 'n gemiddelde kroonbedekking van slegs 17,5% en 'n gemiddelde hoogte van 0,65 m. Die opvallendste grasse is *Aristida congesta*, *Enneapogon scoparius* en *Rhynchelytrum repens*. Ander kruide sluit *Melhania prostrata*, *Tephrosia burchellii* en *Pellaea calomelanos* in.

4. Die *Diospyros lycioides-Sporobolus fimbriatus*-savanne

Hierdie plantgemeenskap word op alkaligraniet laer af teen die suidfronthellings aangetref (figuur 2). Die alkaligraniet dagsoom hier as plate, en hierdie plate en groot rotsblokke bedek sowat 88% van die grondoppervlakte.

Die spesies van spesiegroep 4 (tabel 1) is hoofsaaklik tot hierdie habitat beperk en kan dus as indikatorspesies beskou word.

Die swak ontwikkelde boomstratum het 'n kroonbedekking van slegs 9,0%. Die bome is gemiddeld 4,5 m hoog. Die prominentste bome is *Ziziphus mucronata*, *Brachylaena rotundata* en *Rhus pyroides*, terwyl *Acacia caffra*, *Pappea capensis* en *Combretum molle* ook aangetref word.

Die struikstratum wat gemiddeld 1,6 m hoog is, is ook swak ontwikkel en het 'n gemiddelde kroonbedekking van 8,3%. Die prominentste struike is *Diospyros lycioides*, *Tapiphyllum parvifolium*, *Pavetta zeyheri*, *Vangueria infausta* en *Euclea crispa*.

Die sterker ontwikkelde kruidstratum bedek gemiddeld 45% van die grondoppervlakte en het 'n gemiddelde hoogte van 0,66 m. Die opvallendste kruide sluit *Cheilanthes hirta*, *Conyza podocephala*, *Asclepias decipiens* en *Gnidia capitata* in. Verskeie grasspesies byvoorbeeld *Sporobolus fimbriatus*, *Aristida canescens*, *Elionurus muticus*, *Cynodon dactylon*, *Rhynchelytrum repens* en *Themeda triandra* is prominent in die plantgemeenskap.

5. Die *Acacia caffra-Ziziphus mucronata*-savanne

Hierdie savanne is op alkaligraniet teen noordfronthellings geleë. Die hellings is oor die algemeen nie so steil of so klipperig soos die suidfronthellings nie. Nogtans is gemiddeld steeds 73% van die grondoppervlakte met rotsplate en klippe bedek. Uit tabel 1 blyk dit dat geen van die spesiegroepe slegs tot hierdie plantgemeenskap beperk is nie. Die gemeenskap word egter deur die gesamentlike teenwoordigheid van spesiegroepe 5 en 7 gekarakteriseer.

Die boomstratum wat gemiddeld 5,25 m hoog is en 'n gemiddelde kroonbedekking van 16,2% besit, word deur *Ziziphus mucronata* en *Acacia caffra* gedomineer. Ander bome wat ook hier teenwoordig is, sluit *Brachylaena rotundata*, *Pappea capensis*, *Celtis africana*, *Rhus pyroides* en *Dombeya rotundifolia* in.

Die struikstratum is gemiddeld 2,5 m hoog en bedek gemiddeld 23,5%. Prominente struike is *Pavetta zeyheri*, *Vangueria infausta*, *Maytenus tenuispina*, *Diospyros lycioides*, *Ehretia rigida*, *Rhus leptodictya*, *Grewia flava* en *Maytenus heterophylla*.

Die kruidstratum besit 'n relatief hoë gemiddelde kroonbedekking van 47,5% en is gemiddeld 0,6 m hoog. Opvallende kruide is *Protasparagus suaveolens*, *Pellaea calomelanos*, *Ruellia patula* en *Teucrium trifidum*. Die prominentste grasse sluit *Setaria flabellata*, *Heteropogon contortus*, *Elionurus muticus*, *Cynodon dactylon*, *Rhynchelytrum repens* en *Themeda trianda* in.

6. Die *Acacia karroo-Ziziphus mucronata*-savanne

Hierdie plantgemeenskap word aan die voet van die rante op alluvium en kolluvium aangetref. Los klippe bedek 43,7% van die grondoppervlakte, dit is die laagste persentasie klipperigheid wat oor die hele studiegebied aangetref is. Die klei-inhoud van die grond is hier ook hoër as by die ander gronde in die studiegebied.

Hierdie plantgemeenskap word deur spesiegroep 6 gekarakteriseer. Binne die studiegebied kan hierdie spesies as indikators vir hierdie tipe habitat beskou word.

Die sterk ontwikkelde boomstratum, waarin *Acacia karroo* die dominante boomsoort is, is gemiddeld 5,5 m hoog en het 'n gemiddelde kroonbedekking van 16,6%. *Ziziphus mucronata* is ook prominent, terwyl *Pappea capensis*, *Celtis africana*, en *Rhus leptodictya* ylverspreid aangetref word.

Die struikstratum daarenteen is swak ontwikkel met enkele indiwidue van *Ehretia rigida*, *Diospyros whyteana*, *Euclea crispa* en *Grewia flava* wat hier en daar aangetref word. Die dwergstruik *Ziziphus zeyheriana* neig om op oorbeweide en versteurde kolle in groepe te groei. Die semihoutagtige *Clematis brachiata* rank prominent in sommige van die bome en struike.

Hoewel die plantegroei tekens van vroeëre oorbeweiding toon, is die kruidstratum tog goed ontwikkel, met 'n gemiddelde kroonbedekking van 45% en 'n gemiddelde hoogte van 0,7 m. Die prominentste grassoorte is *Themeda triandra*, *Aristida congesta*, *A. canescens*, *Eragrostis curvula*, *Trachypogon spicatus*, *Elionurus muticus*, *Cynodon dactylon*, *Setaria flabellata* en *Brachiaria serrata*. Ander kruide wat dikwels aangetref word, is *Dicoma gerrardii*, *Corchorus asplenifolius*, *Chascanum hederaceum* en *Hermannia depressa*.

GEVOLGTREKKING

Die plantegroei is suksesvol deur middel van die TWINSPAN-numeriese tegniek en daaropvolgende verfyning met die Braun-Blanquet-tegniek in ekologies verantwoordbare plantgemeenskappe verdeel. Verder is dit duidelik dat die tegniek suksesvol aangewend is om indikatorspesies vir die verskillende habitattipes te identifiseer. So kon indikatorspesies in die geval van plantgemeenskappe 1, 3, 4 en 6 geïdentifiseer word, terwyl plantgemeenskap 2 (op kwartsiet) en 5 (op alkaligraniet) wat tot noordfronthellings beperk is, aan spesifieke kombinasies van wyer verspreide spesies herken kan word.

Hierdie resultate toon die moontlikheid dat spesifieke gesteentes aan die teenwoordigheid van sekere plantspesies uitgewys kan word, terwyl die belangrikheid van gesteentes as ekologiese faktor wat met die verspreiding van plantgemeenskappe gekorreleer is, beklemtoon word.

Ontvang 8 Okt. 1987; aanvaar 1 Des. 1987.

LITERATUURVERWYSINGS

1. Elsenbroek, J.H. (*in prep.*). *Die petrologie en struktuur van die alkaligraniet in die Vredefortkoepel noordwes van Parys* (M.Sc.-verhandeling, PU vir CHO, Potchefstroom).
2. Acocks, J.P.H. (1975). Veld types of South Africa, *Mem. Bot. Opn. S. Afr.*, 40, 1–128.
3. Bredenkamp, G.J. & Theron, G.K. (1978). A synecological account of the Suikerbosrand Nature Reserve I. The phytosociology of the Witwatersrand geological system, *Bothalia*, 12, 513–529.
4. Bredenkamp, G.J. & Theron, G.K. (1980). A synecological account of the Suikerbosrand Nature Reserve II. The phytosociology of the Ventersdorp geological system, *Bothalia*, 13, 199–216.
5. Coetzee, B.J. (1974). A phytosociological classification of the Jack Scott Nature Reserve, *Bothalia*, 11, 329–347.
6. Morris, J.W. (1977). Automatic classification of the highveld grassland of Lichtenburg, south-western Transvaal, *Bothalia*, 12, 267–292.
7. Du Preez, P.J. (1978). *Ekologie van die boomgemeenskappe van die Vredefortdistrik, Oranje-Vrystaat* (M.Sc.-verhandeling, Universiteit van die Oranje-Vrystaat, Bloemfontein).
8. Westhoff, V. & Van der Maarel, E. (1978). The Braun-Blanquet approach. In *classification of plant communities*, Whittaker, R.H. ed. Dr. W. Junk, The Hague, p. 287–399.
9. Hill, M.O. (1979). TWINSPAN – *a fortran program for arranging multivariate data in an ordered two way table by classification of individuals and attributes* (Cornell University, Ithaca, New York).

4.2 A reconnaissance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area.

* Published: *South African Journal of Botany* 55(2): 199 - 206.

S.Afr.J. Bot., 1989, 55(2): 199–206

A reconnaissance survey of the vegetation of the plains in the Potchefstroom–Fochville–Parys area

G.J. Bredenkamp*, A.F. Joubert and H. Bezuidenhout

Department of Botany, University of Pretoria, Pretoria, 0002 Republic of South Africa and Grasslands Research Centre, c/o Highveld Agricultural Region, Private Bag X804, Potchefstroom, 2520 Republic of South Africa

Accepted 23 August 1988

As part of a research programme on the synthesis of the vegetation of the western Grassland Biome, the plant communities of the Potchefstroom–Fochville–Parys area were investigated. The results of a numerical classification (TWINSPAN) of 52 relevés were refined by Braun–Blanquet procedures. The analyses revealed seven plant communities which may be grouped into three major plant communities. A hierarchical classification, description and ecological interpretation of the plant communities distinguished, are presented.

Die plantgemeenskappe van die Potchefstroom–Fochville–Parysgebied is as deel van 'n navorsingsprogram oor 'n sintese van die plantegroei van die westelike Grasveldbioom, ondersoek. Die resultate van 'n numeriese klassifikasie (TWINSPAN) van 52 relevés is met Braun–Blanquet prosedures verfyn. As resultaat is sewe plantgemeenskappe, wat in drie hoofplantgemeenskappe gegroepeer kan word, onderskei. 'n Hiërargiese klassifikasie, beskrywing en ekologiese interpretasie van die plantgemeenskappe word aangebied.

Keywords: Classification, plant communities, western Grassland Biome

*To whom correspondence should be addressed

Introduction

In a description of the Grassland Biome Project, Mentis & Huntley (1982) stated the necessity to identify and determine the location and extent of the major vegetation types and subtypes within the Biome. Scheepers (1987) emphasized this need and as a result a phytosociological research programme, which included a number of projects on the classification and description of western grassland vegetation, was initiated. A first step in the synthesis of the vegetation of the western Grassland Biome is to initiate and create a phytosociological data base for the entire area. As no data, except for broader descriptions by Louw (1951) and Acocks (1975), existed for the Potchefstroom–Fochville–Parys region, this area was identified as a priority area for phytosociological surveying. In this report the results of a reconnaissance survey of the vegetation of the flat or slightly undulating plains, representing the Bc Land Type (Land Type Survey Staff 1984) is presented. The aim of the project was to identify, characterize and describe the plant communities of the area concerned. The results should contribute significantly to the ultimate aim of a phytosociological synthesis of the western Grassland Biome.

The study area

The location of the area is given in Figure 1. The area covers approximately 138 000 ha. Almost 85% of the land has been ploughed, mainly for maize cultivation. Natural vegetation is mostly confined to shallow, rocky, non-arable soils. According to the Köppen classification system (Schulze & McGee 1978) the area has a BShw climate, ie. a cool dry steppe with summer rains. The rainfall is erratic but the mean annual rainfall exceeds 600 mm (Potchefstroom—625 mm, Carletonville—670 mm, Van der Bijl Park—677 mm; Weather Bureau 1986). Summer temperatures are high, the mean maximum monthly temperatures exceed 32°C during October to January, whilst the mean minimum monthly temperatures are below –1°C during the months June to August (Weather Bureau 1986).

The entire area is drained by the Loopspruit and its tributaries (Figure 1). The north-western part of the area is a flat plain, 1 350–1 450 m above sea level. The predominant red Hutton Form soils of this area are derived from alluvium or Pretoria Group shales (Transvaal Sequence), and younger diabase intrusions (Figure 2). This area represents the Bc25c Land Type and also includes the northern part of the Bc36a Land Type (Figure 1). Towards the south and south-east the landscape becomes increasingly more undulating and the altitude gradually increases to almost 1 650 m. The shallow and more rocky soils of the Glenrosa and Mispah soil Forms are mostly derived from Daspoort, Strubenkop and Timeball Hill quartzites and shales or from Hekpoort andesitic lava, all of the Pretoria Group (Transvaal Sequence) (Figure 2). In the southern part of the study area a narrow strip Malmani dolomite and chert, representing the Fa Land Type, occurs (Figures 1 & 2). The Hutton or Mispah Form soils of this flat plain are usually too shallow for maize cultivation, and rocky outcrops of dolomite and chert are abundantly present. The vegetation of the rugged hills and ridges of the Fb, Ib and Ba Land Types was not included in this study (Figure 1).

Methods

Relevés were compiled in 52 stratified random sample

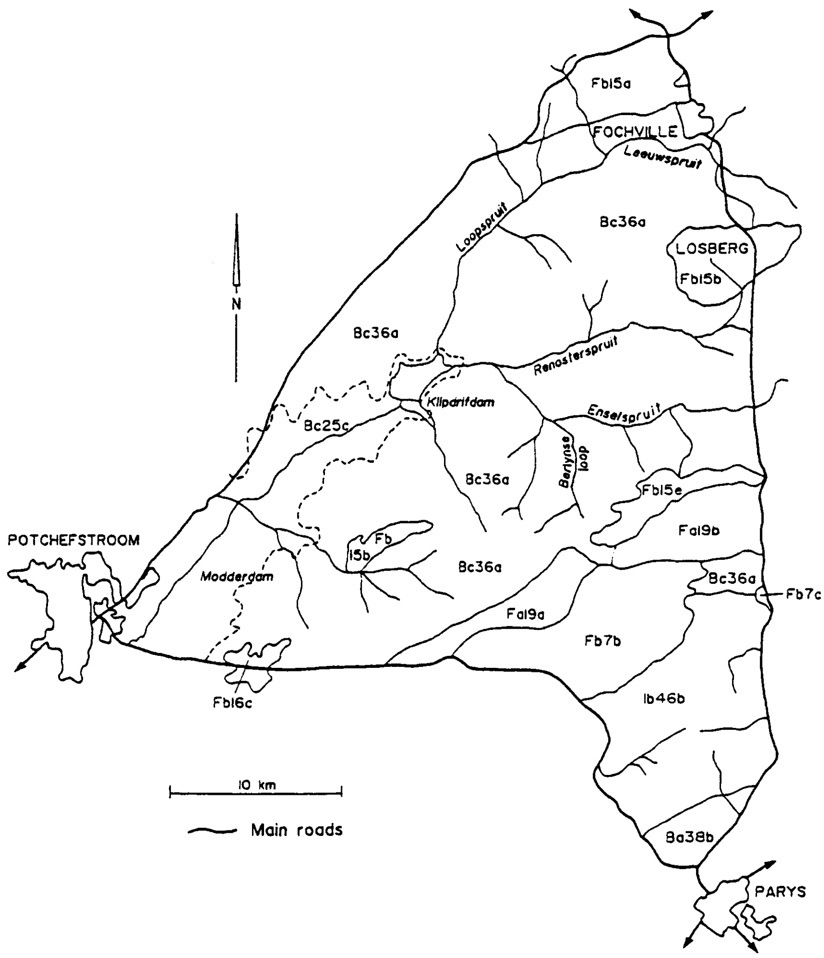


Figure 1 Drainage lines and land types within the study area.

plots. In accordance with Bredenkamp & Theron (1978), plot sizes were fixed on 16 m^2 for grassland vegetation and 100 m^2 for woody vegetation. Stratification of the area was done on 1:150 000 scale areal photographs, on the basis of relatively homogeneous physiographic and/ or physiognomic units. Sample plots were divided among these units *pro-rata* on an area basis. In each sample plot total floristic composition, using the Braun–Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974) was noted. Taxon names and taxon author names conform to those of Gibbs-Russel *et al.* (1985, 1987), except that *Setaria flabellata* Stapf. and *S. sphacelata* (Schumach.) Moss were distinguished as two separate taxa. Additionally the height and cover of the tree, shrub and herbaceous layers were noted. Environmental information included geological formation, soil type, aspect, slope and rockiness of the soil surface. Other soil properties were obtained from Land Type Survey Staff (1984).

Two-way indicator species analysis (TWINSPAN) (Hill 1979) was applied to the floristic data set in order to derive a first approximation of the vegetation types of the area. Refinement of this classification was done by the application of Braun–Blanquet procedures. The results are presented in a phytosociological table (Table 1).

Results

The analyses resulted in the recognition of seven plant communities, which may be grouped into three major community types. The hierarchical classification of these communities is as follows:

1. *Acacia karroo* Woodland on gradual hillslopes and in bottomland situations along river banks.
1.1. *Sporobolus africanus–Acacia karroo* Woodland along river banks.
1.2. *Aristida canescens–Acacia karroo* Woodland on gradual footslopes of quartzite hills.
2. *Heteropogon contortus–Themeda trianda* Grassland on flat plains and slightly undulating landscapes.
2.1. *Heteropogon contortus–Themeda triandra–Trachypogon spicatus* Grassland on shallow, rocky soils of the undulating landscape.
2.1.1. *Hermannia lancifolia* variant on shallow, rocky soils on dolomite.
2.2. *Heteropogon contortus–Themeda triandra–Elionurus muticus* Grassland on deep (not rocky) soils of the flat plains.
3. *Aristida bipartita–Eragrostis plana* Grassland restricted to seasonally wet bottomland situations and shallow drainage lines.
3.1. *Aristida bipartita – Eragrostis plana – Elionurus*

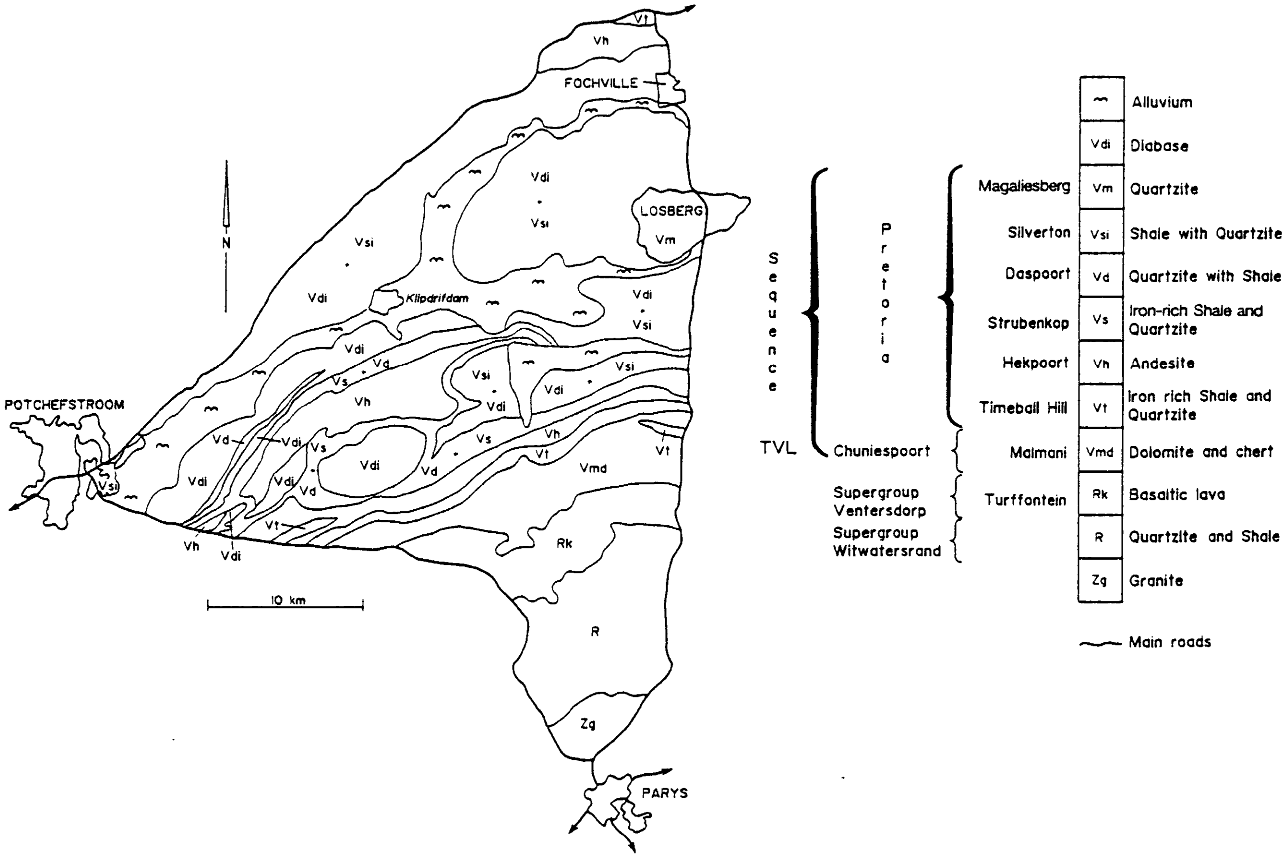


Figure 2 A simpified geological map of the study area (Adapted from Geological Survey 1986).

muticus Grassland of relatively well drained, drier situations (transitional to community 2.2).

3.2. *Aristida bipartita–Eragrostis plana–Setaria sphacelata* Grassland of poorly drained, wet situations.

A summary of the vegetation structure of the plant communities distinguished is presented in Table 2. All vegetation height and canopy cover values referred to in the text are averages for the particular plant community.

1. The *Acacia karroo* Woodland

This community corresponds to the Thornveld briefly described by Louw (1951). Within the study area the *Acacia karroo* Woodland is mostly associated with moderately deep, often clayey (up to 55% clay) alluvial, colluvial or even aeolian soils of recent origin. These soils were deposited on the gradual footslopes of quartzite hills and ridges or on the directly adjacent plains. These soils often represent the Hutton or Shortlands Forms. This Woodland also occurs on the banks of some dry rivulets, especially in upland situations in the catchment areas, near the origins of these water courses. The encroachment of the *Acacia karroo* Woodland into areas not previously occupied by woody vegetation, and the increase of *Acacia karroo* and associated species in areas where they have held a subordinate position in the floristic composition, hamper the habitat interpretation of this community. The increase of *Acacia karroo* vegetation is usually associated with changes in the competitive balance between grass and bush (Louw 1951), brought about by changes in the grazing and/or fire regimes in the management of grasslands (Friedel 1987). Areas occupied by *Acacia karroo* Woodland are often overgrazed and the advanced stage of degradation is indicated by large areas of bare, compacted soil.

The *Acacia karroo* Woodland is characterized by species group A (Table 1) and diagnostic species are *Acacia karroo, Rus pyroides, Protasparagus laricinus, P. suaveolens, Teucrium trifidum, Pavonia burchelli* and *Acacia caffra.*

The vegetation is entirely dominated by tall *Acacia karroo* trees, with a canopy cover of up to 30%. Other woody species include *Rhus pyroides* and sometimes *Acacia caffra.* Locally, on severely degraded areas, *Protasparagus suaveolens, P. laricinus, Aloe davyana* and sometimes *Ziziphus zeyheriana* occur abundantly, and these species seem to increase under conditions of severe overgrazing.

Grasses often found in this community include *Digitaria eriantha, Elionurus muticus, Setaria flabellata, Themeda triandra, Eragrostis curvula, E. racemosa* and *Hyparrhenia hirta.* The presence and high constancy of pioneer grasses such as *Cynodon dactylon, Aristida congesta, Tragus berteronianus* and *Eragrostis obtusa* emphasize the poor condition of this vegetation.

Forbs which are constantly present include the diagnostic *Teucrium trifidum* and *Pavonia burchellii* and also

Table 1 A phytosociological table of the plant communities of the plains in the Potchefstroom–Fochville–Parys area. Species which occur less than four times are excluded from the table

Relevé number	012	013	002	030	048	051	052	049	043	024	003	001	026	027	010	025	008	009	011	014	028	029	031	036	039	016	017	019	020	023	041	044	045	047	006	038	050	035	004	034	015	037	005	040	007	021	018	022	032	033	042	046
Plant community number	1.1		1.2							2.1.1					2.1												2.2									3.1							3.2									
Species group A																																																				
Acacia karroo	4	4		2	2	2	3	3	2																																												
Rhus pyroides	+	+		+	+	+			+										+																											
Protasparagus laricinus	3	+		+			+		+																																										
Protasparagus suaveolens		3	1	+	+		+	+		+										+																+										+	+					
Teucrium trifidum	+	+	+			+	+	+				+								+				+				+	+																			
Pavonia burchellii	+	+						+	+																																										
Acacia caffra		2	2	+																																															
Species group B																																																				
Sporobolus africanus	2	3																																																	
Protasparagus africanus	3	3																																																	
Species group C																																																				
Aristida canescens				+		1	+	+	+									+			+		+			+		+												+												
Vangueria infausta				+					+																																											
Diosporos lycioides			1	+																																															
Ehretia rigida			+	+																																															
Rhus lancea				+			+																																												
Species group D																																																				
Heteropogon contortus			+	+						1	+	+	+			+	+		+	1		+		+		+	+	+	1	+		+			+		+				+										+
Helichrysum rugulosum								+				+					+	+	+			+	+			+		+	+	+	+	+	+	+	+	+		+				+										
Brachiaria serrata											+	+	+	+		+				+		+		+	+			+		+		+	+					1	+		+										
Cymbopogon plurinodis							+	+	+	+		+				+					+						+	+	1		+	+		+							1						+				
Helichrysum miconiifolium								+			+	+	+			+				+	+	+	+		+	+	+		+					+							+										
Ledebouria marginata			+						+	+	+			+		+					+					+		+	+	+	+							+					+										
Trichoneura grandiglumis								+						+	+			+	+	+	+			+	+				+		+						+																
Eragrostis superba			+					+		+											+			+		+				+							+														
Species group E																																																				
Rhynchelytrum repens					+				+		+	+	+		+	+	+	+		+		+		+	+	+								+		+															
Trachypogon spicatus											+		+	+	+			+	+		+	+	1							+				+								+				+						
Triraphis andropogonoides											+		+		+	+		+		+	+	+																+															
Senecio venosus											+			+		+					+	+	+													+										+						
Solanum incanum														+		+	+	+	+				+															+		+														
Stoebe vulgaris												+	1			+	+	+			+			+		+				+			2																			
Gnidia capitata					+									+	+	+	+						+	+						+					+			+																+
Schizachyrium sanguineum											+			+	+					+																												
Tephrosia longipes															+		+				+																												
Species group F																																																				
Hermannia lancifolia											+	+	+	+						+																												
Becium obovatum											+	+	+	+																															+								
Diheteropogon amplectens				+					+		+		+	+									+													+																	
Leucas capensis											+	+	+	+	+																																		
Hypoxis rigidula													+	+																	+																					
Species group G																																																				
Elionurus muticus				+	+	+	+	+	+	+	2	2	1	2	+	+	2	+		+	+	+	+	+	+	2	+	1	+	+	1	+	2	+	+				2	+		1						+				+
Aristida congesta	+	+	+		+		1		+	1		+	+	+	+	+	+	+	+	3	+	+		2	+	+	+		+	+	+	+		+		+	+	+		+													
Setaria flabellata			+	+	+		+	+	+	+	+	2		+		+	+	+				+	+		+	+	+	+	+	+			+	+	+	+	+	+	2		+	+										
Hermannia depressa	+	+			+		+			+					+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+			+		+		+		+		+										
Vernonia oligocephala							+		+	+	+		+		+		+			+		+	+	+	+			+	+		+	+			+	+				+			+							+		+	
Ziziphus zeyheriana		+				+			+	+		+	+			+	+	+						+				+		+	+	+	+	+	+	+			+				+										
Eragrostis racemosa					+	+		+			+	+		+	+	+		+	+		1		+						+		1			+	+	+	+						+										
Crabbea acaulis				+	+		+			+				+		+		+			+	+			+	+	+	+	+	+	+		+							+			+											+	
Felicia muricata			+				+	+	+	+		+			+	+					+		+		+		+		+	+	+															+								
Bulbine narcissifolia			+					+		+		+												+				+			+	+	+						+	+															

Table 1 Continued

Relevé number	00 11 23	0000000 0345544 2081293	00000 20022 43167	000000000000 120011223331 058914891696	000000000 112244440 790314576	0000000 3530313 8054457	0000000000 0402123344 5071822326
Plant community number	1.1	1.2	2.1.1	2.1	2.2	3.1	3.2
Species group H							
Eragrostis plana				+ +	+ +	+ ++ ++	33 ++++2
Aristida bipartita		+	+			+++2	+1 2+
Berkheya radula		+	+	+		+++ ++	++ +++ +
Oenothera rosea			+			+ ++ +	+ ++ +++
Species group I							
Setaria sphacelata	+			+		+ +	1++++3+
Haplocarpha scaposa						+	+ + +++ +
Falkia oblonga						+	+ ++ +
Euclea crispa		+				+	+ +
Geigeria burchellii				+		+	++
Berkheya radula							+1++
Sporobolus fimbriatus		+					+ + +
Setaria nigrirostris	+		+			+	+
Cyperus species						+	++
Juncus species							+ +
Kniphofia typhoides			+				+
Hyperthelia dissoluta							3
Hemarthria altissima							+
Species group J							
Themeda triandra	+	42+2+	+14++	+13++ + 2132	321134+3+	34311+2	++ 3 4+421
Eragrostis curvula		++++	+ ++2	12++2 +++21	2 ++ 11	11 + +	1 + + 1
Cynodon dactylon	++	1 ++1+1	+	+ + + +	+++1 +	++1 +++	1 ++1++
Digitaria eriantha	++	+ ++ +1	+ ++	++ +1 +	+ +++	1++ + +	+ + ++
Hyparrhenia hirta		++ +	++	+ + 1 + +	+ + 1	+	11+++ 1
Cymbopogon excavatus		+	++1	++++ 1+	++	++++	+ ++ +
Anthospermum hispidulum			++	+ ++ +++	+ + +	+ + +	+ + +
Tragus berteronianus	+	++ ++	+	+ + ++	+	++ +	
Sida dregei	++	+	+	+	++++ + +		+
Eragrostis chloromelas		1		+ + +	12 + +	1 1	2 +
Menodora africana		+ +	+	++ +	++	++ +	
Blepharis integrifolius		+++	+ +	+ +	+ +	+ +	
Rhynchosia venulosa		+ +		+ +	+ +	+ +	+
Hibiscus pusillus	+	+ ++		++ +	+	++	+
Senecio species			+	+	+ +	+ +	+ +
Aloe davyana	+	1+ +	+1+	+			
Acalypha angustata		+		+ +++	++		
Eragrostis gummiflua		++	+ +	+ +	+		
Chloris virgata		++		+ + +			+ +
Justicia anagalloides			++ +	+	+		+
Crabbea angustifolia	+	+		+ ++		+	
Panicum coloratum		+ +			+	+	+ +
Commelina africana		+ + +		+ + +			
Eragrostis obtusa	++	+	+	++			
Lactuca serriola				+ +	++ +	+	
Pachycarpus schinzianus				++ +	+ +		
Tephrosia species	+		+	+ + +	+		
Monsonia angustifolia		+		+ + +		++	
Convolvulus sagittatus		+		+	+	+	+
Raphionacme hirsutus		+		+ +	+++		
Helichrysum nudifolium				+ +	++	+	
Dicoma zeyheri				+ + +	++		
Hypoxis rooperi		+			+	+ +	
Indigofera species			+ +	+ +			+
Corchorus asplenifolius				+ ++	+		
Ipomoea obscura				++ +	+		
Cyanotis speciosa		+	+	+ +			
Rhynchosia species			++	+			+
Dicoma anomala	+			+ + +			
Ipomoea crassipes		+	+		++		
Pogonarthria squarrosa		+	+	+ +			
Aristida diffusa			+	2 + 1			
Hibiscus trionum		+		++		+	
Gomphrena celosioides			+	+ +	+		

Table 2 Average height and cover values of the tree, shrub and herbaceous layers of the different plant communities

	Stratum					
	Tree		Shrub		Herbaceous	
Community	Height (m)	Cover (%)	Height (m)	Cover (%)	Height (m)	Cover (%)
1.1	7,0	30	2,5	40	0,8	30
1.2	5,5	20	2,0	14	0,8	65
2.1	0	0	0	0	0,6	71
2.1.1	0	0	0	0	0,5	65
2.2	0	0	0	0	1,0	71
3.1	0	0	0	0	0,7	75
3.2	0	0	0	0	1,0	84

Hermannia depressa, Felicia muricata, Lippia scaberrima, Hibiscus pusillus, Veronia oligocephala, Blepharis integrifolius and *Sida dregei*.

Two different communities of fairly similar floristic composition may be distinguished, namely the *Sporobolus africanus–Acacia karroo* Woodland along dry rivulets and the *Aristida canescens–Acacia karroo* Woodland on gradual footslopes of the hills.

1.1 The *Sporobolus africanus–Acacia karroo* Woodland

This occurs on shale or alluvium, on deep, slightly alkaline and sodic soils in local depressions or other bottomland situations, especially on the banks of seasonally dry rivulets. The Willowbrook and Valsrivier soil forms are often associated with these sites. Virtually no rocks occur on the soil surface.

This community is characterized by species group B (Table 1) and diagnostic species include *Sporobolus africanus* and *Protasparagus africanus*, both with high cover-abundance values. An average of 27 species was recorded per sample plot.

The woody component is extremely dense and these sites have been prone to severe increase of *Acacia karroo*. The tree stratum is 7 m tall with a canopy cover of 30% (Table 2). The 2,5-m tall shrub stratum is even more dense, with the canopies covering up to 40% of the area. The herbaceous layer, by contrast, is poorly developed, with a canopy cover of only 30%, and is dominated by *Sporobolus africanus*.

1.2 The *Aristida canescens–Acacia karroo* Woodland

This is usually associated with moderately deep Hutton Form soils on the gradual footslopes of quartzite hills and the adjacent plains. Although the area is not conspicuously rocky, quartzite rocks and boulders occur sporadically.

Species group C (Table 1) characterizes this community and diagnostic species are *Aristida canescens, Vangueria infausta, Diospyros lycioides, Ehretia rigida* and *Rhus lancea*. An average of 29 species was recorded per sample plot.

The woody component of this community is generally lower and less dense than that of the *Sporobolus africanus–Acacia karroo* Woodland (Table 2). A greater variety of woody species occurs in the *Aristida canescens–Acacia karroo* Woodland. These species are mostly the diagnostic woody species mentioned above.

The herbaceous layer is well developed, 0,8 m tall, with a canopy cover of 65%. *Themeda triandra* is mostly dominant, however, locally on overgrazed and disturbed sites the grass layer becomes open and woody species such as *Acacia karroo, Protasparagus suaveolens, P. laricinus* and *Aloe davyana* increase conspicuously.

2. The *Heteropogon contortus–Themeda triandra* Grassland

This extensive grassland community covers most of the study area. It occurs on the moderately deep to deep soils of the flat plains as well as the shallower soils of the gently undulating areas. Most of the grasslands on the deeper soils have been destroyed by ploughing, mainly for maize cultivation and the natural grasslands on the shallower soils have been grazed intensively for many decades.

The *Heteropogon contortus–Themeda triandra* Grassland is often dominated by widespread grass species such as *Themeta triandra, Eragrotis curvula* and *Elionurus muticus* but is characterized within the study area by species group D (Table 1). Diagnostic species are *Heteropogon contortus, Crabbea acaulis, Helichrysum rugulosum, Brachiaria serrata, Cymbopogon plurinodis, Helichrysum miconiifolium, Ledebouria marginata, Trichoneura grandiglumis* and *Eragrostis superba*.

This major grassland community is divided into two community types, namely the *Heteropogon contortus–Themeda triandra–Trachypogon spicatus* Grassland on the shallow, rocky soils of the undulating landscape, representative of Bankenveld (Acocks 1975) vegetation, and the *Heteropogon contortus–Themeda triandra–Elionurus mutucus* Grassland on deeper, not rocky soils of the flat plains, representative of the *Cymbopogon–Themeda* Veld of Acocks (1975) and of the Sweet Veld of Louw (1951).

2.1 The *Heteropogon contortus–Themeda triandra–Trachypogon spicatus* Grassland

This represents most of the natural vegetation in the study area. This community is restricted to the shallow soils of the slightly undulating landscape in the northwestern and south-eastern parts of the study area. These areas are often adjacent to prominent quartzite hills (Fb Land Type) or dolomite plains (Fa Land Type). Rocks or stones cover up to 15% of the soil surface. The vegetation clearly represents the Bankenveld Veld Type of Acocks (1975). The most prominent and abundant grass species include the widespread *Themeda triandra, Eragrotis curvula, Elionurus muticus, Setaria flabellata, Heteropogon contortus* and *Aristida congesta*, but the typical Bankenveld species are conspicuously present.

The vegetation is often not dominated by a single or a few species, but rather consists of a mixture of co-dominants (Louw 1951). An average of 33 species was recorded per sample plot. The vegetation is 0,6 m tall with an average canopy cover of 71% (Table 2).

The community is characterized by species group E (Table 1) and diagnostic species are *Rhynchelytrum repens, Trachypogon spicatus, Triraphis andropogonoides, Stoebe vulgaris, Senecio venosus, Solanum incanum, Gnidia capitata, Chascanum hederaceum, Eustachys paspaloides, Schizachyrium sanguineum* and *Tephrosia longipes*.

The *Hermannia lancifolia* variant (2.1.1) of this community is clearly associated with the narrow strip of dolomite (Fa Land Type, Figure 1) on the outer fringe of the Vredefort Dome. Floristically this variant can be distinguished by the presence of species group F (Table 1), that consists of the diagnostic species *Hermannia lancifolia, Becium obovatum, Diheteropogon amplectens, Leucas glabrata* and *Hypoxis rigidula*. An average of 32 species was recorded per sample plot. These areas are often overgrazed and various stages of degradation of the vegetation may be observed. This degradation is also emphasized by the low average height (0,5 m) and low average cover (65%) of the vegetation. The vegetation is mostly dominated by *Elionurus muticus*.

2.2 *Heteropogon contortus–Themeda triandra–Elionurus muticus* Grassland

This community occurs on flat landscapes, mostly on deep Hutton Form soils, with no rock visible on the soil surface. Most of these soils have been ploughed for maize cultivation. The geology of these flat landscapes mostly comprises extensive alluvium or shale, with intrusive Hekpoort lava or diabase in many areas. Relic patches of this community occur scattered in the study area. These patches of natural vegetation are mostly utilized as pasture and are often overgrazed. The vegetation is floristically relatively poor, with an average of only 24 species per sample plot. No diagnostic species groups could be identified, but the community can be distinguished by the simultaneous presence of species groups D and G and the conspicuous absence of species groups E and H (Table 1).

The grass layer is usually well developed with an average cover of 71% (Table 2). *Themeda triandra* clearly dominates but other grass species such as *Elionurus muticus, Setaria flabellata, Heteropogon contortus, Digitaria eriantha, Cymbopogon plurinodis, Brachiaria serrata* and *Eragrostis racemosa* are well represented in this vegetation. Forbs often present in this community include *Helichrysum rugulosum, Hermannia depressa, Crabbea acaulis, Vernonia oligocephala, Helichrysum miconiifolium* and *Sida dregei*. Locally, where overgrazing has caused degradation, the woody *Ziziphus zeyheriana, the grasses Aristida congesta, Eragrostis curvula* and *Cynodon dactylon* and the xerophytic forb *Felicia muricata* become prominent.

3. The *Aristida bipartita–Eragrostis plana* Grassland

This community is restricted to seasonally wet, poorly drained bottomland situations often found in or adjacent to shallow drainage lines. The clayey soils of these regions often show vertic or melanic properties and are usually not ploughed. However, these areas are mostly severely overgrazed.

The vegetation is characterized by species group H (Table 1), which comprises the diagnostic species *Eragrostis plana, Aristida bipartita, Berkheya radula* and *Oenothera rosea*. The two diagnostic grass species *Eragrostis plana* and *Aristida bipartita* are conspicuously present and are often amongst the dominants. However, the vegetation is locally dominated by the tall-growing *Hyparrhenia hirta* and *Themeda triandra*. *Eragrostis curvula, Cynodon dactylon* or *Digitaria eriantha* may also be locally prominent.

Two floristically different plant communities, associated with differences in drainage regime can be distinguished, namely the *Aristida bipartita–Eragrostis plana–Elionurus muticus* Grassland on relatively better drained, drier situations, representing a transitional phase to the *Heteropogon contortus–Themeda triandra–Elionurus muticus* Grassland of the flat areas and the *Aristida bipartita–Eragrostis plana–Setaria sphacelata* Grassland of poorly drained, wet bottomland situations.

3.1 The *Aristida bipartita–Eragrostis plana–Elionurus muticus* Grassland

The *Aristida bipartita–Eragrostis plana–Elionurus muticus* Grassland occurs on relatively well-drained, drier situations on the fringes of wetter drainage lines or other bottomland situations. It often represents a transitional zone between the *Aristida bipartita–Eragrostis plana–Setaria sphacelata* Grassland in poorly drained, wet bottomland areas and the surrounding *Heteropogon contortus–Themeda triandra* Grasslands.

An average of 22 species was noted per sample plot, the vegetation is 0,7 m tall and has an average canopy cover of 75% (Table 2). This drier vlei community is floristically differentiated from the wetter bottomlands by the presence of species from species groups D and G (Table 1), which also indicates its floristic relationship to the *Heteropogon contortus–Themeda triandra* Grasslands. The more prominent of these differential species include *Heteropogon contortus, Brachiaria serrata, Elionurus muticus, Aristida congesta, Setaria flabellata* and *Cymbopogon plurinodis*.

3.2 The *Aristida bipartita – Eragrostis plana – Setaria sphacelata* Grassland

This vlei community occurs on poorly drained, wet bottomland situations, mostly on the vertic soils of the Arcadia or Rensburg Forms. These habitats are fairly unstable owing to seasonal flooding and drying, which together with the frequent overgrazing of these sites caused the advanced state of degradation of the vegetation.

The vegetation is characterized by species group I (Table 1). Diagnostic species include the prominent and tall-growing *Setaria sphacelata* and species such as *Haplocarpha scaposa, Falkia oblonga, Berkeya radula, Sporobolus fimbriatus, Setaria nigrirostris, Kniphofia typhoides, Juncus* spp. and *Cyperus* spp., and locally also *Hyperthelia dissoluta* and *Hemarthria altissima*. Although an average of only 18 species was recorded per sample plot, the vegetation is often well developed, up to 1 m tall and with an average canopy cover of 84% (Table 2). Patches of vegetation, dominated by a single or a few grass species are conspicuously present. Species which dominate the vegetation locally are mostly *Themeda triandra, Hyparrhenia hirta, Setaria sphacelata, Aristida bipartita, Eragrostis plana* or *Eragrostis curvula. Cynodon dactylon* is often abundant, indicating the state of degradation of this vegetation.

Conclusions

Because ecologically sound plant communities were distinguished in this reconnaissance survey, the general description and proposed classification of the vegetation could serve as a basis for further detailed phytosociological investigations in the western Grassland Biome. Although the description of the plant communities is based on a hierarchical classification, no attempt was made to formally fix names or ranks of syntaxa, as the adjacent vegetation is inadequatly known. However, the descriptions and ecological interpretations of the plant communities distinguished contribute significantly to the present knowledge of the western Transvaal grasslands, and should be useful in a phytosociological synthesis of these grasslands. Of special interest is that two veld types are represented by two grassland communities, which are grouped into a major grassland community. The floristically and physiognomically different woodland and grassland of bottomlands represent major communities but are, due to scale, not separable as veld types.

Acknowledgement

The CSIR (FRD) is thanked for financial support.

References

ACOCKS, J.P.H. 1975. Veld types of South Africa. *Mem. Bot. Surv. S. Afr.* 40: 1–128.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve. I: The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513–529.

FRIEDEL, M.H. 1987. A preliminary investigation of woody plant increase in the western Transvaal and implications for veld assessment. *J. Grassld. Soc. Sth. Afr.* 4: 25–30.

GEOLOGICAL SURVEY, 1986. Geological map, 1:250 000, 2626 Wes Rand, Government Printer, Pretoria.

GIBBS RUSSEL, G.E. *et al.* 1985. List of species of southern African plants. 2nd edn, Part 1. *Mem. Bot. Surv. S. Afr.* 51: 1–152.

GIBBS RUSSEL, G.E. *et al.* 1987. List of species of southern African plants, 2nd edn, Part 2. *Mem. Bot. Surv. S. Afr.*56: 1–270.

HILL, M.O. 1979. TWINSPAN: A fortran program for arranging multivariate data in a ordered two-way table by classification of individuals and attributes. Cornell, New York.

LAND TYPE SURVEY STAFF 1984. Land types of the maps 2626 Wes Rand, 2726 Kroonstad. Mem. agric. nat. Resour. S. Afr. No.4.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. Bot. Surv. S. Afr.* 24: 1–105.

MENTIS, M.T. & HUNTLEY, B.J. 1982. A description of the Grassland Biome Project. S. Afr. Nat. Sci. Prog. Report No. 62, CSIR, Pretoria.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

SCHEEPERS, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on classification and mapping. Ecosystems Prog. Occas. Report Series No. 16, CSIR, Pretoria.

SCHULZE, R.E. & McGEE, O.S. 1978. Climatic indices and classifications in relation to the biogeography of southern Africa. In: Biogeography and ecology of southern Africa, ed. Werger, M.J.A., Vol. 1, Junk, The Hague.

WEATHER BUREAU 1988. Climate of South Africa. Climate statistics up to 1984. WB 40, Government Printer, Pretoria.

4.3 **The phytosociological of the Faan Meintjes Nature Reserve in the western Transvaal grassland, South Africa.**

Page

* Published: *South African Journal of Botany* 56(1): 54 - 64.

The phytosociology of the Faan Meintjes Nature Reserve in the western Transvaal grassland, South Africa

G.J. Bredenkamp* and H. Bezuidenhout

Department of Botany, University of Pretoria, Pretoria, 0002 Republic of South Africa and Grassland Research Centre, c/o Highveld Agricultural Region, Private Bag X804, Potchefstroom, 2520 Republic of South Africa

Accepted 3 September 1989

As part of a research programme on the synthesis of the vegetation of the grassland biome, and also as part of a vegetation survey programme of conservation areas of South Africa, the plant communities of the Faan Meintjes Nature Reserve were investigated. A TWINSPAN classification, refined by Braun-Blanquet procedures, revealed eleven plant communities which may be grouped into five community types. A hierarchical classification, description and ecological interpretation of the distinguished plant communities are presented.

As deel van 'n navorsingsprogram oor die sintese van die plantegroei van die grasveldbioom, en ook as deel van 'n plantegroei-opname van bewaringsgebiede in Suid-Afrika, is die plantgemeenskappe van die Faan Meintjes-natuurreservaat ondersoek. 'n TWINSPAN-klassifikasie, verfyn deur die toepassing van Braun-Blanquet-prosedures, toon elf plantgemeenskappe wat in vyf plantegroeitipes gegroepeer kan word. 'n Hiërargiese klassifikasie, beskrywing en ekologiese interpretasie van die plantgemeenskappe word aangebied.

Keywords: Classification, conservation area, grassland biome, plant communities, western Transvaal

*To whom correspondence should be addressed

Introduction

Within the phytosociological research programme under the auspices of the Grassland Biome Project (Mentis & Huntley 1982), vegetation and general ecological surveys of conservation areas are considered to have high priority (Nakor 1979). As part of a vegetation survey programme of conservation areas in South Africa, and also as part of the research programme on the synthesis of the vegetation of the western Grassland Biome (Bezuidenhout 1988; Bredenkamp *et al.* 1989b), a semi-detailed classification and description of the vegetation of the Faan Meintjes Nature Reserve was undertaken. This classification is intended as an ecological basis for the establishment of efficient wildlife management programmes and conservation policies for the Reserve. Being a conservation area, the Reserve also serves as permanent reference area for wider reconnaissance surveys in the western Transvaal grasslands. In a semi-popular publication, Bosch (1985) mapped the vegetation and mentioned some of the plant communities of the Reserve briefly. The aim of this study was to classify, describe and interpret the vegetation of the Reserve ecologically. In this report a Braun-Blanquet classification and description of the vegetation is presented.

The study area

The Faan Meintjes Nature Reserve is located 15 km north-east of Klerksdorp (Figure 1). The Reserve covers approximately 930 ha and is situated at an altitude of approximately 1 300 m. The area is situated in the *Cymbopogon – Themeda* veld (veld type 48) of Acocks (1988).

Climate

According to the Köppen classification the area has a Bs-climate, that is a cool dry steppe with summer rains. The rainfall is erratic, but the average annual rainfall is about 604 mm (Botha & de Villiers 1984; Bosch 1985). The mean daily maximum temperature for Klerksdorp, over a period of 49 years, is 25.6°C and the mean daily minimum 9.3°C. Mean daily maximum temperatures exceed 30°C during December and January, while the daily minimum temperature for July is 0.0°C (Weather Bureau 1988).

Geology, topography and soils

Rock types of the Witwatersrand and Ventersdorp Supergroups are represented on the Reserve (Geological survey 1986). Shale, quartzite and conglomerate of the Hospital Hill and Government subgroups (West Rand group) of the Witwatersrand supergroup form two, more or less parallel, north-east south-west ridges in the south-eastern part of the Reserve. Isolated quartzites and shales of the Orange Grove Formation of this Supergroup occur locally. Rocky outcrops of porphyritic lava and schist, Syferfontein Formation of the Dominion Group, occur in the central and south-eastern parts of the Reserve. These rocky areas represent the Fb Land Type (Land Type Survey Staff 1984).

The slightly undulating north-western part of the area, which represents the Ba Land Type (Land Type Survey Staff 1984) is underlain by the lavas of the Rietgat formation (Platberg group) of the Ventersdorp Supergroup. An isolated outcrop of conglomerate, breccia and shale of this formation occur in the central-western part of the Reserve.

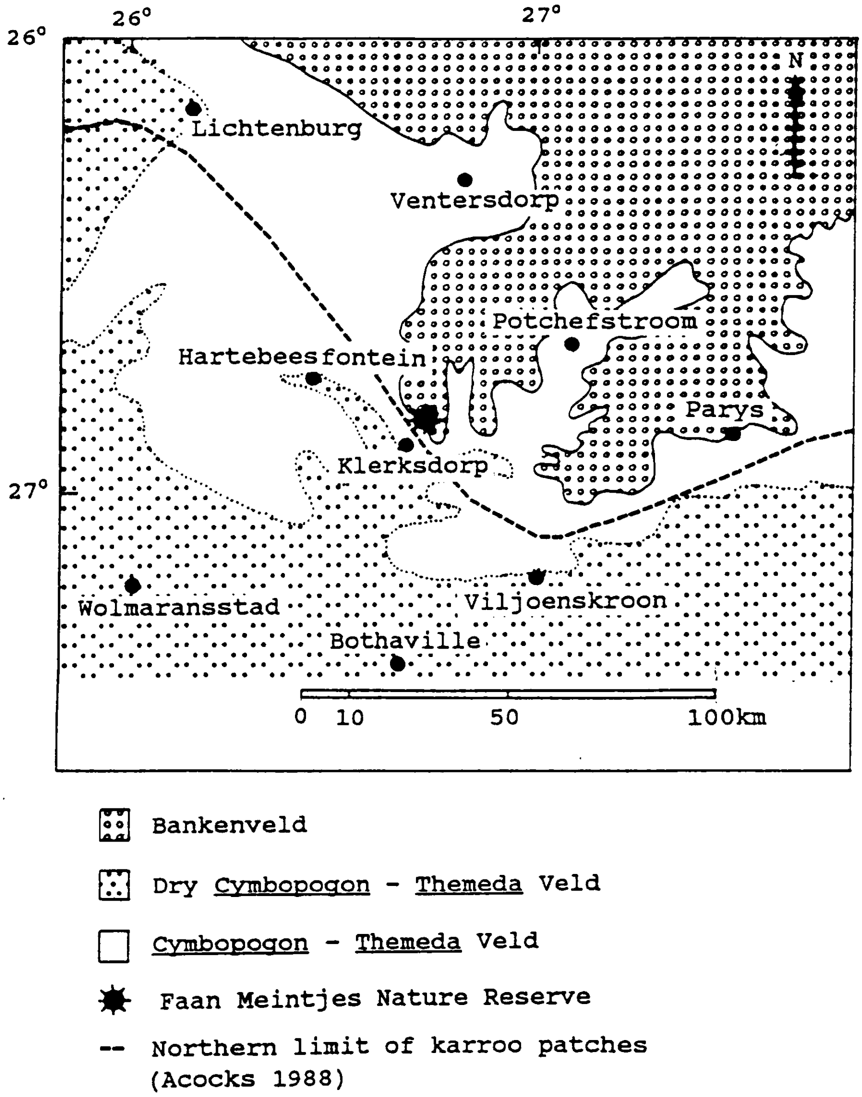


Figure 1 The location of the study area in relation to towns, veld types and Karoo encroachment.

A narrow strip of quaternary alluvium is situated in the central bottomland area of the Reserve.

The soils of the Reserve were classified according to the system of McVicar *et al.* (1977). The soils are generally shallow and rocky, but mostly contain >20% clay. The following types were identified:

1. Very shallow lithosols, mostly of the Mispah form, occur on the rocky quartzite hills and ridges in the south-eastern part of the Reserve.
2. The shallow soils of the slightly undulating areas in the north-western part of the Reserve mostly represent the Williamson series (Glenrosa form) or the shallow Shorrocks series (Hutton form).
3. Deeper soils on relatively flatter areas include the Soetmelk series (Avalon form), the Graspan and Leslie series (Glencoe form), the Ottosdal series (Bainsvlei form), the Shigalo and Makatini series (Hutton form) and the Chitsa series (Longlands form).
4. Soils of the bottomlands represent the Lindley series (Valsrivier form).
5. On seasonally flooded and waterlogged wetlands the Chinyika series (Willowbrook form), the Rensburg series (Rensburg form) and the Lindley series (Valsrivier form) occur.

Methods

Relevés were compiled in 108 stratified random, 900 m^2 (30 m × 30 m) sample plots. Stratification was done on 1:10 000 scale aerial orthophotographs, on the basis of relatively homogeneous physiographic and physiognomic units. Sample plots were divided among these units pro rata on an area basis. In each sample plot all species identifiable at the time of sampling (January/February) were noted and the cover abundance of each species was visually estimated using the Domin-Krajina scale (Mueller-Dombois & Ellenberg 1974). Taxa names usually conform to those of Gibbs-Russell *et al.* (1985 & 1987), however in accordance to Bredenkamp *et al.* (1989b) *Setaria flabellata* Stapf and *S. sphacelata* (Schumach.) Moss were recognized as two separate taxa. Additionally the height and canopy cover of the tree, shrub and herbaceous layers were estimated. Environmental data included identification of geological formation and soil type, and estimation of aspect, slope, and rockiness of the soil surface as well as observations on grazing pressure and trampling.

Seventy-seven of the 108 sample plots intentionally coincided exactly with those of an independent but simultaneous wheel point survey by Bosch *et al.* (1987).

Two-way indicator species analysis (TWINSPAN) (Hill 1979) was applied to the floristic data set in order to derive a first approximation of the vegetation types of the area. Refinement of this classification was done by Braun-Blanquet procedures, as this methodology proved to produce ecologically reliable results (Bezuidenhout *et al.* 1988; Behr & Bredenkamp 1988; Bredenkamp *et al.* 1989a; Bredenkamp *et al.* 1989b). The results of the final classification are presented in a phytosociological table (Table 1). No attempt was made to formally fix names or ranks of syntaxa as the adjacent vegetation is inadequately known. The average height and canopy cover for the tree, shrub and herbaceous layers of the communities distinguished, are given in Table 2. All vegetation height and canopy cover values given in the text refer to these average values.

Results

The analyses resulted in the recognition of eleven plant communities, which may be grouped into five major community types. The hierarchical classification and a brief habitat interpretation of these communities are summarized as follows:

1. *Rhus magalismontana – Aristida vestita* Shrubland of very shallow soils of the rocky quartzite hills and ridges
1.1. *Loudetia simplex – Aristida vestita* Shrubland of north-facing slopes
1.2. *Dombeya rotundifolia – Aristida vestita* Shrubland of south-facing slopes
2. *Protasparagus suaveolens – Grewia flava* Woodland of lava outcrops or adjacent lava or quartzite footslopes and plains
2.1. *Grewia flava – Acacia caffra* Woodland of very shallow soils of summits and slopes of lava outcrops
2.2. *Grewia flava – Acacia karroo* Woodland of shallow soils of footslopes and adjacent plains of quartzite and lava outcrops
3. *Brachiaria serrata – Triraphis andropogonoides* Grassland of rocky shallow soils of the slightly undulating upland landscape
3.1. *Triraphis andropogonoides – Tristachya leucothrix* Grassland of shallow soils on pediments of quartzite hills
3.2. *Triraphis andropogonoides – Schizachyrium sanguineum* Grassland of rocky soils on convex upland areas in the slightly undulating landscape
3.3. *Triraphis andropogonoides – Elionurus muticus* Grassland of less rocky, flat upland plains
4. *Setaria flabellata – Cymbopogon plurinodis* Grassland of deep soils on flat plains
4.1. Typical variant
4.2. *Pentzia globosa* Variant representing an overgrazed phase
5. *Setaria sphacelata – Eragrostis plana* Wetland on alluvium in or near drainage lines
5.1. *Eragrostis plana – Andropogon appendiculatus* Wetland of wetter situations
5.2. *Eragrostis plana – Eragrostis curvula* Wetland of relatively drier situations.

Description of the communities

1. The *Rhus magalismontana – Aristida vestita* Shrubland

This community is strongly associated with the rocky quartzite, shale and conglomerate ridges of the Hospital Hill and Government Subgroups (Witwatersrand Supergroup), representing the Fb land type within the study area. Locally up to 70% of the shallow, sandy lithosols (Mispah form) are covered with large quartzite rocks.

This shrubland is characterized by species group A (Table 1) and the diagnostic species, all strongly associated with these hills, are *Aristida vestita, Tapiphyllum parvifolium, Indigofera comosa, Oldenlandia herbacea, Pellaea calomelanos, Rhus magalismontana, Vangueria infausta, Leonotis microphyllum, Cleome rubella* and *Mundulea sericea*. Most of the generally more common species of the Reserve (species group N, Table 1) are usually absent in this community. The vegetation is dominated by the coarse, tall-growing *Aristida vestita*, which usually has a canopy cover of 30–60%. Shrubs and small trees, 1–3 m tall, occur scattered in this community.

1.1 The *Loudetia simplex – Aristida vestita* Shrubland is restricted to the hot, dry north-facing slopes of these rocky quarzite hills and ridges. Here the vegetation is characterized by the presence of the co-dominant *Loudetia simplex* and the less prominent but very diagnostic *Sporobolus pectinatus* (species group B, Table 1). An average of 28 species were recorded per sample plot.

The woody layer is 2.2 m tall, with a canopy cover of 6.6%. The most prominent species include *Tapiphyllum parvifolium, Vangueria infausta, Mundulea sericea* and sometimes *Rhus leptodictya*. Shorter woody or semi-woody species often found here are *Indigofera comosa, Rhus magalismontana, Leonotis microphyllum*, and *Elephantorrhiza elephantina*.

The herbaceous layer is 0.76 m tall, covers 50% and is dominated by the grasses *Aristida vestita* and *Loudetia simplex*. Other grass species conspicuously present include *Sporobolus pectinatus, Diheteropogon amplectens, Schizachyrium sanguineum, Rhynchelytrum repens* and *Eragrostis curvula*.

Forbs which occur in this community include *Oldenlandia herbacea, Pellaea calomelanos, Cleome rubella, Tephrosia longipes, Bulbostylis burchellii, Rhynchosia venulosa, Commelina africana* and *Pearsonia sessilifolia*.

1.2 The *Dombeya rotundifolia – Aristida vestita* Shrubland occurs exclusively on the cooler and moister, but extremely rocky (70% rock on the soil surface)

Table 1 A phytosociological table of the Faan Meintjes Nature Reserve

RELEVES	0001	00	001010	0110001011100000	00	00000000000000	10000000000000000000000	0000000000000000000	0000000	00000000	0000000
	0280	88	990909	9009090001185009	88	01122235555775	08035711145566666777880	1160661223324662339	7513774	49444443	7223341
	3355	68	149300	9238871940116675	47	21602442357030	60509902454806789124234	3541358588990121126	5175789	22146787	6673639
COMMUNITY NUMBER	1.1	1.2	2.1	2.2	3.1	3.2	3.3	4.1	4.2	5.1	5.2
SPECIES GROUP A											
ARISTIDA VESTITA	4561	43									
TAPIPHYLLUM PARVIFOLIUM	1122	1									
INDIGOFERA COMOSA	1111	1	1		11	1 1	1				
OLDENLANDIA HERBACEA	111	11									
PELLAEA CALOMELANOS	1111	1	111			1					
RHUS MAGALISMONTANA	122	1	1	1		1					
VANGUERIA INFAUSTA	1 1	12									
LEONOTIS MICROPHYLLA	11	11									
MUNDULEA SERICEA	1 1	11									
CLEOME RUBELLA	1	11			11						
SPECIES GROUP B											
LOUDETIA SIMPLEX	3323		1		1	1 11 1	1				
SPOROBOLUS PECTINATUS	11 1					1					
SPECIES GROUP C											
DOMBEYA ROTUNDIFOLIA		11	111								
HIBISCUS ENGLERI	1	11	1								
CHEILANTHES HIRTA		11									
HAEMANTHUS HUMILIS		11									
SUTERA CAMPANULATA		21									
MAYTENUS POLYACANTHA		11	1 1								
TURBINA OBLONGATA		11		1							
SPECIES GROUP D											
GREWIA FLAVA	1		225411	111112221111 1 1		1	1 1 1	1			
PROTASPARAGUS SUAVEOLENS			111111	11111 1111111112			1 1 1 1	1			
TEUCRIUM TRIFIDUM	1		111 1	1111 1 111 11111		1	1 1 1	11 1 11 1		1 1	1 1
PROTASPARAGUS LARICINUS			111	11 11111 1 1111			1	1 1 1			
PAVONIA BURCHELLII			111 1	1 1 1							
SPECIES GROUP E											
ACACIA CAFFRA			31211	1 1 1			1				
RHUS LEPTODICTYA	1	11	111111				1				
EHRETIA RIGIDA			111111	1			1				
ZANTHOXYLUM CAPENSIS			11111								
PROTASPARAGUS AFRICANUS			1111 1								
GREWIA OCCIDENTALIS			1111								
EUCLEA UNDULATA			11 1 1								
PHYLLANTHUS SPECIES			1111		1		1				
ENNEAPOGON SCOPARIUS			2221	1							
CARISSA BISPINOSA			1111								
PAPPEA CAPENSIS			1 11								
MELHANIA PROSTRATA			111								
BARLERIA OBTUSA			111								
OLEA EUROPAEA			1 11								
ACACIA ROBUSTA			11 1								
PAVETTA ZEYHERI			11								
ZINNIA PERUVIANA			11								
ZIZIPHUS MUCRONATA	1		1 1								
SPECIES GROUP F											
ACACIA KARROO			1	11211 122111 213		1	1 1	1 1		1	
SPOROBOLUS FIMBRIATUS				111111 121 111 1			1 1 1 1	11			1

Table 1 Continued

RELEVES	0001 0280 3355	00 88 68	001010 990909 149300	0110001011100000 9009090001185009 9238871940116675	00 88 47	00000000000000 01122235555775 21602442357030	1000000000000000000000000 0803571114556666677788O 60509902454806789124234	0000000000000000000 1160661223324662339 3541358588990121126	0000000 7513774 5175789	00000000 49444443 22146787	0000000 7223341 6673639
COMMUNITY NUMBER	1.1	1.2	2.1	2.2	3.1	3.2	3.3	4.1	4.2	5.1	5.2
SPECIES GROUP G											
TRIRAPHIS ANDROPOGONOIDES		1		1 1	11	21223321421212	12112111122 11111111111	1	1		1
BRACHIARIA SERRATA	1	1		1 1		11114111111111	1 111111 1111 1 1 1111	11 1	1	1 1	1
DIHETEROPOGON AMPLECTENS	1111		1		11	11111112111111	12111 1111111111 111 1				1
ERAGROSTIS RACEMOSA			1		1	1111111111 11	11 11 111111 11111111			1	1 2
GNIDIA CAPITATA				1 1	11	11 1 11111 1	11 11 111 11111 11111	1			
TRACHYPOGON SPICATUS					1	1111 22211 141	1 111 1111 1311 1221		1		
PLEXIPUS ADENOSTACHYUS			1 1 1	1 1		11111111111	1 11 1 111 1 11	11	1		
ACALYPHA ANGUSTATA	1			1 1		11111111 1	11 11 1 1111 111	1 1			
ELEPHANTORRHIZA ELEPHANTINA	1 1				1	1111 11111	1 1 1 1 1 1	1 1 1 1		1	1
HERMANNIA LANCIFOLIA					21	11111 11111 1	111 111 1 111 1				
MARISCUS INDECORUS	1		1	1 1		1 1 1	11 1 11 11 1 111	1 1 1	1 1		
HELICHRYSUM NUDIFOLIUM				1		11 1 11 1	1111 11 1 1 1 11	1 1	1		
JUSTICIA ANAGALLOIDES			11	1 1		11 11	111 11111	1 1		1 1	
SENECIO VENOSUS					1	11 11 1111 111	111 1 11 1				
SENECIO CORONATUS					1	1 111	1 1 1 11 1 1 1				
SOLANUM CAPENSE			1		1	1 1	1 1 11 1 11	1			
HYPOXIS RIGIDULA				1		1	11 1 1111	1	1		
INDIGOFERA HEDYANTHA						1 1 111	1 1 1	1	1	1	
RHYNCHELYTRUM NERVIGLUME						11	1 1 1 1 1	1			
POLYGALA HOTTENTOTTA						1 1 11	1 11				
PYGMAEOTHAMNUS ZEYHERI					1	1 1 1 1	1 1 1				
IPOMOEA CRASSIPES		1				1 1	1 1 1				1
PHYLLANTHUS INCURVUS						1 1	1 1				
SPECIES GROUP H											
TRISTACHYA LEUCOTHRIX					55						
POGONARTHRIA SQUARROSA					22	1 1		1			
LIGHTFOOTIA DENTICULATA					11	1					
INDIGOFERA FILIPES			1		11						
HELICHRYSUM INDICUM					11	1					
GISEKIA PHARNACEOIDES					11						
SPECIES GROUP I											
SCHIZACHYRIUM SANGUINEUM	111		1		1	111111111 1	1 1 11				
DICOMA ANOMALA			1		1	111 1 111 11	1 11	1			
TEPHROSIA LONGIPES	111		1		11	1 11 1 1 1	1				
DIANTHUS MOOIENSIS					1	1 1 11 11	1			1	
BULBOSTYLIS BURCHELLII	1111				11	1 11 11					
DIGITARIA TRICHOLAENOIDES					11	2 1 1	1				
ANDROPOGON SCHIRENSIS	1		1			11111 1	1 1 1	1			
TRIUMFETTA SONDERI						111 1 1					
SPECIES GROUP J											
PENTZIA GLOBOSA				1 1					4111111	11	1 11
FELICIA MURICATA							1	1 1	11 1		
SPECIES GROUP K											
ERAGROSTIS PLANA				1				1 1	2	1 142131	13114 1
MONSONIA ANGUSTIFOLIA								1 1	1 1	1 1111	11 111
SETARIA SPHACELATA								1		121 2513	1 111
ARISTIDA BIPARTITA							1			211111	11 1

Table 1 Continued

RELEVES	0001	00	001010	0110001011100000	00	00000000000000	100000000000000000000000	000000000000000000	0000000	00000000	0000000
	0280	88	990909	9009090001185009	88	01122235555775	080357111455666667777880	116066122332466233 9	7513774	49444443	7223341
	3355	68	149300	9238871940116675	47	21602442357030	605099024548067891242 34	354135858899012112 6	5175789	22146787	6673639
COMMUNITY NUMBER	1.1	1.2	2.1	2.2	3.1	3.2	3.3	4.1	4.2	5.1	5.2
SPECIES GROUP L											
ANDROPOGON APPENDICULATUS								1		1111 51	1
GEIGERIA BURKEI								1 1		11 1111	
VERBENA BONARIENSIS				1				11		11 11 1	1
SALVIA RUNCINATA										1 1 11	
FALKIA OBLONGATA										1 1	
SPECIES GROUP M											
VERNONIA OLIGOCEPHALA			1	1 11111		1111111111 111	111 1111111 11111111111	111 11 11111111	111	11 1 1	1
HELICHRYSUM RUGULOSUM				1 1 1111		21 1 1 1 111	11 111 111 111111111	1111111211111111121	1 111	1 1 1	1 1 1
LACTUCA SERRIOLA				11 1		11 11	111 1111 11 1111111 1	11 111111111111111	1 11	1	1 1
HERMANNIA DEPRESSA			1	1111		1 11 1	11 1 1111 1111 1 111 1	1 1 1111111 11 11	1 1	1 1 1	1 1
CRABBEA ACAULIS				1		1 1 1 1	11 1 111 1 111	111 11111 1 1	1 1111	11 11121	111111
CHAMAESYCE SPECIES				1 1 1 111	1	1 11 11 1	1 111 1111 1 1	1 1 11 1 1 1 1	11111	11 11	1 11
WALAFRIDA DENSIFLORA				111	11	1 1 1	11111 111	11 111 1 11	1 1 1	11 1111	1 1 111
CYMBOPOGON EXCAVATUS			1 1 1	1 1		1 111	11 1 1 11 1111111 1	111 1 1 1 1		111 11	1 11
SIDA DREGEI			1	1 1 11 1		1 1	1 11 111 1 1 11 1	1 1 1 1 1 1	1 1	1	
CORCHORUS ASPLENIFOLIUS				1 1		11 11 11 1	1 1 11 1 1 1	1 1	1 11 1	1 1	1 11
TRICHONEURA GRANDIGLUMIS	1			1	1	11 1 1	1 1 11	1 1 1 1 11	1	1	1
SCHKUHRIA PINNATA			1	11		1	1 1 1	1 1 1	11	111 1	1 1 11
HIBISCUS TRIONUM							1 1 111 11	1 11 1	1 1111	1	11 1
SPECIES GROUP N											
SETARIA FLABELLATA	1		1 1 1	1313522 13345652	31	54441236166325	225445644362442444444245	646652224444436377	114333	313 2211	122111
ERAGROSTIS CURVULA	1111	11	11 1	1111111111111	11	1111 111 11 11	11111 1111 1111111 111	1 11 11311111111111	1 1111	11111122	1221222
DIGITARIA ERIANTHA	1		11122	4131432422114222		11 11 1111	141131111 14111 111112	1212 111322323 2 2	1 3115	11121112	443 111
ELIONURUS MUTICUS	1		1 1 1	111 12111	1	13222211211332	121222123223233211 23232	3311211 1211211 111	112 1	221 11 1	1122112
HETEROPOGON CONTORTUS	1		1 111	1 1 1 3111		11111121221211	111211212214221311121221	1111111 1211111111	1111	121111 1	112 11
THEMEDA TRIANDRA	11		1 1	11 111 113211 11		1 1 1111111111	1 1 1 11111 1111 121111	1111111 1 11 1 1 1	211151	111 1 1	2111111
CYMBOPOGON PLURINODIS			11 1	121111111 2 131		1 1 1 1 1	11111 11 21211121 121	112 14212123241 1	11251	333211 1	2331244
EUSTACHYS PASPALOIDES	1	1	1 1 11	1 111111 1 1111		11 111 111	1 111111 1 11 11 11	11 1 1111111	111	11	1
ANTHOSPERMUM HISPIDULUM	1		1 1	111 111	11	1 1 1 111	11 111 1 1 1111111111	111 1 11111 1 1	1 1	11 1111	11 1
LEDEBOURIA SPECIES			1	111111111 111		11 1 1 111	11 1 11 1 11111111111	111 11 1 11 11	1 111	1 1	11
CYNODON DACTYLON	1		1	1 11 1 111111		1 1 1 1 1	1 11 11 1	111 111 11 12336	31 1121	11 31111	111 111
ARISTIDA CONGESTA	1		11 1	1 111 1111 1	11	1 1 11 1	111 1 1 111 1 1	111 11 11 12113	11 1 11	1	1 1 1
ZIZIPHUS ZEYHERIANA			1 1	11 1111 1111 1		1 11	1 1111 1 111 1 11	11 1 1 111 1	11	1	
SOLANUM INCANUM	1		1 1111	11 1 1 1 1		11 1 1111	1 11 1 1 11	11 1 1 1	1 11	1	1
PANICUM COLORATUM			1111	11 11111 1			1 1	1 1 1	11 1 11	1	111
RHYNCHOSIA VENULOSA	1111	11	1 1	1 1111	1	1 1 1	1 1 1	1 1	1	1	1
BULBINE NARCISSIFOLIA				1		1	1 111	1 1 1 11	1 111	1 111	111 111
CYANOTIS SPECIOSA				111		1 1 111	11 111 1 111 1	1 1 1	1 1		1 1
BARLERIA MACROSTEGIA				1 1 1		1	11 1 1111 1111	1 1 11 11	1 1		
POLLICHIA CAMPESTRIS			111 1	11 1 1 1 1	1		11 1 1 1	11 111	1		
OXALIS SPECIES			1 1	1 111 1 11		1	11 1	1 1 1	1	1	1
CASSIA MIMOSOIDES	1				11	11 11 1 1	1 11 1 11 1	1 11			
ARISTIDA DIFFUSA	4		1	1 1		1 11 1 1	1 1 1 11 1	1 1			
DICOMA ZEYHERI						1 1	1 1 1 1 1111 1	1 111	11		
CONYZA PODOCEPHALA				11				1 111 1 1 1		11111 11	1
ERAGROSTIS SUPERBA			1	1 1 1 11			1 1 1 1 11	1 1 1	1	1	
LEUCAS GLABRATA	1		1	1	11	11 11 11 1	1 11	1	1		
GOMPHRENA CELOSIOIDES			1	1		1 1 1 1	111 1 1		11	1 1	
HIBISCUS PUSILLUS			11	1 1 1			1	1 1	1 1 1	1	11 1
RAPHIONACHE HIRSUTA				1 1 1 11		1	1 11 1 1 1	1	1		1
CRABBEA HIRSUTA			1 1	111		1 111	1 1 11			1	
ARISTIDA CANESCENS			111	1		1	1 1 1 1	1 1 1	1		1
STACHYS SPATULA				11			1	1 1 11 211	1	1 1	1
HYPARRHENIA HIRTA							1 1 1	2 11 1		112	21 1

Table 1 Continued

RELEVES	0001 0280 3355	00 88 68	001010 990909 149300	011000101110000 900909000118500 9 923887194011667 5	00 88 47	00000000000000 01122235555775 21602442357030	10000000000000000000000 08035711145566666777880 60509902454806789124234	0000000000000000000 1160661223324662339 3541358588990121126	0000000 7513774 5175789	00000000 49444443 22146787	0000000 7223341 6673639
COMMUNITY NUMBER	1.1	1.2	2.1	2.2	3.1	3.2	3.3	4.1	4.2	5.1	5.2
CLEMATIS BRACHIATA			1	1 11			1 1 1	1 1 11	1		
COMMELINA AFRICANA	1 1	1	1 111	1		1 1 1			1		
ERAGROSTIS GUMMIFLUA				1		1 1 1	1 1 1 1	1 1	1		
HYPOXIS ROOPERI				1		1	1 1	1 11 1 1			11
ANTHERICUM GALPINII	1				1	1 1 1	1 1	1			1 1
TRAGUS BERTERONIANUS			1	1 1 1 1				1 1	11 1		
HYPOXIS ARGENTEA								1 11 1	1 1	1 1	1
HELICHRYSUM CALLICOMUM					11	1111	1 1	1			
BLEPHARIS ANGUSTIFOLIA					1	11	11	1 1	1		
CRASSULA SCHIMPERI					1	111	1 1 1 1				
RHYNCHELYTRUM REPENS		1	1 1	1 1			1 1				1
LIPPIA SCABERRIMA							1 1	1 1 11 11			
SCABIOSA COLUMBARIA			1			1	11 1	1 1 1			
ERAGROSTIS LEHMANNIANA				1 2				1 1	11 1		
DEVERRA BURCHELLII				1 1				1 1 11			1
ERAGROSTIS CAPENSIS				11			1	1 1			2 1
PEARSONIA SESSILIFOLIA	11			1	1	1 1	1				
CYPHIA ASSIMILIS				1 1 1		1		1	1		1
THESIUM SPECIES	1			1	1	1 11		1			
BERKHEYA RADULA							1	1 1		11	
THESIUM UTILE					1	1 11	11				
VERNONIA GALPINII	1		1			1 1 1			1		
CRABBEA ANGUSTIFOLIA				1 1		1	1 1	1			
LANTANA RUGOSA			1	1 1			1	1			1
SUTERA ATROPURPUREA	1		1			1 1		1		1	
ARISTIDA STIPITATA						11	1	2 4			
SETARIA NIGRIROSTRIS				1				1 24 1			
ASCLEPIAS SPECIES						1	1	1	1	1	
PENTARRHINUM INSIPIDUM	1		1	111							
INDIGOFERA ARGYROIDES				1		1	1 1			1	
LACTUCA CAPENSIS							1 1			1 1	1
ACHYRANTHES ASPERA			1	111							

Table 2 The average height (H) and cover (C) of the tree, shrub and herbaceous strata of the 11 plant communities of the Faan Meintjes Nature Reserve

Community no.	Tree H (m)	Tree C (%)	Shrub H (m)	Shrub C (%)	Herbaceous H (m)	Herbaceous C (%)	Aver. no. species
1.1	0	0	2.2	6.6	0.76	50	28
1.2	0	0	3.0	12.5	0.95	42	24
2.1	5.0	25.0	2.1	32.0	0.36	42	37
2.2	5.8	21.6	1.2	8.3	0.34	51	27
3.1	0	0	0	0	0.90	75	40
3.2	0	0	0	0	0.40	63	39
3.3	0	0	0	0	0.48	66	37
4.1	0	0	0	0	0.40	60	25
4.2	0	0	0	0	0.30	43	27
5.1	0	0	0	0	0.39	63	28
5.2	0	0	0	0	0.58	70	25

south-facing slopes of the quartzite ridges. This community is characterized by species group C (Table 1) which includes the following diagnostic species: *Dombeya rotundifolia, Hibiscus engleri, Cheilanthes hirta, Haemanthus humilis, Sutera campanulata, Maytenus polyacantha* and *Turbina oblongata*. An average of 24 species was recorded per sample plot.

The woody layer is 3 m tall and covers 12.5%. The most prominent species are *Dombeya rotundifolia, Vangueria infausta, Tapiphyllum parvifolium, Mundulea sericea, Maytenus polyacantha, Indigofera comosa, Rhus leptodictya, R. magalismontana* and the semi-woody *Leonotis microphyllum* and *Hibiscus engleri*.

The herbaceous layer is 0.95 m tall, covers 42% and is dominated by *Aristida vestita*. Other grass species present are *Rhynchelytrum nerviglume* and *Eragrostis curvula*.

The most prominent forbs include *Oldenlandia herbacea, Pellaea calomelanos, Cleome rubella, Cheilanthes hirta, Haemanthus humilis, Sutera campanulata, Turbina oblongata*, and *Rhynchosia venulosa*.

2. The *Protasparagus suaveolens – Grewia flava* Woodland

The hilly outcrops of lava, conglomerate, breccia and shale of the Ventersdorp Supergroup, and the adjacent footslopes and plains form the habitat of this major woodland community. The vegetation is characterized by species group D (Table 1) and diagnostic species include the conspicuous woody or semi-woody *Grewia flava, Protasparagus suaveolens*, and *P. laricinus* and also the forbs *Teucrium trifidum* and *Pavonia burchellii*. Species common in the grasslands of the western Transvaal (species group N), are also commonly found, but the species of species group M are, except in special cases (see Community 2.2), absent in this woodland.

2.1. The *Grewia flava – Acacia caffra* Woodland is an upland community, situated on the summits and higher slopes of the lava hills (Fb Land Type). The soils of these areas represent the Mispah or Glenrosa soil forms, are 50–60% covered with rocks, but contain more clay than the sandy soils derived from quartzite.

Diagnostic species characterizing the community include the woody *Acacia caffra, Rhus leptodictya, Ehretia rigida, Zanthoxylum capense, Grewia occidentalis, Euclea undulata, Carissa bispinosa, Pappea capensis, Olea europaea* subsp. *africana, Acacia robusta, Pavetta zeyheri* and *Ziziphus mucronata* and also the semi-woody or herbaceous *Protasparagus africanus, Phyllanthus* sp., *Enneapogon scoparius, Melhania prostrata, Barleria obtusa* and *Zinnia peruviana* (species group E, Table 1). An average of 37 species was recorded per sample plot.

The tree stratum is 5 m tall, covers 25% and is dominated by *Acacia caffra*, with *Rhus leptodictya, Ehretia rigida, Zanthoxylum capense, Euclea undulata, Olea europaea* subsp. *africana, Acacia robusta, Dombeya rotundifolia* and *Ziziphus mucronata* also prominent.

The dense shrub layer, with an average canopy cover of 32%, is 2.1 m tall and is dominated by *Grewia flava* but *G. occidentalis, Carissa bispinosa* and *Pavetta zeyheri* are also prominent.

The herbaceous layer is scanty and dry, 0.36 m tall and covers only 42%. Constantly present grass species are *Enneapogon scoparius, Setaria flabellata, Digitaria eriantha, Elionurus muticus, Heteropogon contortus, C. plurinodis, Aristida congesta, A. canescens, Eragrostis curvula, Panicum coloratum*, and *Eustachys paspaloides*. Other forbs include *Pellaea calomelanos, Teucrium trifidum, Pavonia burchellii, Melhania prostrata, Barleria obtusa, Zinnia peruviana, Solanum incanun, Pollichia campestris* and *Commelina africana*.

2.2. The *Grewia flava – Acacia karroo* Woodland occurs on the lower footslopes of the lava and quarzite hills, below the *Grewia flava – Acacia caffra* Woodland, and on adjacent plains (Ba Land Type). The soil surface is generally not rocky, but the soils are fairly shallow, representing the Hutton and Glenrosa soil forms.

The vegetation is characterized by species group F (Table 1), which includes the diagnostic and dominant *Acacia karroo* as well as the grass species *Sporobolus fimbriatus*. An average of 27 species was recorded per sample plot.

The tree stratum is 5.8 m tall with a canopy cover of 21.6%. *Acacia karroo* is by far the dominant tree, and *A. caffra* is sometimes present.

The shrub layer is 1.2 m tall and fairly open, with a canopy cover of only 8.3%. *Grewia flava* is the most prominent shrub, and other shrubby species include *Protasparagus suaveolens, P. laricinus* and the dwarf shrub *Ziziphus zeyheriana*.

The herbaceous layer is only 0.34 m tall, with a canopy cover of only 51%. The most abundant grass species are *Setaria flabellata, Digitaria eriantha* and *Cymbopogon plurinodis*. Other grass species include the diagnostic *Sporobolus fimbriatus* and also *Elionurus muticus, Heteropogon contortus, Themeda triandra, Eustachys* *paspaloides* and *Eragrostis superba*. The constant presence of species such as *Cynodon dactylon, Aristida congesta, Eragrostis curvula* and *Panicum coloratum* indicate that this area is often utilized by game and that overgrazing has occurred from time to time, especially during the period before the area was proclaimed as a nature reserve. Bosch (1985) mentions the relatively high grazing capacity of this community, due to the high abundance of palatable grass species, preferred by grazing animals. Woody species, especially *Acacia karroo, Protasparagus suaveolens, P. laricinus* and *Ziziphus zeyheriana* seem to increase in obviously overgrazed localities, as was also noted by Bredenkamp *et al.* (1989b) in *Acacia karroo* communities elsewhere in the western Transvaal.

Forbs that occur constantly in this woodland include *Pavonia burchellii, Anthospermum hispidulum, Ledebouria marginata, Solanum incanum, Rhynchosia venulosa, Pollichia campestris, Oxalis* sp. and *Raphionacme hirsuta*.

In certain areas on the plains the *Grewia flava – Acacia karroo* Woodland encroached into the adjacent *Setaria flabellata – Cymbopogon plurinodis* Grassland or *Brachiaria serrata – Triraphis andropogonoides* Grassland. Relevés from these areas also contain the grassland-associated species of species group M (Table 1).

3. The *Brachiaria serrata – Triraphis andropogonoides* Grassland

This extensive grassland community is situated at a lower altitude than rocky hills or ridges, but occupies the upland convex crests in the undulating grassland landscape, or other relatively high-altitude plains. The generally shallow, rocky soils are derived from quartzite and shale (Witwatersrand Supergroup) or lava (Ventersdorp Supergroup).

Although floristic variations, which result in the recognition of various communities, do occur, this entire grassland can be characterized by the many typical Bankenveld species listed in species group G (Table 1). The most prominent and noteworthy species include *Triraphis andropogonoides, Diheteropogon amplectens, Gnidia capitata, Trachypogon spicatus, Plexipus adenostachyus, Acalypha angustata, Hermannia lancifolia, Helichrysum nudifolium* and *Justicia anagaloides*. The dominance of *Setaria flabellata* and high abundance of *Elionurus muticus* and *Heteropogon contortus* are prominent features of this grassland. Three communities were distinguished in this grassland.

3.1. *Triraphis andropogonoides – Tristachya leucothrix* Grassland is restricted to the relatively high-altitude drainage lines, and especially occurs at the foot of quartzite ridges, forming a seam just below the *Loudetia simplex – Aristida vestita* Shrubland. No rocks or stones occur on the soil surface, but the soil is generally shallow, representing the Glenrosa or Hutton soil forms.

Diagnostic species for this community are the dominant *Tristachya leucothrix* and also *Pogonarthria squarrosa, Lightfootia denticulata, Indigofera filipes, Helichrysum indicum* and *Gisekia pharnaceoides* (species group H, Table 1). No trees or shrubs occur in this community. An average of 40 species was recorded per sample plot.

The herbaceous layer is 0.90 m tall, covers 75% and is dominated by *Tristachya leucothrix*. Other prominent grass species include *Pogonarthria squarrosa, Triraphis andropogonoides, Diheteropogon amplectens, Setaria flabellata, Eragrostis curvula, Aristida congesta* and *Digitaria tricholaenoides*.

Other forbs include *Indigofera comosa, Gnidia capitata, Hermannia lancifolia, Tephrosia longipes, Bulbostylis burchellii, Walafrida densiflora, Anthospermum hispidulum, Cassia mimosoides* and *Leucas glabrata*.

3.2 The *Triraphis andropogonoides – Schizachyrium sanguineum* Grassland occurs on convex slopes of upland areas in the undulating landscape. The shallow (<35 cm) Hutton and Glenrosa soil forms are mostly derived from quartzite and locally from shale, with stones and gravel covering 10–40% of the soil surface. The clay content of these soils is approximately 30% (Bosch 1985).

The vegetation is characterized by species group I (Table 1) which includes the diagnostic species *Schizachyrium sanguineum, Dicoma anomala, Tephrosia longipes, Dianthus mooiensis, Bulbostylis burchellii, Andropogon schirensis* and *Triumfetta sonderi*. An average of 39 species was recorded per sample plot. No trees or shrubs occur in this community.

The herbaceous layer is 0.40 m tall and covers 63%. The grass species *Setaria flabellata, Triraphis andropogonoides* and *Elionurus muticus* are dominant, and other constantly present grass species include *Trachypogon spicatus, Heteropogon contortus, Brachiaria serrata, Diheteropogon amplectens, Eragrostis racemosa, E. curvula, Schizachyrium sanguineum, Digitaria eriantha, Themeda triandra* and *Eustachys paspaloides*.

Many forbs occur in this community. The most constantly present include *Gnidia capitata, Plexipus adenostachyus, Acalypha angustata, Elephanthorrhiza elephantina, Hermannia lancifolia, Helichrysum nudifolium, H. rugulosum, Senecio venosus, Dicoma anomala, Vernonia oligocephala, Corchorus asplenifolius, Ledebouria marginata, Solanum incanum* and *Leucas glabrata*.

3.3 The *Triraphis andropogonoides – Elionurus muticus* Grassland occurs on upland plains, on slightly deeper (50 cm) and less rocky Hutton soils derived from quartzite or lava. The clay content of these soils is also approximately 30% (Bosch 1985).

This community may be distinguished by the presence of typical Bankenveld species (species group G, Table 1), and the absence of the species which generally occur on shallower and more rocky soils (species groups H and I, Table 1). An average of 37 species was recorded per sample plot. No trees or shrubs occur in this community.

The average height of the herbaceous layer is 0.48 m and it covers 66%. The most prominent grass species are *Setaria flabellata, Elionurus muticus* and *Heteropogon* *contortus*, but *Triraphis andropogonoides, Trachypogon spicatus, Digitaria eriantha* and *Cymbopogon plurinodis* may be locally abundant. Other grasses include *Brachiaria serrata, Diheteropogon amplectens, Eragrostis racemosa, Cymbopogon excavatus, Themeda triandra, Eustachys paspaloides, Eragrostis curvula, Cynodon dactylon, Aristida diffusa* and *A. congesta*.

Many non-grassy forbs are found in this community. Bankenveld species which occur frequently include *Gnidia capitata, Plexipus adenostachyus, Acalypha angustata, Elephantorrhiza elephantina, Hermannia lancifolia, Mariscus indecorus, Helichrysum nudifolium, Justicia anagalloides, Senecio venosus, S. coronatus, Solanum capense* and *Hypoxis rigidula*. Species restricted to grassland areas in the Reserve include *Vernonia oligocephala, Helichrysum rugulosum, Lactuca serriola, Hermannia depressa, Crabbea acaulis, Chamaesyce* sp., *Walafrida densiflora, Sida dregei, Corchorus asplenifolius* and *Hibiscus trionum*. Species of general occurrence are *Anthospermum hispidulum, Ledebouria marginata, Ziziphus zeyheriana, Solanum incanum, Cyanotis speciosa, Barleria macrostegia* and *Dicoma zeyheri*.

4. The *Setaria flabellata – Cymbopogon plurinodis* Grassland

4.1 The typical variant of this grassland occurs on the moist flat bottomland plains or depressions which covers about 35% of the Reserve. The soils of these plains are mostly >1 m deep, derived from lava and represent the Hutton, Bainsvlei, Avalon, Glencoe, Longlands and Valsrivier forms. No or very little rocks or stones occur on the soil surface.

No characteristic species groups (Table 1) distinguish this community from other communities in the area. The vegetation is relatively poor in species. An average of only 25 species was recorded per sample plot. Only the species of general occurrence (species group N, Table 1) and the species restricted to the grassland communities (species group M, Table 1) occur constantly in this community.

Trees and shrubs are absent and the herbaceous layer is on average only 0.4 m tall and covers 60%. The game species often concentrate on this area which is consequently heavily grazed. The most prominent species are the grasses *Setaria flabellata, Cymbopogon plurinodis* and *Digitaria eriantha*. Other constantly present grass species include *Elionurus muticus, Heteropogon contortus, Themeda triandra, Eustachys paspaloides, Eragrostis curvula, Cymbopogon excavatus* and *Trichoneura grandiglumis*.

Other species often found here are *Vernonia oligocephala, Helichrysum rugulosum, Lactuca serriola, Hermannia depressa, Crabbea acaulis, Chamaesyce* sp., *Walafrida densiflora, Sida dregei, Corchorus asplenifolius, Hibiscus trionum, Stachys spathula, Conyza podocephala, Anthospermum hispidulum, Ledebouria marginata, Ziziphus zeyheriana* and *Solanum incanum*.

4.2 The *Pentzia globosa* Variant clearly represents a severely trampled and overgrazed phase of the *Setaria flabellata – Cymbopogon plurinodis* Grassland. These locally overgrazed areas are mostly restricted to the Valsrivier soil form, where the orthic A soil horizon has been removed by erosion, and the clayey structured B soil horizon has been exposed. Due to this degradation of the habitat, the vegetation became sparse, and this caused the establishment and encroachment of the characteristic karroid species *Pentzia globosa* and *Felicia muricata* (species group J, Table 1). This is a typical example of Karoo encroachment into the grassland biome area, as predicted by Acocks (1988) and discussed by Bosch (1989). Although the scanty vegetation is only 0.3 m tall and covers only 43%, the species of the typical variant (species groups M and N) do still occur in the *Pentzia globosa* Variant. An average of 27 species was recorded per sample plot.

5. The *Setaria sphacelata – Eragrostis plana* Wetland

This community is restricted to the wet bottomland sites in or along drainage lines and water courses. The margalitic soils are represented by the Rensburg, Willowbrook and Valsrivier soil forms. The area is generally preferred by game, and consequently overgrazed.

This wet grassland is characterised by species group K (Table 1) which includes the diagnostic species *Eragrostis plana, Monsonia angustifolia, Setaria sphacelata* and *Aristida bipartita*. In addition to these species are *Setaria flabellata, Digitaria eriantha, Elionurus muticus, Heteropogon contortus, Themeda triandra, Cymbopogon plurinodis, Eragrostis curvula, Cynodon dactylon* and *Hyparrhenia hirta* the most prominent species in the wetland areas.

5.1 The *Eragrostis plana – Andropogon appendiculatus* Wetland community is situated in wet drainage lines, mostly on the vertic or melanic clays of the Rensburg and Willowbrook soil forms. The diagnostic species are *Andropogon appendiculatus, Geigeria burkei, Verbena bonariensis, Salvia runcinata* and *Falkia oblongata* (species group L, Table 1). An average of 28 species was recorded per sample plot. The vegetation is overgrazed, covers 63% and is 0.39 m tall.

In addition to the diagnostic species mentioned under species groups K and L (Table 1), and the prominent species mentioned under the *Setaria sphacelata – Eragrostis plana* Wetland, are the following species also constantly present: *Vernonia oligocephala, Crabbea acaulis, Chamaesyce* sp., *Walafrida densiflora, Schkuhria pinnata, Anthospermum hispidulum, Bulbine narcissifolia* and *Conyza podocephala*.

5.2 The *Eragrostis plana – Eragrostis curvula* Wetland occurs on better-drained and drier situations than the previous community, mostly on the Valsrivier soil form. The diagnostic species from species group K (Table 1) are present, but this community lacks the species of species group L (Table 1). An average of 25 species was recorded per sample plot. The vegetation is taller (0.58 m) and denser (70%) than the related *Eragrostis plana* – *Andropogon appendiculatus* Wetland. In addition to the species mentioned under the *Setaria sphacelata* – *Eragrostis plana* Wetland, are *Crabbea acaulis, Walafrida densiflora, Schkuhria pinnata, Bulbine narcissifolia* and *Pentzia globosa* also constantly present.

Concluding remarks

As very little is known about the phytosociology of western Transvaal grasslands, the description and ecological interpretation of the identified plant communities contribute significantly to the present knowledge of these grasslands, and the results should be useful in a phytosociological synthesis.

The habitat and floristic composition of the plant communities of the rocky hills and ridges and also the shallow soils of upland situations in the undulating landscape, indicate that these communities represent Bankenveld rather than *Cymbopogon* – *Themeda* Veld of Acocks (1988).

The delimitation and description of the plant communities, together with the vegetation map of Bosch (1985) can be used to formulate a vegetation management programme for the Reserve. Of special interest are the probable increase of *Acacia karroo* and associated species and the signs of Karoo encroachment in the Reserve. The increase of *Acacia karroo, Protasparagus laricinus, P. suaveolens*, and *Ziziphus zeyheriana* and also *Aloe davyana*, in *Acacia karroo*-dominated communities and adjacent grasslands in the western Transvaal, is *inter alia* a consequence of poor pasture condition (Friedel 1987) due to previous and present overgrazing by cattle and game (Louw 1951). The extreme deterioration of grassland vegetation, associated with soil loss and the establishment of karroid shrubs, is often due to continuous and severe overgrazing (Roux & Opperman 1982). This is part of the desertification process in southern Africa (Roux & Vorster 1983), and represents a change in domain of attraction, from grassland to Karoo vegetation (Bosch 1989). An understanding of the plant communities of the area, and in which habitats, under which management practices vegetational changes have been taking place, is of fundamental importance for devising sound management and conservation strategies.

Acknowledgement

This research was funded by the Foundation for Research Development, CSIR. Part of the research was conducted while both authors were employed by the Potchefstroom University for CHE.

References

ACOCKS, J.P.H. 1988. Veld types of South Africa. 3rd edn. *Mem. bot. Surv. S. Afr.* 57: 1–146.

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the vegetation of the Witwatersrand National Botanic Garden. *S. Afr. J. Bot.* 54: 525–533.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc.-tesis, Potchefstroom Univ. vir CHE.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel, noordwes van Parys. *S.A. Tydskr. Natuurweten. Tegnol.* 7: 4–9.

BOSCH, O.J.H. 1985. Die weiveld van die Faan Meintjes-natuurreservaat: 'n ekologiese ondersoek. Stadsraad Klerksdorp en Total S.A. Klerksdorp.

BOSCH, O.J.H. 1989. Degradation of the semi-arid grasslands of southern Africa. *J. Arid Environ.* 16: 165–175.

BOSCH, O.J.H., JANSE VAN RENSBURG, F.P. & TRUTER, S. DU T. 1987. Identification and selection of benchmark sites on litholitic soils of the western grassland biome of South Africa. *J. Grassl. Soc. S. Afr.* 4: 59–62.

BREDENKAMP, G.J., BOSCH O.J.H., BEZUIDENHOUT, H. & JANSE VAN RENSBURG, F.P. 1989. A comparison of vegetation classifications from wheel point and total floristic data sets. *Vegetatio* (in press).

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains of the Potchefstroom – Parys – Fochville area. *S. Afr. J. Bot.* 55: 199–206.

FRIEDEL, M.H. 1987. A preliminary investigation of woody plant increase in the western Transvaal and implications for veld assessment. *J. Grassl. Soc. S. Afr.* 4: 25–30.

GEOLOGICAL SURVEY 1986. Geological map, 1:250 000, 2626 Wes Rand, Government Printer, Pretoria.

GIBBS-RUSSELL AND THE STAFF OF THE NATIONAL HERBARIUM, 1985. List of species of southern African plants. 2nd edn, Part 1. *Mem. bot. Surv. S. Afr.* 51: 1–152.

GIBBS-RUSSELL AND THE STAFF OF THE NATIONAL HERBARIUM 1987. List of species of southern African plants. 2nd edn, Part 2. *Mem. bot. Surv. S. Afr.* 56: 1–270.

HILL, M.O. 1979. Twinspan: A fortran program for arranging multivariate data in an ordered two-way table by classification of individuals and attributes. Cornell Univ., New York.

LAND TYPE SURVEY STAFF 1984. Land types of the maps 2626 Wes Rand, 2627 Kroonstad. *Mem. agric. nat. Resour. S. Afr.* 4: 1–441.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. bot. Surv. S. Afr.* 24: 1–105.

MACVICAR, C.M., DE VILLIERS J.M., LOXTON, R.F., VERSTER, E., LAMBRECHTS, J.J.N., MERRYWEATHER, F.R., LE ROUX, J. VAN ROOYEN, T.H. & HARMSE, H.J. VON M. 1977. Soil classification: A binomial system for South Africa. Depart. Agric. Tech. Serv., Pretoria.

MENTIS, M.T. & HUNTLEY, B.J. 1982. A description of the grassland biome project. S. Afr. Nat. Prog. Rep. No. 62, CSIR, Pretoria.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

NAKOR, 1979. National plan for nature conservation. Depart. Environ. Plan., Pretoria.

ROUX, P.W. & OPPERMAN, D.P.J. 1982. Gronderosie in die Karoobioom. CSP, CSIR, Pretoria.

ROUX, P.W. & VORSTER, M. 1983. Vegetation change in the Karoo. *Proc. Grassl. Soc. S. Afr.* 18: 25–29.

WEATHER BUREAU 1988. Climate of South Africa, climate statistics up to 1984. WB 40. Government Printer, Pretoria.

4.4 The vegetation of the Bc land type in the western Transvaal Grassland, South Africa.

Page

* Published: *Phytocoenologia*
19(4): 497 - 518.

Phytocoenologia	19 (4)	497 - 518	Berlin-Stuttgart, July 12, 1991

The vegetation of the Bc land type in the western Transvaal Grassland, South Africa

by H. BEZUIDENHOUT and G.J. BREDENKAMP, Pretoria

with 2 photos, 6 figures and 1 table

Abstract. This report forms part of a research programme on the synthesis of the vegetation of the western Grassland Biome in South Africa. The vegetation of the Bc land type in the western Grassland was investigated. Using a numerical classification technique (TWINSPAN) as a first approximation, the classification was refined by applying Braun-Blanquet procedures. The result is a first comprehensive syntaxonomical and synecological account of the vegetation of the Bc land type of the western Grassland Biome. A hierarchical classification as well as description and ecological interpretation of the syntaxa are presented. In the phytosociological table two new alliances and seven new associations are recognized. This report should contribute significantly to the present knowledge and ecological understanding of the western Transvaal Grasslands.

Introduction

MENTIS & HUNTLEY (1982) stated the necessity to determine the location and extent of the major vegetation types within the Grassland Biome. The fact that ACOCKS's (1988) broad description of the South African vegetation is one of the most noted classifications, indicates the necessity of vegetation classifications. In the western Grassland Biome only ACOCKS's broad classification, as well as smaller local studies, such as those of LOUW (1951), COETZEE (1972), MORRIS (1973), VAN WYK (1983) and BEZUIDENHOUT (1988) exist. In a reconnaissance survey of a part of the Mooi River catchment area (BREDENKAMP et al. 1989) some of the communities of the Bc land type have been mentioned, while KOOIJ et al. (1990) described some degraded plant communities from the B land type in the north-western Orange Free State. None of these studies include a formal syntaxonomical account.

As part of a phytosociological research programme on the synthesis of the vegetation of the western Grassland Biome in South Africa (BOSCH & JANSE VAN RENSBURG 1987, BEZUIDENHOUT & BREDENKAMP 1990), the vegetation of the Bc land typ in the western Transvaal was classified.

According to a land-use classification system based on homogeneous terrain form, soil pattern and climate the area is described as the Bc land type (LAND

0340-269X/91/0019-0497 $ 5.50

TYPE SURVEY STAFF 1984). The soils which represent a catena of ferrallitic and red adepal (structureless) soils (MACVICAR et al. 1977) occupy more than a third of this land type. The soils are derived from quartzite and shales and sometimes from Ventersdorp lavas. The geology of the Bc land type represents mainly the Ventersdorp Supergroup and Transvaal Sequence (SACS 1980). The landscape varies from a flat to undulating plain, with an altitude of 1370 m above sea-level, sometimes dissected by prominent quartzite ridges with altitudes of up to 1550 m (Fig. 3). The Bc land type area is drained by the Loopspruit and its tributaries in the east and by the Schoonspruit and its tributaries in the west.

The results should contribute considerably to the knowledge of western Transvaal grasslands, and to a phytosociological synthesis of the western Grassland Biome.

Study area

The study area represents the western part of the Highveld Agricultural Region, Transvaal, South Africa. The study area is bounded by latitudes 25°45' and 27°15' and longitudes 24°45' nd 27°45' east. The Bc land type is situated in the centre as well as to the western parts of the study area (Fig. 1). According to the LAND TYPE SURVEY STAFF (1984) the Bc land type covers approximately 534 160 hectares with about 20 % (106 832 ha) unsuitable for agronomy.

According to the Köppen climate classification system two climatic regions, namely a cool dry steppe with summer rains (BS) and a warm temperate climate with summer rains (CW) are represented in the Bc land type. The rainfall is erratic, especially in the western part of the Bc land type where it is sometimes lower than 450 mm per year while in the western part the rainfall is over 600 mm per year (Fig. 2). Summer temperatures are high, with the mean maximum monthly temperatures exceeding 32 °C during October to January, whilst the mean minimum monthly temperatures are below -1 °C during the months June to August (WEATHER BUREAU 1988).

Methods

The first stratification of the study area was based on land types whereafter terrain types were used in a successive stratification. Sample plots were allocated to the land types *pro-rata* on an area size basis. Within the land type the terrain types, topographical position such as crest (1), scarp (2), midslope (3), footslope (3a), bottomland flats (4) and floodplains (5) were recognized (Fig. 3, adapted from LAND TYPE SURVEY STAFF 1984). Plot sizes were fixed on 16 m^2 for the grassland vegetation and 100 m^2 for woody vegetation. Relevés were compiled in 108 sample plots. The cover-abundance for every species present in the sample plot, was estimated according to the Braun-Blanquet scale. An estimated height and canopy cover average for the tree, shrub and herbaceous

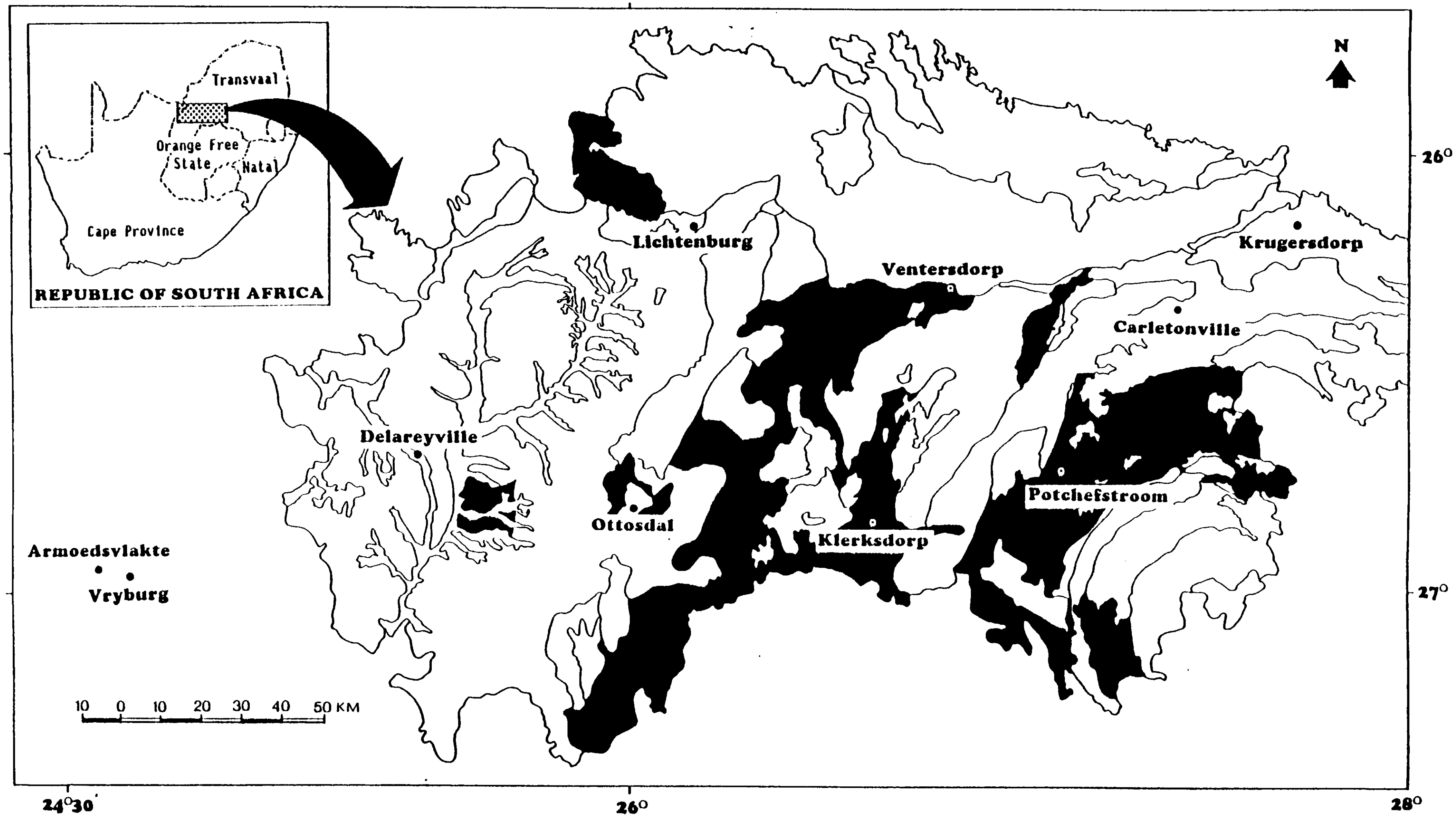


Fig. 1. The location of the Bc land type (black) in the western Transvaal Grassland, South Africa.

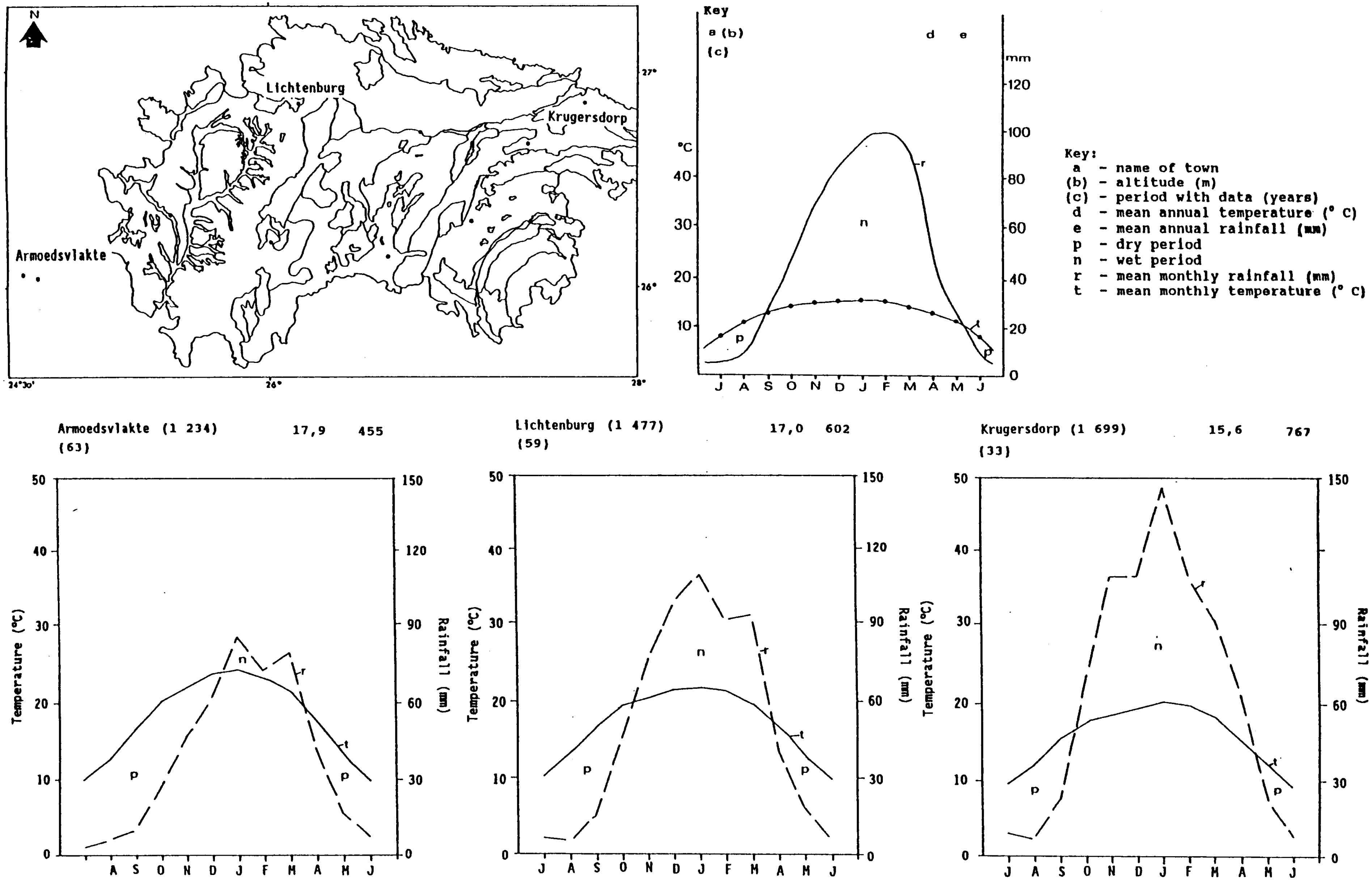
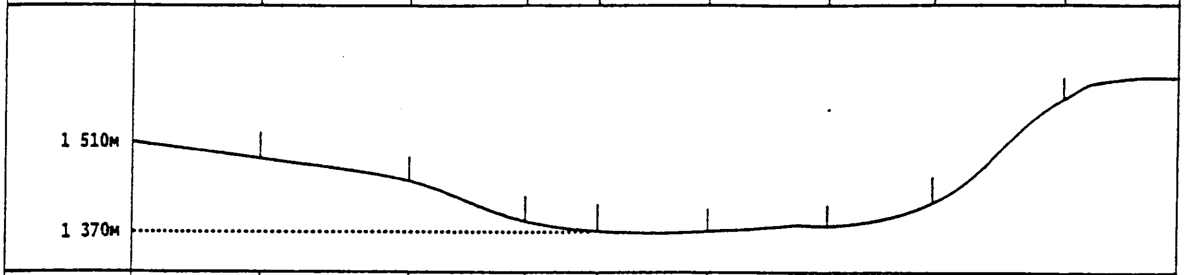


Fig. 2. Climate diagrams for selected towns in the study area.

SYNTAXA (IN TEXT)	2.1.2	1.1.2/2.2	2.3	1.3/2.3	3.1/3.2	2.3/1.3	1.1.1/2.2	1.2	2.1.1



TERRAIN TYPES (IN TEXT)	1/3	/3	3	4	5	4	3A	2	1
SOIL TYPES (IN TEXT)				1.3 ·		2.3			
	SF / %*	SF / %*	SF / %*	SF / %*	SF / %*	SF / %*	SF / %*	SF / %*	SF / %*
	Ms/Gs 41 Hu 30 Litho 25	Ms/Gs 36 Hu 33 Litho 3	Hu 45 Ms/Gs 40 Litho 7	Hu 31 Sw 26 We 22	Rg 52 Va 36	Ms/Gs 31 Va 17 Hu 13	Hu 45 Ms/Gs 40 Litho 7	Litho 70 Ms/Gs 30	Ms/Gs 50 Litho 45 Hu 5

Ms = Mispah, Gs = Glenrosa, Hu = Hutton, Va = Valsrivier, Sw = Swartland, We = Westleigh
Av = Avalon, Rg = Rensburg, Litho = Lithosols
SF = Dominant soil forms, %* = % in terrain type

Fig. 3. The location of the syntaxa on the topographical terrain types.

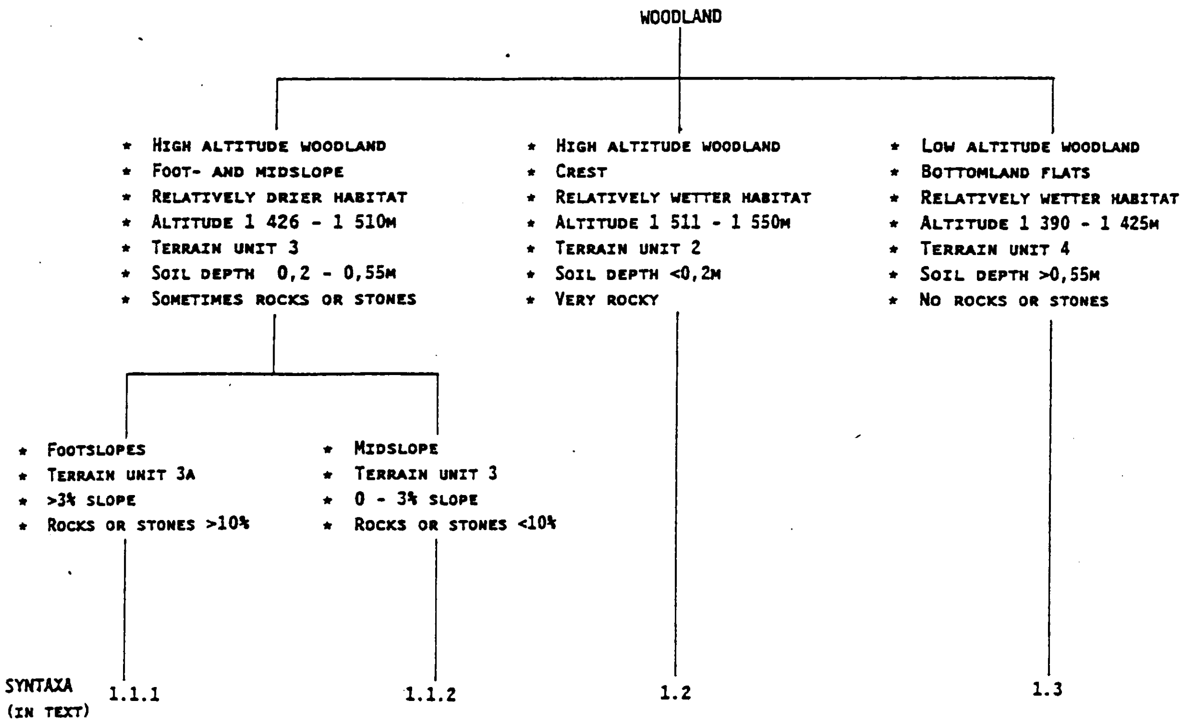


Fig. 4. Dendrogram to illustrate the habitat relationships of the woodland syntaxa.

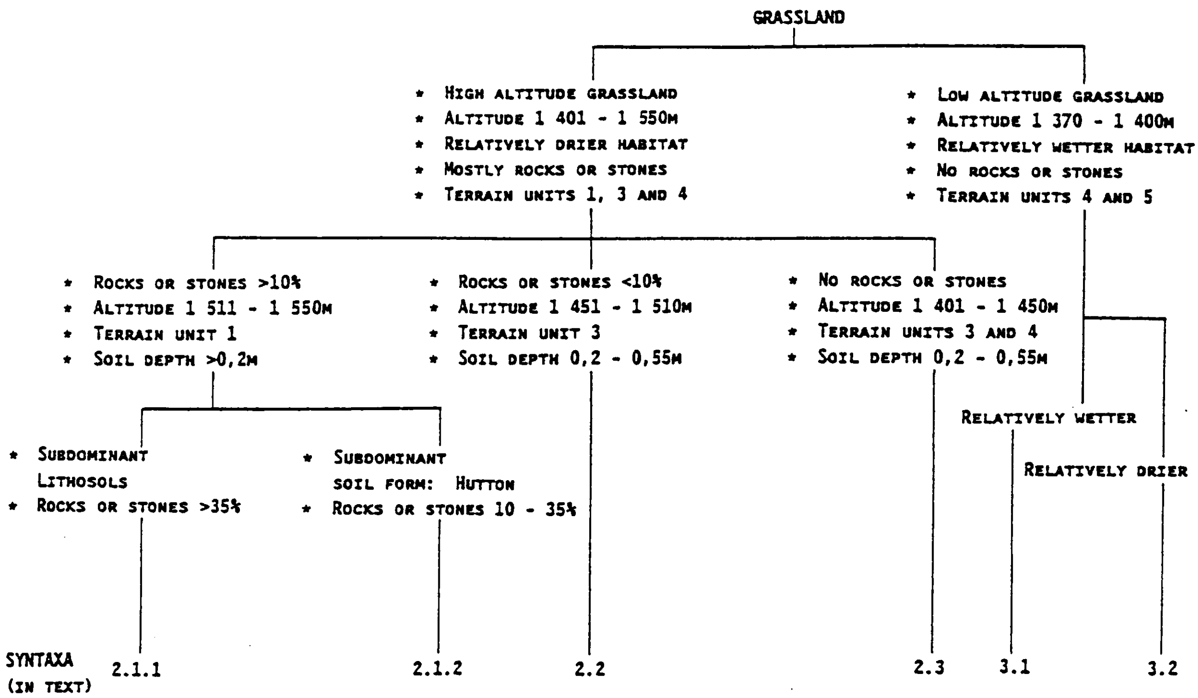


Fig. 5. Dendrogram to illustrate the habitat relationships of the grassland syntaxa.

layers is given for every individual community. Environmental parameters such as terrain type, soil type, soil depth, rock type and rockiness of the soil surface as well as an estimation of slope and aspect were noted in all sample plots (Figs. 4 and 5). The TWINSPAN classification algorithm, as described by HILL (1979a), was used complementary to the Braun-Blanquet procedures for analysing the floristic data. The final result of the classification procedure is a phytosociological table (Table 1). An ordination algorithm, DECORANA (HILL 1979b) was also applied to the floristic data. Taxa names mostly conform to those of GIBBS RUSSELL et al. (1985, 1987). This is the first comprehensive vegetation classification of the entire Bc land type of the study area and therefore new syntaxa are described and a formal syntaxonomy in accordance to the Code of Phytosociological Nomenclature (BARKMAN et al. 1986) is applied to the classification. This report forms part of the synthesis of the vegetation of the entire western Grassland Biome of South Africa.

Results

Classification

In the phytosociological table (Table 1), two alliances and seven associations are recognized. The hierarchical classification of these vegetation units is as follows:

1. Acacion karroo
1.1. Sporobolo africani-Acacietum karroo
1.1.1. Sporobolo africani-Acacietum karroo ziziphetosum mucronatae
1.1.2. Sporobolo africani-Acacietum karroo nidorelletosum resedifoliae
1.2. Vanguerio infaustae-Acacietum caffrae
1.3. Elionurus muticus-Acacia karroo community
2. Heteropogonion contorti
2.1. Trachypogono spicati-Triraphietum andropogonoidis
2.1.1. Trachypogono spicati-Triraphietum andropogonoidis helichrysetosum miconiifolii
2.1.2. Trachypogono spicati-Triraphietum andropogonoidis aristidetosum diffusae
2.2. Sporobolo discospori-Heteropogonetum contorti
2.3. Themedo triandrae-Heteropogonetum contorti
3. Eragrostidetum planae
3.1. Aristida bipartita Variant
3.2. Themeda triandra Variant (inops)

Description of the syntaxa

The vegetation of the Bc land type can be divided into two broad physiognomic classes namely woodland and grassland (Fig. 6). The woodland competes with the grassland for more or less the same habitat (see Fig. 3), as was noted by FRIEDEL (1987). The vegetation types of the Bc land type is disturbed in a mosaic pattern and it is often difficult to establish exact boundaries between communities. The reason for this is mostly disturbance by the intervention of man. The grassland is often overgrazed and burned, as indicated by the presence of a large number of species of low successional status (Table 1; species group N).

1. Acacion karroo all. nov.

Type: relevé 13
The Acacion karroo is characterized by species group F (Table 1) and the diagnostic species are the woody species *Acacia karroo* and *Rhus pyroides* and the shrub-like species *Protasparagus laricinus* and *P. suaveolens*. The alliance represents a woodland, and could easily be recognized in the veld. The habitat of the Acacion karroo represents a variation of soil types, terrain types, rockiness of the soil surface and different grazing regimes (Fig. 4). The "natural" habitat for the Acacion karroo is mostly associated with moderately deep, often clayey alluvial, colluvial or even aeolian soils of recent origin (BREDENKAMP & BEZUIDENHOUT 1990). This habitat is usually found at the footslopes and bottomland flats of the Bc land type. This alliance is represented by 27 relevés and three associations are easily distinguished.

Table 1. A phytosociological table of the Bc land type in the western Transvaal, South Africa.

Syntaxa (in text)	1.1.1	1.1.2	1.2	1.3	2.1.1	2.1.2	2.2	2.3	3.1	3.2
Higher syntaxa	1 (1.1)	1 (1.1)	1	1	2 (2.1)	2 (2.1)	2	2	3	3
Sample plots	2022022 6197168 8302267	6666246 2333543 2372978	010 320 032	4410000060 1154445551 3483891281	000000 203202 731615	6422442224241200 0589552874682611 2161020918714404	3242222422240160222123 9116781168135014683 59 5870059854264397984 76	000000040060 440223410224 578049166314	000000000000000002 022303433540141338 521273275064805842	224441 581486 835900
Species group A										
Sporobolus africanus	+32 232	1 1+ ++		+		++ + + + +	+ + + +			+
Protasparagus africanus	+3 +3++	+++		+		+				
Species group B										
Ziziphus mucronata	+ + + +	+		+1		+				
Boscia albitrunca	+ + +									
Species group C										
Rhus lancea	+	21+ 1	+	+			+			
Nidorella resedifolia		+++					+			
Pseudognaphalium oligandrum		++++					+			
Species group D										
Vangueria infausta			++	+		+				
Aloe davyana	+		+ 1	+	1 +	+		+		
Celtis africana	+		++							
Rhus rigida			++							
Species group E										
Grewia flava	2 3++++	1++ 2+	++	+		+ +	+2			
Diospyros lycioides	2+ ++	1+++	++1	+		+ +	2 + +			
Clematis brachiata	+++ 3	++ ++	+			+ +				
Ehretia rigida	+	+++++++	+ +	+						
Acacia caffra	2 + +4	+	+22				+			
Maytenus heterophylla	+ +	+ +	+	+						
Species group F										
Acacia karroo	44+444+	2313323	2	21322323+		2 +	4 R 3			+ +
Protasparagus laricinus	++++3++	+++ +	++	1+++ ++		+ +	+	+		+
Teucrium trifidum	+++++++	+++	++	+++ ++++ +	+	++ +	+			+
Protasparagus suaveolens	+3++ ++	1 +++1	++1	+ ++++ +			+ +	+	+ +	
Rhus pyroides	++3 + +	12++	++	+2++ + +		+				
Pavonia burchellii	+ +	++ ++		+ +						

Species group G										
Triraphis andropogonoides				+	+ + +	1++ + + + 3133++	+ +			
Trachypogon spicatus				2 +	++1+	+ 2 + +		+ +	+ +	
Plexipus hederaceum		+		+ +	+ +	++++++ ++ + +++	+ + +			
Gnidia capitata	+ +	+	+	+	+ ++ +	+ + ++ ++ +	+ + +	+ +	+	
Diheteropogon amplectens			+	+	++++	1 + +		+		
Schizachyrium sanguineum					++	+ 4 ++				
Solanum incanum	+ +			+	+ +	+ + + +	+ + +	+	+ +	
Dianthus mooiensis				+	+	+ + +	+			
Tephrosia longipes	+	+			+ +	+ +	+			
Leucas capensis				+	++ ++	+ + + +	++ +			+
Species group H										
Helichrysum miconiifolium				+	+ +++		+ +	+ ++	+	
Senecio venosus					+++ +	+ +	+	+	+	
Ledebouria marginata			+	+ +	++ +		+	++ + +	+	
Hermannia lancifolia	+			+	++ ++	+ +	+			++
Senecio coronatus					++	+ +	+	+		+
Loudetia simplex					++					
Species group I										
Aristida diffusa		+	+		+	++ 2+1 + ++	+ +			
Lightfootia denticulate	+	+ +				+ ++ + +++ +	+ +	+		+
Cassia mimosoides				+		++++ +++ ++++	+ + +			
Pogonarthria squarrosa		++		+	+	1 + + + + +				
Dicoma anomala	+	+				++ +++ ++ ++++	+ +	+	+	
Kyphocarpa angustifolia		+				+++++ +++ 2+	+			
Acrotome hispida						++ + ++	+ +			
Zornia glochidiata		+		+ +		+ + + +				
Anthephora pubescens		+				+1 1 1				
Indigofera comosa	+					+ + ++ +				
Andropogon schirensis	+				+	2+ ++	+		+	
Pygmaeothamnus zeyheri						+ ++ +	+			+
Lotononis foliosa						+ + + +	+			
Bewsia biflora						+ ++	+			
Bulbostylis burchellii				+		+ ++ +				
Sporobolus pectinatus					+	+ +				
Species group J										
Tephrosia semiglabra		+		++		+ + +	+++++ + ++ +	++		+
Ipomoea obscura				+ +		+ +	++ +++ + ++ + +			
Hibiscus trionum	+	+		+ +		+	++ ++ ++ + +	+ +	+	+ +
Sutera atropurpurea				+		+	++ +2 + + +			+
Sporobolus discosporus	+					R	+ ++ + +			
Deverra burchellii						+	+ ++ + +	+		
Stachys spathulata	+						+ + + +			
Helichrysum caespititium						+ + +	+ + ++			
Tephrosia burchellii	+					+ +	+ + ++			
Rhynchosia totta							++ +			+
Microchloa caffra						R +	+ + +	+		

Table 1. (cont.)

	1.1.1	1.1.2	1.2	1.3	2.1.1	2.1.2	2.2	2.3	3.1	3.2
Sample plots	2022022 6197168 8302267	6666246 2333543 2372978	010 320 032	4410000060 1154445551 3483891281	000000 203202 731615	6422442224241200 0589552874682611 2161020918714404	324222242240160222123 911678116813501468359 587005985426439798476	000000040060 440223410224 578049166314	000000000000000002 022303433540141338 521273275064805842	224441 581486 835900
Syntaxa (in text)	1	1	1	1	2	2	2	2	3	3
	1.1	1.1	1.2	1.3	2.1	2.1	2.2	2.3	3.1	3.2
	1.1.1	1.1.2			2.1.1	2.1.2				
Species group K										
Trichoneura grandiglumis	`   +  +`	`  +    `		`     +   +`	`+     `	` ++++++ + + ++++`	`  + + + ++ +     ++++`	`   + ++     `	`               +  `	
Lactuca serriola				`        ++`		`     ++++ ++++  `	` + ++ + ++   +++ ++  `	` +          `	`        +        +`	`+  +  `
Solanum panduriforme	`   +  +`			`  +       `	`    + `	`  ++++ ++  + +  `	`+ + ++   +     +++ ++`			
Helichrysum nudifolium		` +     `		`         +`		`+ +   ++    +++ `	`    + ++++     + ++ +`	`++          `	`              +   `	`+     `
Mariscus indecorus	`+      `	`     ++`				`   ++ ++ +++    `	`+  +++   +       + ++`	`          + `		
Dicoma gerrardii		`  +    `		`        + `		`  +++ ++   +++ +`	`    + +      ++ +  ++`	`     +      `		
Schkuhria pinnata	`++   + `		`  +`	` +        `		`   +  + +   ++  `	`++ ++          + +++ `		`                 +`	
Gomphrena celosioides	`  +   +`				`    ++`	`++++  +++ +    +`	`      +     +  +   + `	`          + `	`               +  `	
Eustachys paspaloides	`      +`	` +     `	`  +`	`     ++   `	`    ++`	`R ++ +   2  +++ `	`  +   + +     +      `			
Cyanotis speciosa	`   +  +`		`  +`		`    ++`	`+ +   ++ ++  +  `	`     +      +   + +  `			`     +`
Species group L										
Heteropogon contortus		` ++   +`	`+ +`	` +        `	`+1+++ `	`+   +  +++ +   +`	` ++ ++   ++  ++   + +`	`+ ++ ++  1  `	`       ++ +    +  `	`+     `
Brachiaria serrata				`  +       `	`+ +++ `	`+ ++++ ++ ++  + `	`      +   +          `	`++++ ++     `	`       +   1    + `	
Helichrysum rugulosum	`      2`			`     +   +`	`  + + `	`+     +         `	` ++ +++ ++  + ++++++ `	`++++  + ++ +`	`       ++      +  `	
Justicia anagalloides	`   +  +`	`     + `		`  +       `	`++  + `	`+ +   + + + ++  `	`  +             +  + `	`         ++ `	`          +       `	`  +   `
Acalypha angustifolia	`   +  +`			`      +   `	`  +   `	`    + + ++      `	`+ + ++++  +       +  `	`  ++     +  `	`          +       `	
Stoebe vulgaris	`  +   +`			`  +       `	`   1++`	` ++ +    +      `	`   ++     R+    ++  +`	`2 +      +  `		
Cymbopogon excavatus	`      +`			`      +   `	`1  +++`	`  +   +22     + `	` +    2          +   `	` ++     +   `	`  ++ + +  ++  + + `	
Species group M										
Elionurus muticus	`   +  +`	`      +`	`+  `	` +2+++++  `	`22+12+`	`1++++ ++3 ++++++`	`  12  ++  ++++1+ 2  2`	`2+2+++1+++++`	` +     1  +2     + `	`+ +   `
Eragrostis racemosa	`   2   `			`  + +++  +`	`+++ ++`	`+ +2++ ++ +   + `	`   +  + + + + ++  +  `	`+1      +1  `	`       +       +  `	`     +`
Crabbea acaulis	`  +    `		`+  `	`+ + +  +  `	`+    +`	`  + +   + + +   `	`+++ + ++ ++ + ++ ++ +`	`+  +++++ ++ `	`      ++    +     `	
Rhynchelytrum repens	`   +  +`			`  +++     `	` + +++`	`  +   + +     ++`	`  +   +    +       + `	` ++  +      `	`               +  `	
Polygala hottentotta		` +     `	`+  `	`++        `		`  + +     + ++  `	`+   +       +  +  + +`	`       +    `		`     +`
Species group N										
Ziziphus zeyheriana	` ++2 ++`	`    ++ `		` +++  +   `	`   +++`	`+ +     ++      `	`  ++ 4+ ++ ++  ++++  `	`+++++ ++++ +`	`       ++         `	
Felicia muricata	`+  + + `	` + + ++`	`  +`	`++++ + ++ `	`  + ++`	`  ++  +   +++ + `	`  +   ++          ++ `	`   +++++ ++ `	`             +    `	`+    +`
Lippia scaberrima	`   + ++`	` +    +`	`+ +`	`+ +  ++   `	`    + `	`++  ++ + ++ +   `	`+ 1++++ + R+   + +  +`	`  +    +++  `	`        +         `	
Tragus berteronianus	`4 +3+2 `	`    +  `	`+  `	`++   +++++`		`      +   +    +`	`1+ ++++    + 1  ++ + `	`    ++ + +  `	`        +       + `	
Corchorus asplenifolius	`     + `	`+  +++ `		`+ +       `		`  ++  ++  + + + `	`++++++++ + ++  +  +++`	`     + +    `	`               +  `	`  +   `
Aristida canescens	`  3+  2`		`+  `	`   + +1+  `	`  +   `	`   +      + +   `	`   +3++ 3++   + 2   +`	`       +   +`	`                ++`	
Sida dregei	` +  + +`	`  + +  `		`   +      `	`    + `		`  ++  ++ +  ++++ ++++`	` +++     + +`	`             +    `	` +    `
Raphionacme hirsuta	`  ++ ++`	`    +  `		`   +      `	`     +`	`+     +  + ++   `	`+    ++   +   +  ++ +`	`   +     +  `		
Eragrostis obtusa	` + ++++`	`+  +  +`		`       +  `			`+++    ++      ++   +`	`    ++    + `	`                 +`	
Eragrostis capensis	`+     +`	`   ++++`		`+         `		`  +   + + +     `	`+  +    3++    +++   `	`+           `	`               +  `	
Barleria macrostegia		`  + ++ `		` ++     + `		`      + + +    +`	`   +++  ++  +   +++ +`			`+    +`
Eragrostis superba	`  ++   `	` +   + `	`  +`	`     +    `		` +      ++   +  `	`+   +2  +  + +     + `	`    + +     `	`           +      `	
Eragrostis gummiflua		` +1+  +`		`   + +    `	`    + `	`++  +   +  1 +  `	`                 ++  `	`+ + +       `		
Blepharis angustifolia	`+  2 ++`	`      +`		`+         `		`             ++ `	`+    ++ +++    ++    `	`       +    `		`     +`
Pollichia campestris	`+    ++`			`   +      `		` + + + + +++ +  `	`     +           ++  `	`   +        `		

Species group O										
Eragrostis plana				+			+ 2	+	3+ + ++++ 2+ 3++ +	+2 123
Falkia oblonga									+ +++ +	+2+2 +
Berkheya radula	+			+			+ +		+++ ++1 +	++ + +
Species group P										
Oenothera rosea		+					+		+ +++++++ ++ +	
Aristida bipartita				+		+			+ 1+ 2 ++++ 2	
Haplocarpha scaposa									++++ + +	
Species group Q										
Themeda triandra	+ 2 ++2	++2312		21 +422+ +	+12++1	R++ 3++++++++ +	312+223+2214122+2+ 1	+331+332+114	+43+44223411 ++314	33333+
Eragrostis curvula	+	+11+ 21	+++	1 + + 2+	2 +++1	222++ 3 ++1+4 2	22++ +2++++2 +++ 1	112 +2++ +1	++ 11++1+1 +	+1+1+
Aristida congesta	2+ ++++	11+1 1	+	+ ++ +11+	+ +++	++ ++++ +++ +++3	1+1++2+++4 2 R 23++2	+++1+++ +++	+ ++	
Cynodon dactylon	+ +++	+ ++	1	+ +1+++1 +		+ + ++ ++ +	++ +++ + + + ++	+++++++ ++1	+ 1 1++1+ +1++++	+++1
Cymbopogon plurinodis	+ ++ 2	1 ++ +	+	++ +	+++	+2 1+ +2++	+ +3+2+ + + +++2+++ +	+ ++ ++11+	+ 1	+2 1
Digitaria eriantha	+++++ +	3++ 2	+	++ 1+++	++	+ + + +++	++++ + + 2 4	+ + ++++ +	+ +++++ + 1+2	+ +
Setaria sphacellata	+++ ++	++++++		+		21++1 2 +++ +	+++2+1++ + ++2	+	+1+ +3+ ++ + 2	++ +
Hermannia depressa	+ +++	+ +		+ + + +	+ +	+ + + + +	+ +++++ +++++ +++++++	+++++++ +	++ ++	+
Anthospermum hispidulum		+ +		+	+ ++	+ +++ +++ + ++++	+++++++ +++++ ++	+ + +	+ + ++ + +	+
Vernonia oligocephala	+	+ +		+ ++ +	+ + ++	+ + +	+ +++ ++++ + +	+ + ++++	+ ++ +	+
Hibiscus pusillus	+ +++	+	+	++ + +		+ +	++ +++++ + ++ ++ +	+ + +	+ ++	+
Setaria flabellata			+ +	2+++++	+++ 2+	+	+ 2	++++++ ++	++ 2 ++	3
Scabiosa columbaria	+ + +			+		+ +	+++++++++++ + ++ + +	+ +	+ + ++	++ +
Eragrostis chloromelas	+	+		1 +		1+ ++	++ ++ +++ 14+3 4	2 + +	2 + 11	+
Hyparrhenia hirta	+	R	+	++ +	++	+ +	+ +	1+ + +	+1+ + + 1 1	
Panicum coloratum		12+1+ 1	2+	1+ +		+	+ +	1 1+	+ + +	+ +
Monsonia angustifolia		+		+ +		+ + +	++ + + + + + +	+ +	++ +	+ + +
Crabbea angustifolia	++	+ +		+ +		+ + +++++	+ +++	+	+	+
Chamaesyce hirta	+			+ +		+ + +++	+ + + + ++		+	++ +
Becium obovatum					++ ++		+ +++	+	+ +	++
Walafrida densiflora		++				+ +	+ ++	+ +	+ +	+ +
Conyza podocephala	++			+		+	+ +	+	+ + +	+ +
Eragrostis lehmanniana	++	+		+		+ +	++ 1 +			+
Rhynchelytrum repens			+	+	+		+ + +	+ +	+ ++	
Blepharis integrifolia				+++	+			+++++	+ +	
Geigeria burkei						+	+ +	+	+ +	++++
Nenodora africana			+	+				+ +++ +	++ +	
Bulbine narcissifolia			+	+	+		+	+ + + +	++	
Cucumis hirsutus		+				++ +	+ ++ +	+ +		
Chloris virgata		+ +		+		+	+	+ +	+ +	
Rhynchelytrum nerviglume					+	+ + +	+ + + +		+	
Commelina africana			+	+ +	+	+ ++ ++				
Ipomoea bathycolpos	++	+		+ +		+ + +			+	
Senecio species					+			+ + +	++ + + +	
Oxalis species	+					+	++ +			
Setaria nigrirostris	+						+		+ + +	
Solanum capensis		+		+			+ + + +			
Brayulinea densa	+			+		+	+ +	+		
Chloris pycnothrix	+	+					+ + + +			
Oxygonum dregeanum		+				+ + +	+ +			
Euclea crispa	+		+						+ + +	
Gazania krebsiana				+			+ +			+
Ipomoea crassipes				+	+ +	+	+ +			
Tephrosia species						+	+ +	+		
Cyperus species				+		+			+ + +	
Aristida stipitata						+ +				+

1.1. Sporobolo africani-Acacietum karroo ass. nov.

Type: relevé 13

The Sporobolo africani-Acacietum karroo is found on the footslopes and midslopes of the undulating terrain. The habitat is relatively drier than that of the other two associations (Fig. 4). The altitude varies between 1426–1510 m above sea-level. The soil depth is 0.2–0.55 m. The dominant soil forms are the Mispah, Glenrosa and Hutton forms (LAND TYPE SURVEY STAFF 1984). This association is associated with the Vanguerio infaustae-Acacietum caffrae (1.2) of high altitudes but it occurs on better drained localities (Fig. 6). In Table 1, species group A characterizes this association and the diagnostic species are *Sporobolus africanus* and *Protasparagus africanus*. The vegetation is dominated by *Acacia karroo*. True to habitat differences, two subassociations could be identified within this association (Fig. 4).

1.1.1. Sporobolo africani-Acacietum karroo ziziphetosum mucronatae subass. nov.

Type: relevé 13

This subassociation is strongly associated with the footslopes (Fig. 3, no. 3a) within the Bc land type. Here, more than 10 % of the soil surface is covered by rocks and stones. The slopes are between 3 and 6 % (Fig. 4). The diagnostic species (Table 1, species group B) *Ziziphus mucronata* and *Boscia albitrunca* characterizes this subassociation. An average of 31 species was recorded per sample plot.

The woody component, with *Acacia karroo*, *Ziziphus mucronata*, *Boscia albitrunca*, *Acacia caffra*, *Diospyros lycioides*, *Rhus pyroides* and the shrub *Grewia flava*, is dense with the tree stratum 6.8 m tall and a canopy cover of 20 %. The shrub stratum is 2.4 m tall with a canopy cover of 35 % while the herbaceous layer is 0.75 m tall with a canopy cover of 38 %, and is poorly developed. Grass species prominent in this community are *Sporobolus africanus*, *Tragus berteronianus*, *Aristida canescens*, *Eragrostis obtusa*, *Themeda triandra*, *Aristida congesta* and *Cymbopogon plurinodis*.

The most prominent forbs/semi-shrubs are *Protasparagus africanus*, *P. suaveolens*, *P. laricinus*, *Clematis brachiata*, *Teucrium trifidum*, *Ziziphus zeyheriana* and *Blepharis angustifolia*.

The presence of *Ziziphus zeyheriana*, *Tragus berteronianus*, *Aristida canescens* and *Aristida congesta* emphasizes the poor condition and state of degradation of this vegetation. A similar community was mentioned by BREDENKAMP et al. (1989).

1.1.2. Sporobolo africani-Acacietum karroo nidorelletosum resedifoliae subass. nov.

Type: relevé 632

This subassociation represents a woodland which is restricted to western parts of the Bc land type. The rainfall in the western parts is considerably lower than the eastern parts of the Bc land type (Fig. 2). The terrain type is usually a flat midslope (Fig. 3, no. 3) with less than 10 % rocks or stones on the soil surface and less than 3 % slope (Fig. 4). One tree species, *Rhus lancea*, and two forb species *Nidorella resedifolia* and *Pseudognaphalium oligandrum* are the diagnostic species for this community (Table 1, species group C). The soils are often relatively deep (8 0.5 m) without stones or rocks in the top soil and the soils are thus suitable for agronomy. At some localities the trees have been uprooted and the land ploughed. Due to the good grazing potential of this subassociation, the vegetation is often used for grazing by livestock. An average of 30 species per sample plot was noted.

In this subassociation the dominance of *Themeda triandra* is conspicuous (Table 1, species group Q). The tree stratum is, according to EDWARDS's (1983) structural classification, an open woodland. This provides the farmers with excellent veld for cattle and sheep farming. The tree stratum is well developed and is 5.6 m tall with a canopy cover of 11 %. The shrub stratum is also well developed, 2.1 m tall and has a canopy cover of 20 %. The most prominent woody species are *Grewia flava*, *Diospyros lycioides*, *Ehretia rigida*, *Maytenus heterophylla*, *Acacia karroo* and *Rhus pyroides*. The presence of *Rhus lancea* and *Ehretia rigida* differentiates this subassociation from the Sporobolo africani-Acacietum karroo ziziphetosum mucronatae. The presence of *Rhus lancea* indicates a presence of lime in the soil, in the western grassland and this was confirmed by the occurrence of this subassociation in the western part of the Bc land type where lime is present in the soil.

The herbaceous layer is 0.8 m tall and has a canopy cover of 67 %. It is well developed and provides adequate fodder for the livestock. The grasses which are prominent in this subassociation are *Sporobolus africanus*, *Eragrostis capensis*, *E. gummiflua*, *Themeda triandra*, *E. curvula*, *Aristida congesta* and *Panicum coloratum*. The forbs/semi-shrubs *Protasparagus africanus*, *P. laricinus*, *P. suaveolens*, *Clematis brachiata*, *Pavonia burchellii* and *Corchorus asplenifolius* are also conspicuous in this subassociation.

1.2. Vanguerio infaustae-Acacietum caffrae ass. nov.

Type: relevé 123

The Vanguerio infaustae-Acacietum caffrae is associated with rocky outcrops of quartzite ridges (Fig. 3, no. 2). This habitat is more moist than that of the previous association (1.1; Fig. 6). According to THERON (1973) the rocky outcrops tend to have more water available for the vegetation than the footslope and midslope habitats, where Sporobolo africani-Acacietum karroo (1.1) occurs. The altitude of this association is 1511 to 1550 m above sea-level. According to the LAND TYPE SURVEY STAFF (1984) 70 % of the soil surface is quartzite rocks and 30 % of the soils represent the Mispah and Glenrosa soil forms, with a shallow (9 0.2 m) orthic A horizon on rock or on litocutanic B horizons (Fig. 4).

The diagnostic species (Table 1, species group D) are the tree *Celtis africana*, the shrubs *Vangueria infausta* and *Rhus rigida* and the succulent *Aloe davyana*. An average of 27 species per sample plot was recorded. The tree stratum is

4.5 m tall and the canopy cover is 18 %, while the shrub stratum is 2 m tall and the canopy cover 27 %. Other woody species present in this association are *Grevia flava, Diospyros lycioides, Ehretia rigida, Acacia caffra, A. karroo* and *Rhus pyroides*.

The herbaceous layer is poorly developed with prominent grass species *Eragrostis curvula* and *Panicum coloratum*. The prominent forbs/semi-shrubs are *Protasparagus laricinus, P. suaveolens, Teucrium trifidum* and *Lippia scaberrima*. The canopy cover of the herbaceous layer is 28 % and it is 0.3 m tall.

The forbs and grasses of species group N are, with the exception of *Lippia scaberrima*, only rarely found in this association. This is typical of the high altitude vegetation on rocky outcrops in the western Transvaal Grassland Biome.

1.3. Elionurus muticus-Acacia karroo community (without syntaxonomic rank) (Photo 1)

This communiy is strongly associated with the bottomland plains (Fig. 3, no. 4). This is the wettest habitat within the Acacion karroo. In Fig. 6 the ordination clearly shows that this community is as far as floristic composition and habitat are concerned, closely related to the hygrophilous Eragrostidetum planae (3). The altitude of this community is 1390–1425 m above sea-level. The soil differs from the other associations of the Acacion karroo, as well, in that it is deeper than 0.55 m and the dominant soil forms

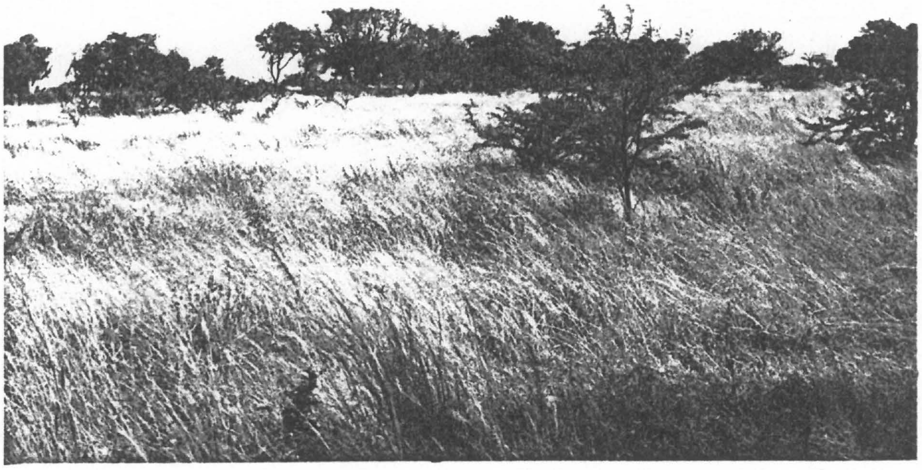


Photo 1. Aspect of the Elionurus muticus-Acacia karroo community.

are Hutton, Valsrivier and Swartland (Fig. 4). Where the soil depth is shallower than 0.55 m and the clay content is less than 15 % the Themedo triandrae-Heteropogonetum contorti (2.3) replaces this community (Fig. 3).

The diagnostic species of the alliance are also the differential species of the Elionurus muticus-Acacia karroo community (Table 1, species group F). Although no diagnostic species were identified for this community it probably represents an association, as this specific species combination and habitat is typical for this vegetation. The prominent woody component, including *Acacia karroo, Rhus pyroides* and occasionally *Ziziphus mucronata*, is on average 4.6 m tall and has a canopy cover of 15 %. The shrub stratum is 1.7 m tall and has a canopy cover of 13.5 % while the herbaceous layer has a canopy cover of 49 % and is 0.7 m tall. The most prominent grasses are *Elionurus muticus, Eragrostis racemosa, Rhynchelytrum repens, Tragus berteronianus, Aristida canescens, Themeda triandra, Eragrostis curvula, Aristida congesta, Cynodon dactylon, Digitaria eriantha* and *Setaria flabellata*. The forbs/semi-shrubs that are present are *Protasparagus laricinus, P. suaveolens, Teucrium trifidum, Ziziphus zeyheriana* and *Felicia muricata*.

The presence of species group M (Table 1) shows that this community is in competition with the grassland. Some researchers (FRIEDEL 1987, BREDENKAMP et al. 1989) stated that this community is an encroachment of the *Acacia karroo* woodland into grassland communities. The presence of the grasses *Tragus berteronianus, Aristida congesta, Cynodon dactylon* and all the forbs/semi-shrubs, indicate that this community had been severely grazed and is badly managed.

2. Heteropogonion contorti all. nov.

Type: relevé 267
The high altitude grasslands are characterized by species group L (Table 1). The following species are diagnostic for this alliance; the grass species *Heteropogon contortus, Brachiaria serrata, Cymbopogon excavatus*, and the forbs *Helichrysum rugulosum, Justicia anagalloides, Acalypha angustifolia* and *Stoebe vulgaris*. With the exception of syntaxa 2.1.1 and 2.1.2 the rest of the Heteropogonion contorti forms a mosaic (distribution pattern) with the Acacion karroo (Fig. 3). At some localities the Acacion karroo tends to encroach the grasslands because of bad management practises.

2.1. Trachypogono spicati-Triraphietum andropogonoidis ass. nov.

Type: relevé 267
In the Bc land type this high altitude grassland occurs 1510–1550 m above sea-level (Fig. 5). The shallow (9 0.2 m) soil has more than 10 % rocks or stones on the surface. The terrain type is terrain unit 1, which indicates that this association correlates well with quartzite ridges (Fig. 3). The clay content of the soil is usually less than 15 %. The association is characterized by species

group G (Table 1), with diagnostic species the grasses *Triraphis andropogonoides*, *Trachypogon spicatus*, *Diheteropogon amplectens*, *Schizachyrium sanguineum* and the forbs *Plexipus hederaceus*, *Gnidia capitata*, *Solanum incanum*, *Dianthus mooiensis*, *Tephrosia longipes* and *Leucas capensis*. The Trachypogono spicati-Triraphietum andropogonoidis can be divided in two subassociations Trachypogono spicati-Triraphietum andropogonoidis helichrysetosum miconiifolii (2.1.1) and Trachypogono spicati-Triraphietum andropogonoidis aristidetosum diffusae (2.1.2) (Fig. 5). In the ordination of the vegetation of the Bc land type the association is clearly differentiated from the other syntaxa (Fig. 6).

2.1.1. Trachypogono spicati-Triraphietum andropogonoidis helichrysetosum miconiifolii subass. nov.

Type: relevé 3
This subassociation is found at the highest altitudes in the Bc land type (Fig. 3). At these localities more rocks or stones cover the soil surface (8 35 %) than in the case of the Trachypogono spicati-Triraphietum andropogonoidis aristidetosum diffusae (2.1.2) (Fig. 5). The subdominant soil form is Hutton in the Trachypogono spicati-Triraphietum andropogonoidis aristidetosum diffusae (2.1.2) while rocks is subdominant in the Trachypogono spicati-Triraphietum andropogonoidis helichrysetosum miconiifolii habitat (Fig. 3).

Species group H characterizes this subassociation with the diagnostic grass *Loudetia simplex* and forbs *Helichrysum miconiifolium*, *Senecio venosus*, *Ledebouria marginata* and *Hermannia lancifolia* (Table 1). No trees and shrubs were noted in this subassociation. The herbaceous layer is well developed and although it is not very tall (0.47 m) it has a canopy cover of 67.5 %. The dominant grass species are *Triraphis andropogonoides*, *Trachypogon spicatus*, *Diheteropogon amplectens* and *Schizachyrium sanguineum*. The dominant forbs are *Plexipus hederaceus* and *Tephrosia longipes*. The relative absence of species group N (Table 1) is an indication of a lesser degree of degradation than in the Trachypogono spicati-Triraphietum andropogonoidis aristidetosum diffusae (2.1.2). An average of 32 species was noted per sample plot.

2.1.2. Trachypogono spicati-Triraphietum andropogonoidis aristidetosum diffusae subass. nov.

Type: relevé 267
This subassociation occurs at similar altitudes than the Vanguerio infaustae-Acacietum caffrae (1.2), but has slopes of less than 3 %. The outcrops of the quartzite are also less than in the Vanguerio infaustae-Acacietum caffrae (Fig. 3). The subdominant soil form is Hutton, which is an indication of more soil on the parent material (Fig. 5). Diagnostic species (species group I, Table 1) are the grasses *Aristida diffusa*,

Pogonarthria squarrosa, Andropogon schirensis, Bewsia biflora, Anthephora pubescens and the small grass *Sporobolus pectinatus* where there are rock sheets. The diagnostic forbs are *Lightfootia denticulata, Cassia mimosoides, Dicoma anomala, Kyphocarpa angustifolia, Acrotome hispida, Zornia glochidiata, Indigofera comosa, Pygmaeothamnus zeyheri, Lotononis foliosa* and *Bulbostylis burchellii.*

Woody strata are not always present but have an average canopy cover of 6 % and are between 1 and 5 m tall. The dominant woody species, if present, are *Acacia karroo, Grewia flava* and *Diospyros lycioides*. By contrast, the herbaceous layer is well developed and is 0.8 m tall and has a canopy cover of 60 %. This subassociation is species-rich as can be seen in Table 1 (species groups G, I, K, L, M and Q). An average of 40 species per sample plot was noted. Other than the diagnostic species, the prominent grasses in this subassociation are *Triraphis andropogonoides, Diheteropogon amplectens* and *Setaria sphacellata* (Table 1). No other forbs are prominent in this subassociation except for the diagnostic species already mentioned. The presence of species from species group K indicate that there is a relationship between the Trachypogono spicati-Triraphietum andropogonoidis aristidetosum diffusae (2.1.2) and Sporobolo discospori-Heteropogonetum contorti (2.2) (Table 1). The soil pattern of both these syntaxa are very similar and thus seems to be the binding abiotic factor (Fig. 3).

2.2. Sporobolo discospori-Heteropogonetum contorti ass. nov.

Type: relevé 417
The next two grassland associations are found on the midslopes of the Bc land type (Fig. 3). The Sporobolo discospori-Heteropogonetum contorti is associated with less than 10 % stones or rocks on the soil surface, altitudes of 1451–1510 m above sea-level, soil depths of 0.2–0.55 m and a soil pattern which indicates three co-dominant soil forms (Fig. 3). There is no structure in the diagnostic soil horizons and the clay content is less than 35 % (LAND TYPE SURVEY STAFF 1984). The habitat of the Sporobolo discospori-Heteropogonetum contorti is wetter than Trachypogono spicati-Triraphietum andropogonoidis (2.1) but drier than Themedo triandrae-Heteropogonetum contorti (2.3) and Eragrostidetum planae (3) (Fig. 6).

The diagnostic species which characterize this association include the grasses *Sporobolus discosporus* and *Microchloa caffra* and the forbs *Tephrosia semiglabra, Ipomoea obscura, Hibiscus trionum, Sutera atropurpurea, Deverra burchellii, Stachys spathulata, Helichrysum caespititium, Tephrosia burchellii* and *Rhynchosia totta* (species group J, Table 1). An average of 36 species per sample plot was noted.

The woody component, which is poorly represented in this association, shows that when this association is poorly managed, there might be an increase of *Acacia karroo* and associated species giving rise to the Elionurus muticus-Acacia karroo community. Presently the woody component has a canopy cover of only 3.5 %. The herbaceous layer is 0.75 m tall and has a canopy cover of 55 %. This association is dominated by the grass species *Themeda triandra, Elionurus muticus, Aristida canescens* and *Aristida congesta.* Many forbs are present but not dominant (Table 1). The diagnostic grass species usually occur in bare rocky patches or in sandy depressions (GIBBS RUSSELL et al. 1990).

2.3. Themedo triandrae-Heteropogonetum contorti ass. nov.
(Photo 2)

Type: relevé 8
This association occurs at altitudes of 1410–1450 m above sea-level, that is below the Sporobolo discospdori-Heteropogonetum contorti, but above the Eragrostidetum planae (Fig. 3). No rocks or stones occur on the soil surface and the subdominant soil type is the Valsrivier form. The clay content of the soil is more than 35 % and the diagnostic B horizon may have structure (Fig. 5). The diagnostic species of the Heteropogonion contorti are also diagnostic for this association and the absence of species groups G, J and K differentiates this association. This association corresponds to the Heteropogon contortus-Themeda triandra-Elionurus muticus Grassland described by BREDENKAMP et al. (1989). This association is relatively more poor in species composition, with an average of only 26 species per sample plot. The absolute dominance of *Themeda triandra* (Table 1) is associated with the relatively species-poor situations.

Photo 2. Aspect of the Themedo triandrae-Heteropogonetum contorti.

Occasionally a tree and/or shrub stratum may be present in the sample plots but mostly it is absent. The grass layer is dominant in the herbaceous layer and prominent species are *Heteropogon contortus, Brachiaria serrata, Elionurus muticus, Themeda triandra, Eragrostis curvula, Aristida congesta, Cymbopogon excavatus* and *Cynodon dactylon* (Table 1). The conspicuous forbs are *Helichrysum rugulosum, Crabbea acaulis, Ziziphus zeyheriana, Felicia muricata* and *Sida dregei.*

3. Eragrostidetum planae ass. nov.

Type: relevé 46
This association is characteristic of the seasonally wet bottomlands of the Bc land type (Fig. 3). The margalitic soils are represented by the Rensburg and Valsrivier soil forms. These vertic black clay soils are usually not ploughed and are mostly overgrazed. According to the ordination this association occurs on wetter habitats than the other syntaxa described here (Fig. 6). This association has relationships with the Elionurus muticus-Acacia karroo community (1.3) and the Themedo triandrae-Heteropogonetum contorti (2.3) (Fig. 6). Eragrostidetum planae is characterized by species group O (Table 1), with the diagnostic grass species, *Eragrostis plana* and forbs species *Falkia oblongata* and *Berkheya radula.*

This association can be divided into two variants.

3.1. Aristida bipartita Variant

The habitat of this variant is wetter than that of the Themeda triandra Variant. The diagnostic species (species group P, Table 1) are the grass *Aristida bipartita* and forbs *Oenothera rosea* and *Haplocarpha scaposa.* Typically of the floodplains (Fig. 3, no. 5) no trees and shrubs are present. However the herbaceous layer is well developed and is 0.96 m tall and has a canopy cover of 83 %. An average of 18 species per sample plot was noted. A related community, the Aristida bipartita-Eragrostis plana Vlei Grassland, was described by Kooij et al. (1990).

3.2. Themeda triandra Variant (inops)

This variant has no diagnostic species and is floristically different from the Aristida bipartita Variant by the absence of species group P (Table 1). Most of the sample plots were sampled in the western parts of the Bc land type. The herbaceous layer is 0.65 m tall and has a canopy cover of 70 %. An average of 19 species per sample plot was noted. The prominent grass species in this variant are *Eragrostis plana, Cymbopogon plurinodis* and *Themeda triandra* and prominent forbs are *Falkia oblongata* and *Berkheya radula.* The rainfall is less than in the case of the other variant.

Ordination

In the scatter diagram the distribution of the relevés along the first and second axes of the ordination is given (Fig. 6). The distribution of the relevés indicates a distinct discontinuity among some of the plant units. On the second axis the Acacion karroo can be clearly distinguished from the Heteropogonion contorti and the Eragrostidetum planae while on the first axis Heteropogonion contorti and Eragrostidetum planae can be separated. The scatter diagram also illustrates a gradient which could be related to the soil depth, clay content, drainage and rockiness of the soil surface (Fig. 6). All the syntaxa to the left of the scatter diagram are associated with drier habitats while those to the right of the diagram are associated with wetter habitats or seasonally wet bottomlands. The top left syntaxa indicate high altitude grasslands with the central syntaxa the lower altitude woodlands and grasslands. Syntaxa situated at the bottom left represent the high altitude woodland.

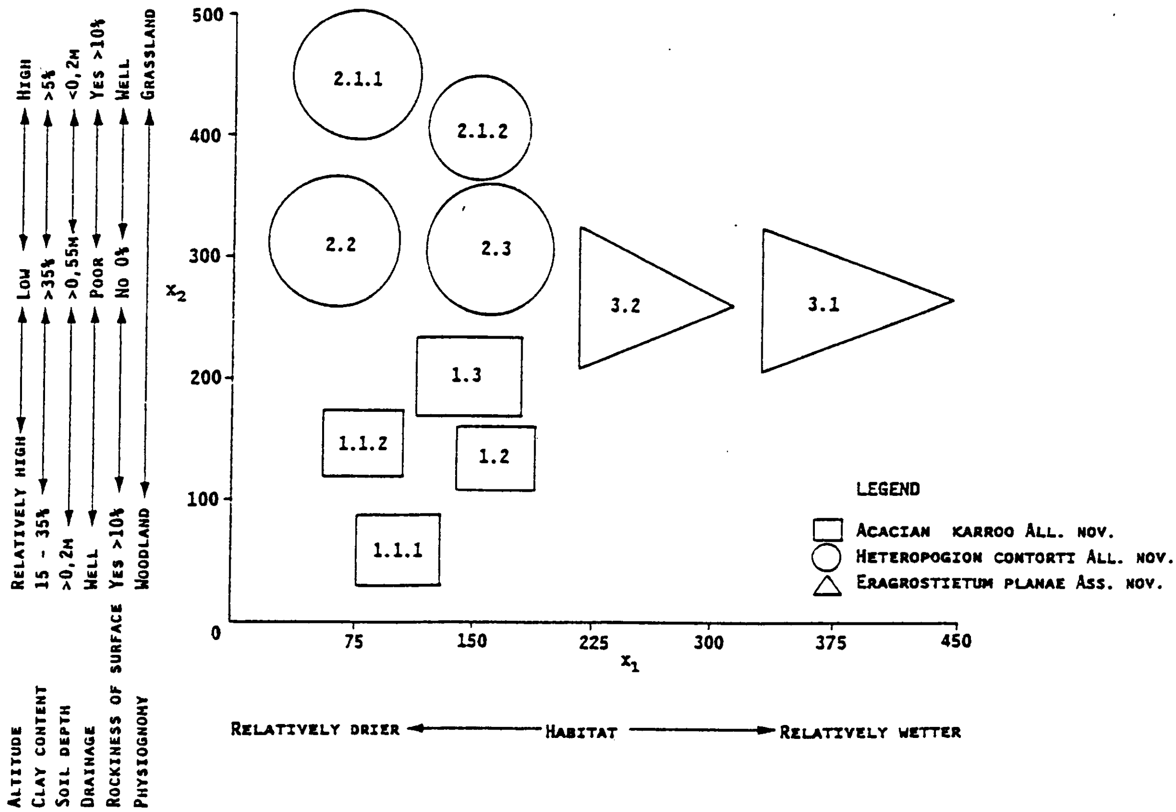


Fig. 6. The relative positions of the syntaxa (numbers refer to text) along the first two axes of ordination.

Conclusions

This is the first comprehensive synecological account of the grasslands of the Bc land type, and also one of the first formal syntaxonomical classifications of regional grasslands in Southern Africa. This syntaxonomy forms the basis for further syntaxonomical investigation in the region. New syntaxa described include 2 alliances, 7 associations, 4 subassociations and 2 variants.

The vegetation of the Bc land type can be divided into two structural units (Fig. 6), woodland and grassland. The woodland has different habitats (species group F, Table 1). As was noted in the past (BEZUIDENHOUT 1988), the bottomland flats are low in species richness and this Bc land type is no exception. The presence of species group N indicates that this vegetation of the Bc land type is in a state of degradation. The main factors contributing to this are the relatively low rainfall of the area over the past ten years and the continued overgrazing of the natural vegetation by domestic stock. This description and ecological interpretations of the plant communities contribute significantly to the understanding and present knowledge of the western Transvaal grasslands. This classification of vegetation and associated habitat should form the basis for all vegetation management planning of the region.

The results of the ordination support the proposed classification and emphasize the habitat gradients associated with the gradient between plant communities.

Acknowledgement. Mrs. D. BEZUIDENHOUT is thanked for assistance in the preparation of this manuscript.

References

Acocks, J.P.H. (1988): Veld types of South Africa. – Mem. Bot. Surv. S. Afr. 57: 1–146.

Barkman, J.J., Moravec, J. & Rauschert, S. (1986): Code of Phytosociological Nomenclature, 2nd edition. – Vegetatio 67: 145–195.

Bezuidenhout, H. (1988): 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. – M.Sc.-thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

Bezuidenhout, H. & Bredenkamp, G.J. (1990): A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa. – Phytocoenologia 18: 387–403.

Bosch, O.J.H. & Janse van Rensburg, F.P. (1987): Ecological status of species on grazing gradients on the shallow soils of the western grassland biome in South Africa. – J. Grassl. Soc. South. Afr. 4: 143–147.

Bredenkamp, G.J. & Bezuidenhout, H. (1990): The vegetation of the Faan Meintjes Nature Reserve, Transvaal. – S. Afr. J. Bot. 56: 54–64.

Bredenkamp, G.J., Joubert, A.F. & Bezuidenhout, H. (1989): A reconnaissance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area. – S. Afr. J. Bot. 55: 199–206.

Coetzee, B.J. (1972): 'n Plantsosiologiese studie van die Jack Scott-natuurreservaat. – M.Sc.-thesis, University of Pretoria, Pretoria.

Edwards, D. (1972): A broad-scale structural classification of vegetation for practical purposes. - Bothalia 14: 705–812.

Friedel, M.H. (1987): A preliminary investigation of the woody plant increase in the western Transvaal and implications for veld assessment. - J. Grassl. Soc. South. Afr. 4: 25–30.

Gibbs Russell, G.E., Reid, C., Van Rooy, J. & Smook, L. (1985): List of species of southern African plants. Ed. 2. Part 1. - Mem. Bot. Surv. S. Afr. 51: 1–152.

Gibbs Russell, G.E., Watson, L., Koekemoer, M., Smook, L., Barker, N.P., Anderson, H.M. & Dallwitz, M.J. (1990): Grasses of southern Africa. - Mem. Bot. Surv. S. Afr. 58: 1–437.

Gibbs Russell, G.E., Welman, W.G., Retief, E., Immelman, K.L., Germishuizen, G., Pienaar, B.J., Van Wyk, M. & Nicholas, A. (1987): List of species of southern African plants. Ed. 2. Part 2. - Mem. Bot. Surv. S. Afr. 56: 1–270.

HIll, M.O. (1979a): TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. - Cornell University, New York.

— (1979b): DECORANA - A Fortran program for detrended correspondence analysis and reciprocal averaging. - Cornell University, New York.

Kooij, M.S., Bredenkamp, G.J. & Theron, G.K. (1990): Classification of the vegetation of the B land type in the north-western Orange Free State. - S. Afr. J. Bot. 56: 309–318.

Land Type Survey Staff (1984): Land types of the maps 2626 West Rand and 2726 Kroonstad. - Mem. agric. ant. Resour. S. Afr. 4: 1–441.

Louw, W.J. (1951): An ecological account of the vegetation of the Potchefstroom area. - Mem. Bot. Surv. S. Afr. 24: 1–105.

MacVicar, C.N. & co-workers (1977): Soil classification - A binomial system for South Africa. - Dept. Agricultural-technical services, Pretoria.

Mentis, M.T. & Huntley, B.T. (1982): A description of the Grassland Biome Project. - S. Afr. Nat. Sci. Prog. 62: 1–29.

Morris, J.W. (1973): Automatic classification and ecological profiles of south-western Transvaal Highveld grassland. - Ph.D.-dissertation, University of Natal, Pietermaritzburg.

SACS (1980): Stratigraphy of South Africa. Part 1 (comp. L.E. Kent). Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia, and the Republics of Botswana, Transkei and Venda. - Dept. Mineral and Energy Affairs, Pretoria.

Theron, G.K. (1973): 'n Ekologiese studie van die plantegroei van die Loskopdam-natuurreservaat deel 1 en 2. - D.Sc.-dissertation, University of Pretoria, Pretoria.

Van Wyk, S. (1983): 'n Plantekologiese studie van die Abe Bailey-natuurreservaat. - M.Sc.-thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

Weather Bureau (1988): Climate of South Africa. - WB 40: 1–475. Government Printer, Pretoria.

Addresses of the authors:
(Please address all correspondence to the second author.)
Mr. H. Bezuidenhout, Grassland Research Centre, Private Bag X05, Lynn East, 0039, Republic of South Africa.
Prof. G.J. Bredenkamp, Dept. of Botany, University of Pretoria, 0002, Republic of South Africa.

4.5 The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa.

* Published: *South African Journal of Botany* 59(3): 319 - 331.

The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa

H. Bezuidenhout,*† G.J. Bredenkamp and G.K. Theron
Department of Botany, University of Pretoria, Pretoria, 0002 Republic of South Africa

Received 17 August 1992; revised 12 February 1993

Relatively little is known about the vegetation of the western Grassland Biome in South Africa. The classification of the vegetation of the Bd and Ea land types forms part of a research programme on the synthesis of the vegetation of the western Grassland Biome in South Africa. This is a first formal classification of the vegetation of the study area. Using a numerical classification technique (TWINSPAN) as a first approximation, the classification was refined by applying Braun-Blanquet procedures. The result is a phytosociological table where one new order, three new alliances and eight new associations are recognized. The new syntaxa are ecologically interpreted as well as described. Associated gradients in habitat are identified by using an ordination algorithm (DECORANA). This study should contribute to the present knowledge and ecological understanding of the vegetation of the western Transvaal grassland.

Relatief min inligting is oor die plantegroei van die westelike grasveldbioom van Suid-Afrika beskikbaar. Die klassifikasie van die plantegroei van die Bd- en Ea-landtipes vorm deel van die sintese van die plantegroei van die westelike grasveldbioom van Suid-Afrika. Die studie is 'n eerste formele klassifikasie van die streek se plantegroei. 'n Numeriese klassifikasie (TWINSPAN) is as eerste stap ter verfyning van die roudata aangewend. Daarna is die Braun-Blanquet-prosedure gevolg om een nuwe orde, drie nuwe alliansies en agt nuwe assosiasies in 'n fitososiologiese tabel te identifiseer. Die nuwe sintaksons word ekologies geïnterpreteer en beskryf. Geassosieerde gradiënte in habitat is deur toepassing van 'n ordeningstegniek (DECORANA) geïdentifiseer. Hierdie studie behoort 'n waardevolle bydrae tot die kennis oor die plantegroei en ekologie van die grasveld van Wes-Transvaal te lewer.

Keywords: Grassland Biome, Braun-Blanquet procedures, vegetation classification, Bd and Ea land types, Western Transvaal.

* To whom correspondence should be addressed at: Scientific Services, National Parks, P.O. Box 110040, Hadison Park, Kimberley, 8306 Republic of South Africa.

† Some of the data for this research were collected while this author was employed by the Department Agricultural Development, Grassland Research Centre, Private Bag X05, Lynn East, 0039 Republic of South Africa.

Introduction

The necessity for a classification of the major vegetation types within the Grassland Biome was stated by Mentis and Huntley (1982). In the formulation of a management policy, proper land use should be emphasized, and for this purpose a classification of the vegetation is essential (Van Rooyen *et al.* 1981). As part of a phytosociological research programme on the synthesis of the vegetation of the western Grassland Biome in South Africa (Bredenkamp *et al.* 1989; Bezuidenhout & Bredenkamp 1990; Kooij *et al.* 1990), the vegetation of the western Transvaal was studied. In this report the vegetation of the Bd and Ea land types is described. It was also decided to include limited data from the adjacent Ae and Ah land types to obtain an indication of the Grassland – Kalahari Thornveld (Acocks 1988) transitional area.

Relatively little is known about the vegetation of the Bd and Ea land types, as only the broad classification of Acocks (1988) is available. Morris (1973) classified the vegetation of the Lichtenburg area, but for the rest no phytosociological data are available. To the south-west of the study area, Gubb (1989) completed a broad-scale vegetation classification with the help of LANDSAT MSS interpretation.

This study is therefore a first attempt to classify the vegetation of the western part of the western Transvaal on a phytosociological basis. The results should contribute considerably to the knowledge of western Transvaal grasslands, and to a phytosociological synthesis of the western Transvaal grasslands (Bezuidenhout, in prep.). It will also help to further the understanding of the vegetation of the drier western part of the study area and variations thereof, as well as provide scientific guidelines for management and conservation.

Study area

The entire study area represents the western part of the western Transvaal, in the Highveld Agricultural Region. The study area is bounded by latitudes 25° 45′ and 27° 15′ south and longitudes 24° 45′ and 28° 00′ east (Figure 1). The Bd and Ea land types are situated in the western part of the study area. These land types cover approximately 831 090 ha, of which only 5% (41 554 ha) is unsuitable for agronomy (Land Type Survey Staff 1984). Vegetation is therefore often restricted to non-arable bush clumps, shallow soils, aeolian sands and pans. This normally leads to overutilization and degradation of the existing vegetation. It is also necessary to stress that the low rainfall makes it a high-risk area for agronomy. Nevertheless, even though it was good cattle and sheep farming area (Morris 1976), the best

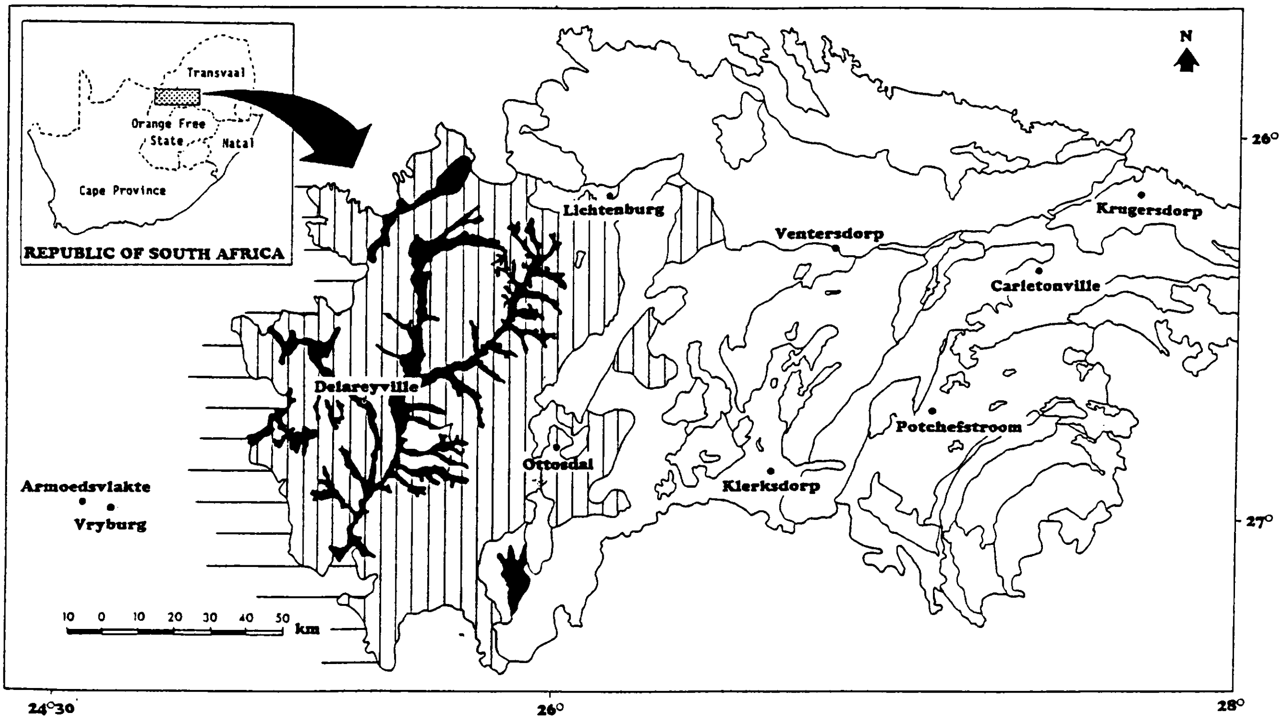


Figure 1 The location of the Bd (|||) and Ea (■) land types in the grasslands of the western Transvaal with the adjacent A (═) land types.

'veld' has been ploughed.

According to Acocks (1988), three veld types are represented in or are adjacent to the Bd and Ea land types. The largest part of the Bd and Ea land types falls in the northern variation of the Dry *Cymbopogon* – *Themeda* veld (Veld Type 50a) which merges westwards into the Kalahari Thornveld Proper (Veld Type 16a) and Vryburg Shrub Bushveld (Veld Type 16b). In the latter two veld types the Ae and Ah land types are predominantly present.

The landscape varies from a flat to gently undulating plain, with an altitude of 1370 – 1460 m (Figure 2). The summer rainfall is erratic, with an average of 455 mm per annum. The temperature is high and the mean daily temperature exceeds 30°C during the summer months (Weather Bureau 1988). The study area is drained by the Harts River and its tributaries in the west while the Schoonspruit and Mooi River with their tributaries drain the central part of the study area.

Soil nomenclature follows the MacVicar *et al.* (1977) classification. The dominant soil forms in the Bd land type are yellow soils such as the Avalon and/or Pinedene soil forms (23% of the land type) and sometimes the Clovelly soil form. The dominant soil forms in the Ae and Ah land types are Clovelly and/or Hutton (80% of the land type). The dominant soil form of the Ea land type, which associates with the Harts River and its tributaries, is Rensburg

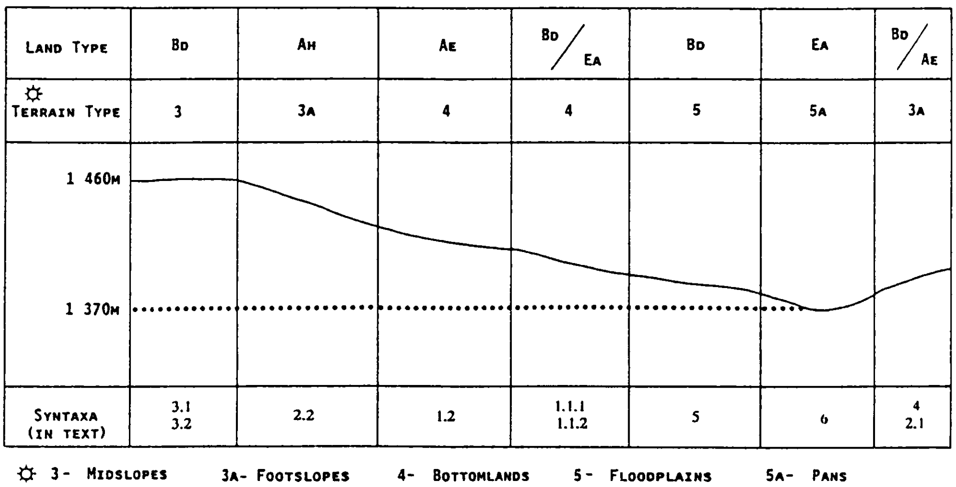


Figure 2 The location of the syntaxa on the topographical terrain types within the Bd, Ea and A land types of the grasslands of the western Transvaal, South Africa.

(60% of the land type) (Land Type Survey Staff 1984). This is an indication of the heterogeneity of the soils in the Ae, Ah, Bd and Ea land types. It was decided to combine the data from the Ae, Ah, Bd and Ea land types, because too little vegetation was available for sampling in the Ea land type and the sampling of the Ae and Ah land types was limited, as most of these areas fall outside the study area. These land types are situated in a mosaic adjacent to the Bd land type, which covers 82% of the area covered in this report.

The major rock types are from the Ventersdorp Supergroup which consists mainly of Ventersdorp lava, sometimes overlain by calcrete. To the western part of the area aeolian sands cover the Ventersdorp Supergroup (Harmse 1967). Basement Complex granite may occur sporadically. Along the Harts River, alluvium and debris of old diamond diggings can be found. Pans occupy 5% of the area covered in this report.

This is the first comprehensive vegetation classification of the Bd and Ea land types of the study area. This report forms part of a comprehensive synthesis of the vegetation of the entire western Grassland Biome of South Africa.

Methods

The first stratification of the study area was based on land types whereafter terrain types were used. Sample plots were allocated to the land types *pro rata* on an area size basis (Bezuidenhout 1988). The following topographical positions (terrain types) are distinguished in the Ae, Ah, Bd and Ea land types: midslopes (3), footslopes (3a), bottomland flats (4), floodplains (5) and pans (5a) (Figure 2, adapted from Land Type Survey Staff 1984). Relevés were compiled in 85 sample plots. Plot sizes were fixed on 16 m^2 for the grassland vegetation and 100 m^2 for woody vegetation in accordance with Bredenkamp and Theron (1978). The cover-abundance for each species present in the sample plots was estimated according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). An estimated height and canopy cover average for the tree, shrub and herbaceous layers are given for each individual community. Environmental data included identification of rock type, terrain type, soil type, soil depth, soil texture and estimation of rockiness of the soil surface, slope and aspect (Figures 3 and 4). Observations on grazing pressure and trampling were noted as well. Some of the Kalahari Thornveld Proper (Veld Type 16a; Ae and Ah land types) and Vryburg Shrub Bushveld (Veld Type 16b; Ae land type), as described by Acocks (1988), were also sampled (15 relevés). This was done to establish any floristic relationships between the different veld types. The TWINSPAN classification algorithm (Hill 1979a) was used for analysing the floristic data, as a first approximation, and subsequently Braun-Blanquet procedures were used to refine these results. The final result of the classification procedure is a phytosociological table (Table 1). An ordination algorithm, DECORANA (Hill 1979b) was also applied to the floristic data (Figures 5, 6 and 7). Taxa names mostly conform to those of Gibbs Russell *et al.* (1985, 1987). New syntaxa are described and a formal syntaxonomy, in accordance with the Code of Phytosociological Nomenclature (Barkman *et al.* 1986), is compiled.

Results

Classification

In the phytosociological table (Table 1), one order, three alliances, eight associations and one community without a syntaxonomic rank are recognized. This is because too little information is known about this community to formally assign a syntaxonomic rank. The hierarchical classification of these syntaxa is as follows:

A. *Grewio flavae – Acacietalia karroo*
- 1. *Rhoo lanceae – Acacion karroo*
  - 1.1 *Rhoo pyroidis – Acacietum karroo*
    - 1.1.1 *Rhoo pyroidis – Acacietum karroo protasparagetosum africani*
    - 1.1.2 *Rhoo pyroidis – Acacietum karroo nidorelletosum resedifoliae*
  - 1.2 *Tarchonantho camphorati – Acacietum karroo*
- 2. *Acacion eriolobae*
  - 2.1 *Stipagrosto uniplumis – Acacietum eriolobae*
  - 2.2 *Terminalietum sericeae – Acacietum eriolobae*

B. Unspecified orders (to indicate that the following syntaxa are not classified under any order) (Coetzee 1983)
- 3. *Hermannio depressae – Elionurion mutici*
  - 3.1 *Trirapho andropogonoidis – Elionuretum mutici*
  - 3.2 *Sporobolo fimbriati – Elionuretum mutici*
- 4. *Themeda triandra – Elionurus muticus* Grassland (community without syntaxonomic rank)
- 5. *Circio vulgaris – Eragrostidetum planae*
- 6. *Diplachno fuscae – Echinochloetum holubii.*

Description of the syntaxa

The vegetation of the area concerned can be divided into two broad physiognomic classes, namely woodland and grassland, as was also noted by Bezuidenhout and Bredenkamp (1991). The vegetation can also be divided into two different floristic classes: the panveld (species group P) and the rest of the vegetation of the Bd and Ea land types (species group Q) (Table 1). The species of species group Q (Table 1) are generally found in all the major vegetation units, except in the pans.

A. *Grewio flavae – Acacietalia karroo* ord. nov.

This order is characterized by species group I (Table 1), which includes the woody species *Acacia karroo, Grewia flava* and *Ehretia rigida*. This order represents the entire woodland syntaxa within the A, Bd and Ea land types.

1. *Rhoo lanceae – Acacion karroo* all. nov.

Type: relevé 462.

The woodland syntaxa of the Ae, Bd and Ea land types are strongly related to soil type (Figure 6). The *Rhoo lanceae – Acacion karroo* is characterized by species group E (Table 1) and the diagnostic species are the woody species *Diospyros lycioides, Ziziphus mucronata* and *Rhus lancea* while the shrub-like species *Protasparagus laricinus, P. suaveolens* and *Pollichia campestris* are also diagnostic of this alliance. The species of species group I (Table 1) have a wider occurrence, but are very prominent in this alliance. This vegetation is clearly related to the *Acacia karroo* riparian thicket class, described by du Preez and Bredenkamp (1991), but the presence of the prominent *Rhus lancea, Grewia flava* and *Ehretia rigida* indicates that the

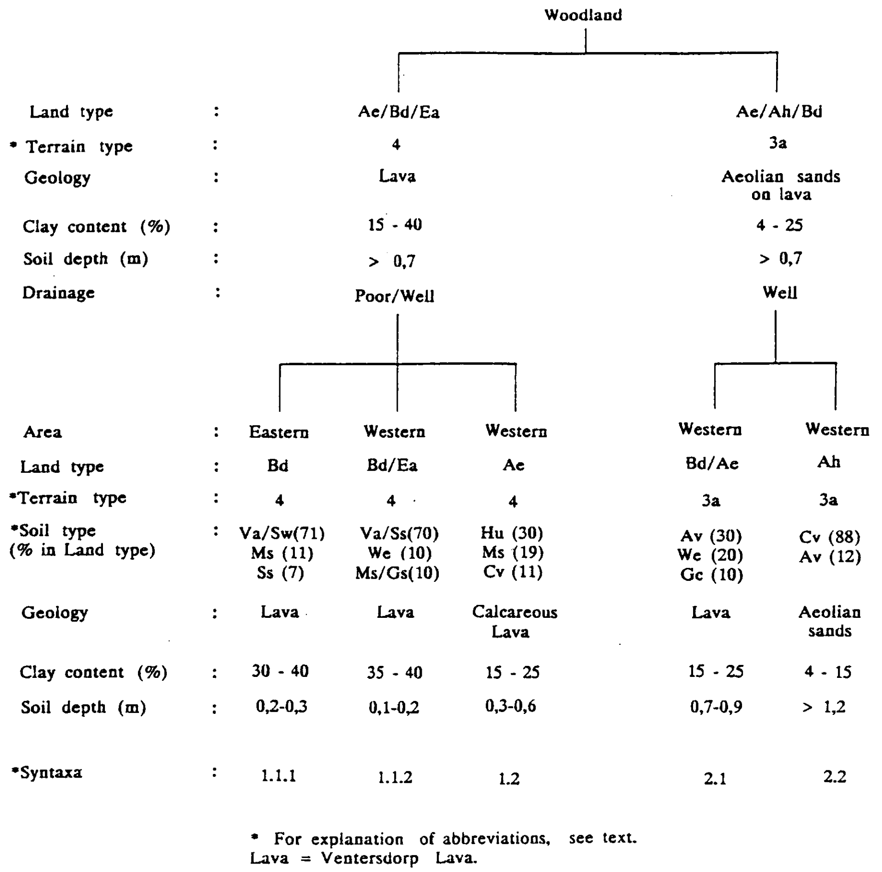


Figure 3 A dendrogram to illustrate the habitat relationships of the woodland syntaxa of the Bd, Ea and A land types in the grasslands of the western Transvaal, South Africa.

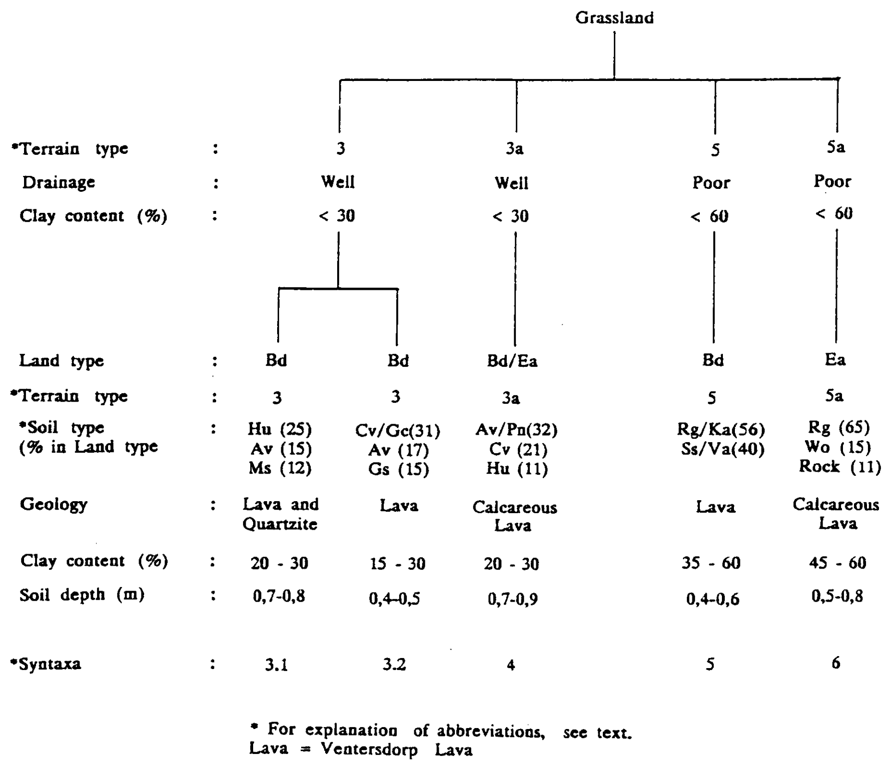


Figure 4 A dendrogram to illustrate the habitat relationships of the grassland syntaxa of the Bd, Ea and A land types in the grasslands of the western Transvaal, South Africa.

Table 1 A phytosociological table of the Bd and Ea land types and adjacent Ae and Ah land types in the western Transvaal, South Africa

Syntaxa (in text)	1 / 1.1 / 1.1.1	1 / 1.1 / 1.1.2	1 / 1.2	2 / 2.1	2 / 2.2	3 / 3.1	3 / 3.2	4	5	6
Sample plots	444444663444444663 666677239666677239 024503549024503549	666666666 010012334 906836019	6666666 5777722 3896778	6666 0024 5191	6666 5555 6745	4444444446 5556666771 3451389122	4336666 0992560 0783254	46666464666666 60240735435578 70437658060120	246666644466644 654443456714457 364789296415675	66666 77777 01345
Species group A										
Rhus pyroides	1111+ ++1111+ ++	+++++ + +	+				+			
Maytenus heterophylla	+ + + +	++								
Pavonia burchellii	++ + +++ + +	+ ++ +		+	+					
Teucrium trifidum	++++ + ++++ +	+ +			+					
Species group B										
Protasparagus africanus	+1++++ +1++++	+		+						
Clematis brachiata	+++ ++ +++ ++	+								
Talinum caffrum	++ ++									
Species group C										
Pseudognaphalium oligandrum	+ +	++1+++++	++ +++	+	+			+		
Nidorella resedifolia		+++2+++1	+ ++	+				+ + +		
Species group D										
Tarchonanthus camphoratus		++ +R	32322+					R		
Eragrostis rigidior			+11	1				+		
Aloe transvaalensis		+	+ ++							
Species group E										
Diospyros lycioides	++++ + ++++ +	22+ + + +	+	+++		+ +	+	+		
Ziziphus mucronata	+1++ 2+ ++1++ 2+ +	++ + +	+ +	+ 1	+					
Rhus lancea	+ ++ 1 + ++ 1	R +R+ 31	+ +++1	1			1			
Protasparagus laricinus	1 +++ +++1 +++ +++	++++ ++	+ +	+		+	R +	+		
Protasparagus suaveolens	11222+2++11222+2++	++++++1+	++ ++	+			R			
Pollichia campestris	+ + + + + +	++ +	+ +	+		+++	+			
Species group F										
Stipagrostis uniplumis	1 1			++21	+					
Schmidtia pappophoroides		+	+	+1				+		
Brachiaria nigropedata		+		+ 2		+				
Rhus ciliata	+ +		1+ +	+ +			+	R +		
Species group G										
Terminalia sericea					3333					
Grewia flavescens					1+					
Ozoroa paniculosa					++					
Dicerocaryum eriocarpum		+			++					
Dichrostachys cinerea					1					
Species group H										
Acacia erioloba		+	+	1R2	11		R	R		
Acacia hebeclada	1 1	+	+ +	R+	++++	+1	R			
Hermannia tomentosa				++	++		+			
Species group I										
Acacia karroo	32333233 32333233	2+32231+2	2+ +121	+2	++	+R+ 1		R R	R	
Grewia flava	1+ 2+ 1+ 2+	1 ++3 1	+11+112	22+	2+ 1					
Ehretia rigida	1+++ 1 1+++ 1	++ ++	+ +	+ 1	+ +					
Species group J										
Brachiaria serrata				+		+ ++++ 1+	+ +			
Triraphis andropogonoides				+	+	+ ++++ +++				
Dicoma anomala				+		++ +++ ++				

Table 1 Continued

Syntaxa (in text)	1 / 1.1 / 1.1.1	1 / 1.1 / 1.1.2	1 / 1.2	2 / 2.1	2 / 2.2	3 / 3.1	3 / 3.2	4	5	6
Sample plots	444444663444444663 666677239666677239 024503549024503549	666666666 010012334 906836019	6666666 5777722 3896778	6666 0024 5191	6666 5555 6745	4444444446 5556666771 3451389122	4336666 0992560 0783254	46666464666666 60240735435578 70437658060120	246666644466644 654443456714457 364789296415675	66666 77777 01345
Helichrysum callicomum	+			+		++ +++ ++		+	+	
Kyphocarpa angustifolia	+ + + +			+		+ ++++ +++	+	+ +		
Eustachys paspaloides						+++ +1 +	++			
Indigofera comosa						+++++				
Leucas capensis						++++ ++				
Gazania krebsiana	+ +			+		++++ ++	+		+	
Gnidia capitata	+ + + +			+ +		+++++		+		
Stoebe vulgaris		R +				++++ ++	+	+ +	+	
Blepharis angusta	++ + + ++ + +		+			++++ + ++	+	++	+	
Diheteropogon amplectens				+		+1 +				
Eragrostis racemosa						2 ++++				
Acalypha angustata			+ +			++ + +	+			
Zornia glochidiata					++	+ ++ +		+		
Acrotome hispida						+ ++				
Cyanotis speciosa						+ + +				
Deverra burchellii						+++	+		+	
Helichrysum nudifolium						+ ++		+	+	
Lotononis foliosa		+				++ + +				
Aristida stipitata	+ +					+ + +				
Tephrosia semiglabra		+	+			+ + +			+	
Senecio venosus						++				
Species group K										
Sporobolus fimbriatus		+					+++			
Sebaea grandis						+	+++			
Polygala hottentotta	+ +	+		+		+	+ + +		+ ++	
Digitaria argyrograpta	+ +					+ ++	+21	+		
Plexipus hederaceus		+	+	+		++	++ +			
Melinis nerviglume	+ +	+		++		+ +	+ ++	+	+	
Aristida canescens		+					+2	+	1	
Sporobolus discosporus				+			+ +			
Merremia species							++			
Species group L										
Eliomurus muticus		+	+	+		1 +1++++	++++++	+ + + +	+	
Hermannia depressa		+++ +				+++ ++	+++++	+ + ++		
Solanum panduriforme	+ + + +	+				+++++ ++	++++ +			
Trichoneura grandiglumis				+		+++ + +++	+ ++ +	R+ +		
Sida dregei	+ +	+ +	++	+		++++ +	+ + +	+ +		
Vernonia oligocephala	+ +		+	+		+++ ++	+++ ++			
Mariscus indecorus	++ ++	+ +				++++	++++ +	+	+	
Species group M										
Aristida diffusa				+	++2	++11+11++			+	
Anthephora pubescens	+ +			++ 1	+2	++ +1+1 1				
Crabbea angustifolia		+	+	+ +		+ ++		+		
Elephantorrhiza elephantina			+	+ +	1	+ ++ +	+			
Tephrosia burchellii	+ +			+ +	+	+ ++ ++	+			
Cassia mimosoides				+ +	+	++++ + +				
Species group N										
Sporobolus africanus	1122+ 11 1122+ 11	1+22121 +	+ + +1	+++		+2 +1 +++	+	++ 1 1	+ 1	
Felicia muricata	+ + ++ + +	+++ +	+ ++	++	+ ++	+ ++ ++	+ + +	+ + ++	+	
Lippia scaberrima	++ ++ ++ ++	+ +	+ +	+	+ +	++++ + +++	+++	+ +	+	
Barleria macrostegia	+++ +++	+++ ++ +	+	++ +	++	+++ ++	+ +	+++ +		
Tragus berteronianus	+ + + +	+ +++		+ +	++++	++	+ 1	+ + ++++	+	
Dicoma anomala	+ +	+ ++ +	++	++		+++ ++ + +	+ +++	+ + +		
Eragrostis capensis	+ +	++ ++	+ +			+ + ++	++1 ++	++ ++	+	
Eragrostis superba	+++ + +++ +	++		++		1++ +	+ + 1	+ 1	+	
Eragrostis lehmanniana	+ + + +	+ +	1	+	211+	++ +1		1+ 1	+	
Ziziphus zeyheriana	+ +	+ + +	+			+++		+ +		
Heteropogon contortus			2++++			++++	+ + +	+ +		

Table 1 Continued

Sample plots	444444663444444663	666666666	6666666	6666	6666	4444444446	4336666	46666464666666	246666644466644	66666
	666677239666677239	010012334	5777722	0024	5555	5556666771	0992560	60240735435578	654443456714457	77777
	024503549024503549	906836019	3896778	5191	6745	3451389122	0783254	70437658060120	364789296415675	01345
Syntaxa (in text)	1			2		3		4	5	6
	1.1		1.2	2.1	2.2	3.1	3.2			
	1.1.1	1.1.2								
Species group O										
Eragrostis plana							+	+ +	+2 2 111 2	+1
Cirsium vulgare								+	+++++ + ++ +	
Conyza podocephala		+			+			+ 2	+ ++++++ ++	
Becium obovatum						+			+++++ + +	
Berkheya radula								+	+++++ +	
Merremia tridentata									++ + +	
Species group P										
Diplachne fusca										22223
Echinochloa holubii										22223
Cyperus esculentus										++++
Schoenoplectus corymbosus										++++
Gnaphalium filagopsis										++++
Schoenoplectus muricinux										++++
Species group Q										
Eragrostis curvula	+++ 1+1+2+++ 1+1+2	21++11 +1	1++12++	3 +	++	1+22 222 1	+111111	212212++11+12+	+1++++R+121+	
Themeda triandra	+++11+2+ +++11+2+	+11+1+ 2	1 +2	1+ +	+	2++++11++1	+1++122	2+ 2233222+222	23223323223222+	R
Aristida congesta	+1+ + 1+++1+ + 1++	+1+ ++++	+++21	+ +	+++	2+ + + +	+++11	11+ +++3++1	++ +++ + R	
Cynodon dactylon	1+ +1+1+11+ +1+1+1	+ + +++	++	+	1+	+ ++++	++ +	++ ++++++2 ++	+ + 1+++++1 1	
Digitaria eriantha	1+++ 2+ 1+++ 2+	1++ ++	+1++1	+++	++11	+	+ ++	311+ 1111++	+++++112 1+ 1	
Cymbopogon plurinodis	++ ++ ++ ++	+ ++1 1	+ +1++1	+	+	++++++ +	+1++ +	+++ ++1 ++	4+++++ ++21	
Setaria sphacelata	+ +2 ++ + +2 ++	++ +	+ +	+		++2 ++12++	+2+++	+ + + +++	221 +1111+ +2	
Hibiscus pusillus	+++ + +++ +	++ ++++	++++	+		+++ ++	++++ +	+ ++ ++	+ + ++	
Eragrostis obtusa	++++ +1++++ +1	++ + 1	+ ++			+	++ + +	+++ 1 +++	++ ++++ +	
Panicum coloratum	+2 +2	++ ++ +	+	++			+ +	1 +++++ ++	+++++1++ + ++	
Corchorus asplenifolius	+ + + +	+++ +++	+ ++ +			+++ ++	++	+++ + +	++ + + ++	
Anthospermum hispidulum		+	+ +	+ +	+	++++++++++		++++ + +++	+ +	
Walafrida densiflora	+ + + +	++++ +++	++ +++		+	+ +	++	+++ +	+ ++ + +	
Monsonia angustifolia	+ + + +	+ + +	+	+++		+	+	++ ++	+ ++ ++ ++	
Hibiscus trionum	+ +	+ + + +	+++			++ +		++++	++ ++ +++	
Eragrostis gummiflua	+ + + +		+ + ++	+ +		+ +1+++ +		+2+ + 1	+ +	
Lightfootia denticulata	++ ++	++ +		+ ++		+++ +++ +		+ + +	++ ++	
Chamaesyce hirta		+		++	++	+ + ++		++ +	++++ + ++	
Crabbea acaulis			+			+++ + ++	++	+ + ++ ++	+ ++ +	
Geigeria burkei		+	+		1+	+++	++ +	++ +	+ + + ++	
Stachys spathulata	+ +	+1+					++ + +	+ +++ + ++	+++++ + +	+
Berkheya onopordifolia	++ ++	+ + +				++ +++	++	+ + +	+	
Raphionacme hirsuta	+ +	++	+	++		++ + ++		+ +	+	
Gomphrena celosioides	+ + + +	+ +	+			++++ +++			+ + + +	
Lactuca serriola		+ + +	+	+	+	++ ++ +	+		+ ++ +	
Scabiosa columbaria				+		+ + +	+++ +	+ + +	+ + + + +	
Pentzia globosa	RR+ ++ RR+ ++	+ +	+	+		+ 1	+	+ +		
Sutera atropurpurea		+	+ +			+ ++	++	+	+ + + + +	
Osteospermum muricatum	+ + + +	+	+			+	+	+ + +	+ + +	
Crassula lanceolata		+	1				+ ++	++ + +	+	
Helichrysum rugulosum		+				+		+ ++ ++	+	+ +
Solanum incanum	+ +++ + +++					++++ ++				
Oxygonum dregeanum				++		++++ + +		+		
Commelina africana				++			+	+++	+ +	
Justicia anagalloides		++		+		+++			+ +	
Pogonarthria squarrosa			+	1 1		+	+	+ +		
Schkuhria pinnata		— +		R			+		+ +	
Hermannia lancifolia				+		+		+ + +	+ +	
Kyllinga alba				++	+		+	++ +		
Mariscus capensis				+		+	+	+ +	+ +	
Commelina benghalensis		+ +		+		++ +	+			
Cyperus species		+ +				+ +++	+			
Helichrysum caespititium				+		+++	+	+		
Chloris virgata		- R							1 + +	
Ipomoea bathycolpos					+ +	++			+	
Solanum capensis	+ +					+		+ +		
Berkheya species	+ +					+ + +				
Cymbopogon excavatus	+ +		1	+				+		
Sphenostylis angustifolia		+ +						+ +		

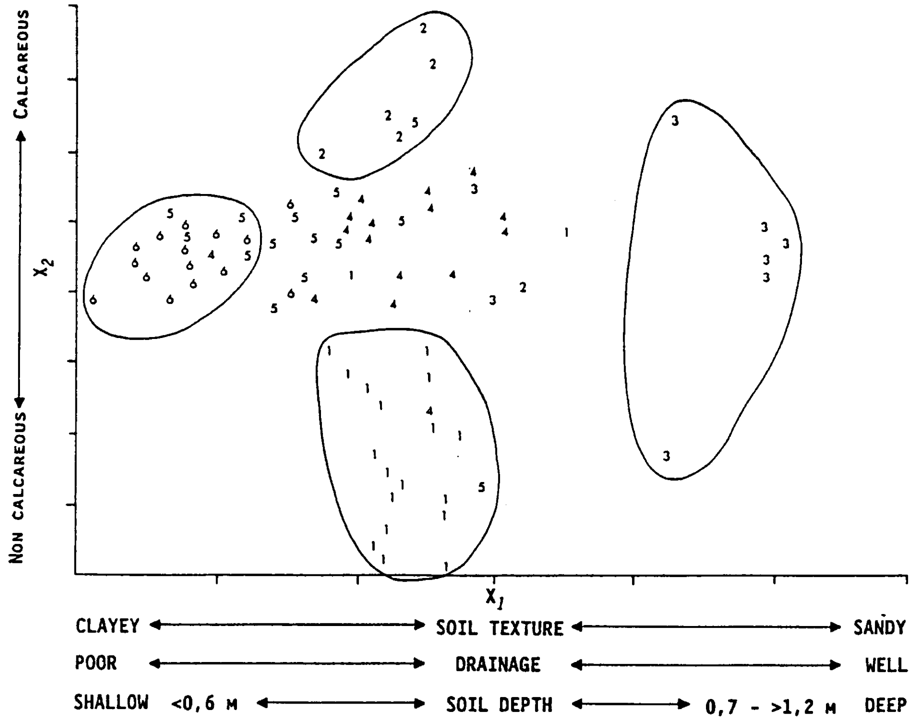


Figure 5 The relative positions of the syntaxa along the first two axes of the ordination of the Bd, Ea and A land types in the grasslands of the western Transvaal, South Africa (1, *Rhoo pyroidis – Acacietum karroo*; 2, *Tarchonatho camphorati – Acacietum karroo*; 3, *Acacion eriolobae*; 4, *Hermannio depressae – Elionurion mutici*; 5, *Themeda triandra – Elionurus muticus* Grassland; 6, *Circio vulgaris – Eragrostidetum planae*).

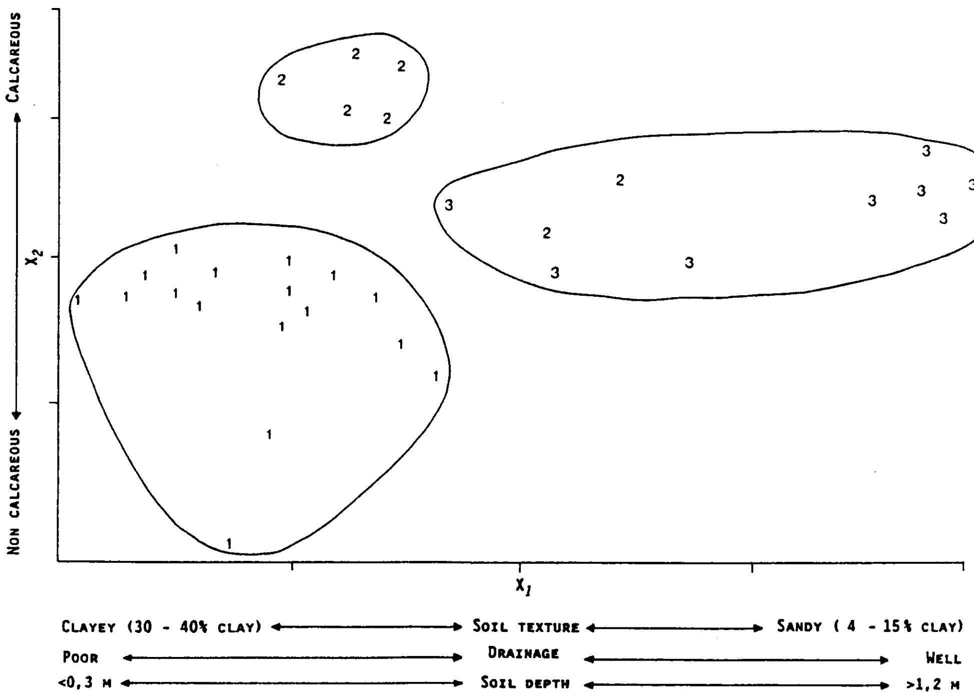


Figure 6 The relative positions of the woodland syntaxa along the first two axes of the ordination of the Bd, Ea and A land types in the grasslands of the western Transvaal, South Africa (1, *Rhoo pyroidis – Acacietum karroo*; 2, *Tarchonatho camphorati – Acacietum karroo*; 3, *Acacion eriolobae*).

Rhoo lanceae – Acacion karroo is a distinct alliance. Species group I (Table 1) suggests a probable new order under the *Acacia karroo* class, but this can only be confirmed after a syntaxonomic synthesis. The habitat for the *Rhoo lanceae – Acacion karroo* is strongly associated with moderately deep, clayey alluvial soils. Aeolian soils

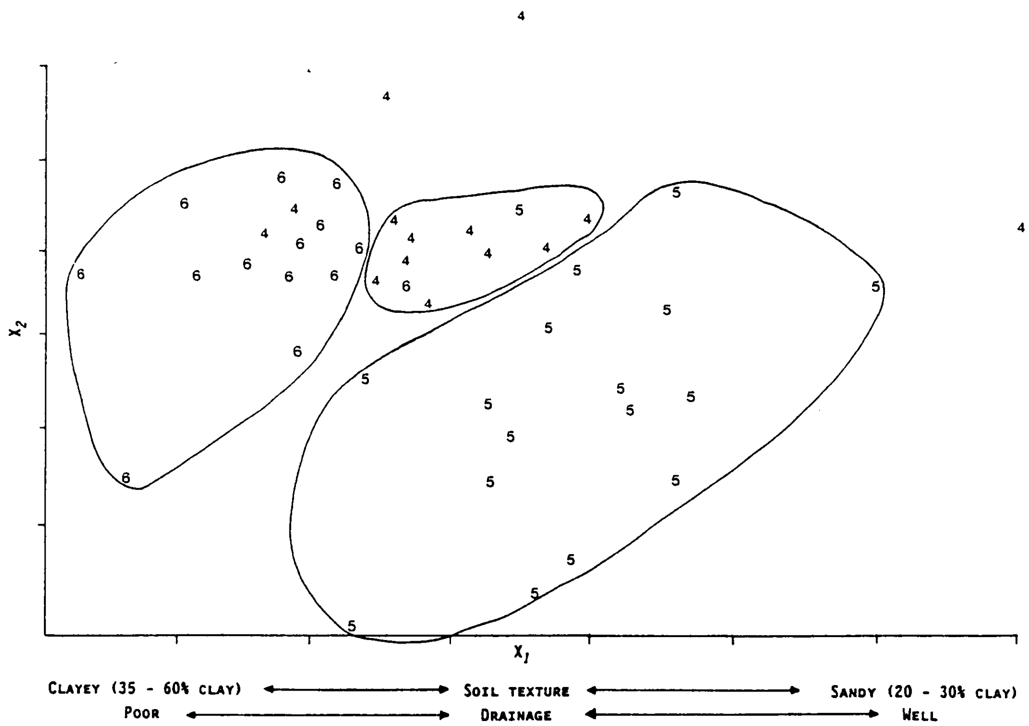


Figure 7 The relative positions of the grassland syntaxa along the first two axes of the ordination of the Bd, Ea and A land types in the grasslands of the western Transvaal, South Africa (4, *Hermannio depressae – Elionurion mutici*; 5, *Themeda triandra – Elionurus muticus* Grassland; 6, *Circio vulgaris – Eragrostidetum planae*).

(not deeper than 0.2 m) of recent origin sometimes cover the alluvial soils. This habitat is found at the bottomland flats of the Ae land type (Figure 2). The *Rhoo lanceae – Acacion karroo* could easily be recognized in the veld and is excellent veld for cattle and sheep farming. This alliance is represented by 25 relevés, consisting of two associations, one of them with two subassociations which are easily distinguished.

1.1 *Rhoo pyroidis – Acacietum karroo* ass. nov.

Type: relevé 462.

This association (with two subassociations) represents most of the woody vegetation within the Bd and Ea land types. Moderately deep (0.3 m), poorly drained, clayey alluvial soils are associated with this association (Figure 6). The dominant soil forms are the Valsrivier (Va), Swartland (Sw), Sterkspruit (Ss), Westleigh (We), Mispah (Ms) and Glenrosa (Gs) forms (Land Type Survey Staff 1984) (Figure 3). The bottomland flats of the Ae, Bd and Ea land types are typical habitat for this association. Sometimes these flats can also be referred to as 'footslopes', although they are not typical footslopes as defined by the Land Type Survey Staff (1984). Small ridges occur in the study area with 'footslopes'. Diagnostic species are from species group A (Table 1), namely: woody species *Rhus pyroides* and *Maytenus heterophylla* as well as the forbs *Pavonia burchellii* and *Teucrium trifidum*. The physical habitats of the two subassociations are quite similar but the rainfall is considerably lower in the western part than in the eastern part of the study area. This excellent veld normally results in overgrazing and disturbance of this association as cattle gives preference to this vegetation (Bezuidenhout & Bredenkamp 1991).

1.1.1 *Rhoo pyroidis – Acacietum karroo protasparagetosum africani* subass. nov.

Type: relevé 462.

This subassociation is restricted to the eastern part of the Bd land type. The abiotic factors are the same as were described for *Rhoo pyroidis – Acacietum karroo* (Figure 3). The diagnostic species *Protasparagus africanus*, *Clematis brachiata* and *Talinum caffrum* (Table 1, species group B) characterize this subassociation. Similar vegetation communities were described by Bezuidenhout and Bredenkamp (1990, 1991). On average, 26 species were recorded per sample plot.

The dominant woody component is dense with the tree stratum 5.3 m tall and a canopy cover of 17%. *Acacia karroo*, *Grewia flava*, *Ehretia rigida*, *Diospyros lycioides*, *Ziziphus mucronata*, *Rhus lancea*, *R. pyroides* and *Maytenus heterophylla* and the shrub-like forb species *Protasparagus laricinus*, *P. suaveolens*, *P. africanus* and *Pollichia campestris* are conspicuously present. The shrub stratum is 2.6 m tall with a canopy cover of 23% whilst the well-developed herbaceous layer is 0.7 m tall with a canopy cover of 67%. Widespread species (Table 1, species groups N and Q) are also represented in this subassociation. The presence of relatively palatable grasses in this area indicates the good grazing potential of this subassociation (Bosch & Janse van Rensburg 1987).

1.1.2 *Rhoo pyroidis – Acacietum karroo nidorelletosum resedifoliae* subass. nov.

Type: relevé 608.

This subassociation is typical of the *Rhoo lanceae – Acacion* *karroo* woodland in the western part of the Ea and Bd land types. This subassociation is restricted to the bottomland flats (Figure 2), with moderately deep, alluvial soils (Figure 3). The rainfall is lower than in the eastern part of the study area. This subassociation sometimes occurs on the edges of pans in the Delareyville area. The diagnostic species *Nidorella resedifolia* and *Pseudognaphalium oligandrum* (Table 1, species group C) differentiate this subassociation. On average, 31 species per sample plot were noted.

The trees that are prominent in this subassociation are *Acacia karroo, Ehretia rigida, Ziziphus mucronata, Rhus lancea, R. pyroides* and *Maytenus heterophylla*, are 5.5 m tall and have a canopy cover of 10%. The well-developed shrub stratum, with shrub species such as *Grewia flava* and *Diospyros lycioides*, is 1.8 m tall and has a canopy cover of 13.8%. The herbaceous layer is 0.7 m tall and has a canopy cover of 69%. Prominent grass species of this subassociation are *Sporobolus africanus, Eragrostis curvula* and *Themeda triandra*. Prominent forbs are *Corchorus asplenifolius, Barleria macrostegia* and *Hibiscus pusillus*, and shrub-like forb species such as *Protasparagus laricinus* and *P. suaveolens* are common to the area. A similar community was mentioned in the Bc land type in the western Transvaal grasslands by Bezuidenhout and Bredenkamp (1991).

1.2 *Tarchonantho camphorati – Acacietum karroo* ass. nov.

Type: relevé 653.

This association is strongly associated with less clayey soil (< 25%) than the previous association and with calcareous rocks sometimes covering the soil surface (Figure 6). The soil forms that represent this association are the Hutton (Hu), Mispah (Ms) and Clovelly (Cv) forms (Figure 3). The association is restricted to the bottomland flats of the Ae land type which occurs in the adjacent Vryburg Shrub Bushveld (Veld Type 16b; Acocks 1988) (Figure 2). The diagnostic species (Table 1, species group D) are the shrub *Tarchonanthus camphoratus*, the grass *Eragrostis rigidior* and the succulent *Aloe transvaalensis*. On average, 24 species were recorded per sample plot.

The tree stratum is 4.25 m tall and the canopy cover is 3.5%, while the well-developed shrub stratum is 2.1 m tall with a canopy cover of 24%. The prominent trees in the association are *Acacia karroo* and *Rhus lancea* while the prominent shrubs are *Tarchonanthus camphoratus, Rhus ciliata* and *Grewia flava*. The herbaceous layer has a canopy cover of 70% and is 0.7 m tall. The most prominent grasses are *Eragrostis rigidior, Sporobolus africanus, Heteropogon contortus, Eragrostis curvula* and *Cymbopogon plurinodis*.

2. *Acacion eriolobae* all. nov.

Type: relevé 656

This alliance is associated with the aeolian soils, of recent origin, in the Bd land type and adjacent Ae and Ah land types. The deep (> 0.7 m) well-drained soils with a clay content of less than 25% are situated on the footslopes of the A land types (Figure 2). This alliance is related to Acocks's (1988) Kalahari Thornveld Proper (Veld Type 16a). This woodland is characterized by species group H (Table 1). The following species are diagnostic for this alliance: the tree *Acacia erioloba*, the shrub *Acacia hebeclada* and the forb *Hermannia tomentosa*. The presence of species from group M (Table 1) characteristically indicates sandy soils within the A land types. Species of species groups E and I (Table 1) are also present but could be seen as outliers from the adjacent *Cymbopogon – Themeda* Veld and are not typical of this alliance.

2.1 *Stipagrosto uniplumis – Acacietum eriolobae* ass. nov.

Type: relevé 629.

This association is found on the boundary of the study area, where it is characteristically found on relatively deep (0.7 – 0.9 m) well-drained yellow sands (Figure 6). It occurs on the footslopes of the Ae and Bd land types (Figure 2). The dominant soil forms of this association are Avalon (Av), Westleigh (We) and Glencoe (Gc) (Land Type Survey Staff 1984). Diagnostic species (Table 1, species group F) are the grass species *Stipagrostis uniplumis, Schmidtia pappophoroides* and *Brachiaria nigropedata* as well as the shrub *Rhus ciliata*. On average, 37 species were recorded per sample plot.

The tree stratum with a cover of 10% and a height of 5 m is represented by the prominent tree *Acacia erioloba*. The prominent shrub species are *Rhus ciliata, Acacia hebeclada, A. karroo, Grewia flava, Diospyros lycioides* and *Ehretia rigida*. The shrub layer covers 10% of the area and is 1.5 m tall. The herbaceous layer is 0.8 m tall and has a canopy cover of 57%. Prominent grasses are *Stipagrostis uniplumis, Schmidtia pappophoroides, Brachiaria nigropedata, Anthephora pubescens, Sporobolus africanus* and *Digitaria eriantha*. Forbs that are constantly present are *Hermannia tomentosa, Barleria macrostegia* and *Monsonia angustifolia*. A similar community, the Kalahari transitional grassland, was described by Gubb (1989).

2.2 *Terminalietum sericeae – Acacietum eriolobae* ass. nov.

Type: relevé 656.

This association is also found on the footslopes but mainly in the Ah land type (Figure 2). Aeolian sand has been deposited on the footslopes of small ridges. The dominant soil forms are Clovelly (Cv) and Avalon (Av) (Land Type Survey Staff 1984). The soil depth is deeper than 1.2 m. This habitat is typical of the Kalahari Thornveld Proper (Veld Type 16a) (Acocks 1988). On average, 21 species per sample plot were noted. One tree species, *Terminalia sericea*, and three shrub species, *Grewia flavescens, Ozoroa paniculosa* and *Dichrostachys cinerea*, and one forb, *Dicerocaryum eriocarpum* are the diagnostic species for this association (Table 1, species group G).

The tree stratum is 6 m tall and the canopy cover is 10%, while the well-developed shrub stratum is 2.15 m tall and the canopy cover 21%. Other woody species present in this association are *Acacia erioloba, A. hebeclada* and *Grewia flava*. The herbaceous layer has a canopy cover of 66% and is 0.63 m tall. The grass species that are prominent in this association are *Aristida diffusa, Tragus berteronianus, Eragrostis lehmanniana, Aristida congesta* and *Digitaria eriantha*. Forbs such as *Hermannia tomentosa* and *Felicia muricata* are abundant. Gubb (1989) briefly described a similar closed, short *Terminalia* woodland which occurs on yellow, leached, distrophic sands.

3. *Hermannio depressae – Elionurion mutici* all. nov.

Type: relevé 453.

The relatively high altitude grasslands of the Bd and Ea land types are characterized by species group L (Table 1). This alliance is found on the midslopes or the footslopes of the Bd land type (Figure 2). The following species are diagnostic: the grass species *Elionurus muticus* and *Trichoneura grandiglumis* and the forb species *Hermannia depressa, Solanum panduriforme, Sida dregei, Vernonia oligocephala* and the sedge *Mariscus indecorus*.

Two associations are distinguished in this alliance, with 17 relevés representing it.

3.1 *Trirapho andropogonoidis – Elionuretum mutici* ass. nov.

Type: relevé 453.

The *Trirapho andropogonoidis – Elionuretum mutici* is found on the midslopes of the Bd land type (Figure 2). The well-drained, sandy soils with the dominant soil forms Hutton (Hu), Avalon (Av) and Mispah (Ms), are typical habitat for this association (Figure 4). The association is characterized by species group J (Table 1), with diagnostic species being the grasses *Brachiaria serrata, Triraphis andropogonoides, Eustachys paspaloides, Diheteropogon amplectens, Eragrostis racemosa* and *Aristida stipitata*. *Dicoma anomala, Helichrysum callicomum, Kyphocarpa angustifolia, Indigofera comosa, Leucas capensis, Gazania krebsiana, Gnidia capitata, Stoebe vulgaris, Blepharis angusta* and *Acalypha angustata* are characteristic forbs for this association (Table 1). On average, 48 species were noted per sample plot.

No trees were noted in the association and a poorly developed shrub stratum with a canopy cover of 5% that is not very tall (1.2 m) is present. Prominent shrubs are *Acacia karroo, A. hebeclada* and *Diospyros lycioides*. The herbaceous layer is 0.6 m tall and has a canopy cover of 52%. Other than the diagnostic species, the prominent grasses in this association are *Elionurus muticus, Aristida diffusa, Anthephora pubescens, Sporobolus africanus, E. curvula, Themeda triandra, Setaria sphacelata* and *Eragrostis gummiflua*. Prominent forbs are *Solanum panduriforme* and *Cassia mimosoides* (Table 1).

3.2 *Sporobolo fimbriati – Elionuretum mutici* ass. nov.

Type: relevé 398.

This association is also found on the midslopes of the Bd land type, where it forms a mosaic with the *Trirapho andropogonoidis – Elionuretum mutici*. The soil is shallower and not as well drained as that of the latter association (Figure 4). Clovelly (Cv), Glencoe (Gc), Avalon (Av) and Glenrosa (Gs) soil forms are the dominant soil forms in this association (Figure 4). For a midslope grassland association this vegetation is not species-rich, with an average of 28 species per sample plot.

Both tree and shrub strata are absent. The herbaceous layer is well developed, is 0.77 m tall and has a canopy cover of 69%. The diagnostic grass species are *Sporobolus fimbriatus, Digitaria argyrograpta, Melinis nerviglume, Aristida canescens* and *Sporobolus discosporus*. Diagnostic forb species are *Sebaea grandis, Polygala hottentotta, Plexipus hederaceus* and *Merremia* species (Table 1, species group K). Other grass species which are prominent in this association are *Elionurus muticus, Eragrostis capensis, E. curvula, Themeda triandra, Aristida congesta, Cymbopogon plurinodis* and *Setaria sphacelata* while prominent forb species are represented by *Hermannia depressa, Solanum panduriforme, Vernonia oligocephala* and the sedge *Mariscus indecorus*.

4. *Themeda triandra – Elionurus muticus* Grassland (without syntaxonomic rank)

In spite of the relative absence of species group L (Table 1), this community is provisionally classified under the *Hermannio depressae – Elionurion mutici*, but no syntaxonomic rank is assigned to this grassland. The proper syntaxonomic position will only be determined in a final syntaxonomic synthesis of the entire western Transvaal grasslands. This plant community is associated with the flat footslopes of the Bd and Ea land types. The soil type is a mixture of poorly-drained and well-drained soils. The soil depth varies between 0.7 and 0.9 m. Sometimes calcareous rocks are scattered in this plant community (Figure 4). The dominant soil forms are Avalon (Av), Pinedene (Pn), Clovelly (Cv) and Hutton (Hu). When the soil type tends to be more sandy (< 20% clay), this plant community is in competition with the *Stipagrosto uniplumis – Acacietum eriolobae*. It also relates to *Circio vulgaris – Eragrostidetum planae* (Figure 7). On average, 21 species per sample plot were noted.

There are no diagnostic species for this association, but species of species groups N and Q (Table 1) are prominent. The herbaceous layer is 0.72 m tall with a canopy cover of 77%. The following grasses are prominent: *Eragrostis curvula, E. obtusa, Themeda triandra, Aristida congesta, Cynodon dactylon, Digitaria eriantha, Cymbopogon plurinodis* and *Panicum coloratum*. Prominent forbs include *Anthospermum hispidulum, Crabbea acaulis* and *Stachys spathulata*. A similar community was described by Gubb (1989) which occurs in the Vryburg – Stella Grassland. This grassland may be a transitional grassland from two veld types, namely: Kalahari Thornveld (Veld Type 16) and Dry *Cymbopogon – Themeda* Veld (Veld Type 50) (Acocks 1988).

5. *Circio vulgaris – Eragrostidetum planae* ass. nov.

Type: relevé 263.

This association is restricted to the floodplains of the Bd land type. The margalitic soils are represented by the Rensburg (Rg), Katspruit (Ka), Sterkspruit (Ss) and Valsrivier (Va) soil forms (Figure 4) (Land Type Survey Staff 1984). The clayey soils are poorly drained and are seasonally wet. Ploughing activities are limited and the land is mostly overgrazed. This association is characterized by species group O (Table 1), with the diagnostic grass species, *Eragrostis plana* and forbs species *Cirsium vulgare, Conyza podocephala, Becium obovatum, Berkheya radula* and *Merremia tridentata*. On average, 20 species were recorded per sample plot.

Both tree and shrub layers are absent. The herbaceous layer is well developed, 0.76 m tall and has a canopy cover of 82%. The prominent grass species are *Eragrostis plana, E. curvula, Themeda triandra, Cynodon dactylon, Digitaria eriantha, Cymbopogon plurinodis, Setaria sphacelata* and *Panicum coloratum*. Apart from the diagnostic species, other prominent forbs are *Monsonia angustifolia, Hibiscus trionum* and *Chamaesyce hirta*.

6. *Diplachno fuscae – Echinochloetum holubii* ass. nov.

Type: relevé 670.

This association is restricted to the pans in the Ea land type (Figure 2). The dominant soil forms are Rensburg (Rg) and Willowbrook (Wo), with scattered rocky outcrops sometimes present (Figure 4). Under normal circumstances these pans are seasonally wet but during good rain years they could have annual water. Floristically this association differs substantially from the rest of the vegetation in the study area. The presence of species group P and the absence of species group Q (Table 1) characterize this difference. On average, seven species per sample plot were noted.

The herbaceous layer is well developed and is 1.2 m tall with a canopy cover of 85%. The diagnostic species (Table 1, species group P), which are also the prominent species, are the grasses *Diplachne fusca* and *Echinochloa holubii* and sedges *Cyperus esculentus, Schoenoplectus corymbosus, S. muricinux* and forb *Gnaphalium filagopsis*. After an ordination was done on the total number of relevés of the Bd, Ea, Ah and Ae land types, it was apparent that the *Diplachno fuscae – Echinochloetum holubii* forms a distinctly separate group while the rest of the relevés are all grouped closely together. A similar community was described by Kooij *et al.* (1991) to the south-east of the study area.

Ordination

In the phytosociological table a clear discontinuity could be recognized between the *Diplachno fuscae – Echinochloetum holubii* and the rest of the vegetation of the Ae, Ah, Bd and Ea land types (Table 1). This was also verified by the ordination of the total data set which is not presented in this paper. The distribution of the relevés, excluding the relevés of the *Diplachno fuscae – Echinochloetum holubii*, is given along the first and second axes of the scatter diagram (Figure 5). Although no distinct discontinuity can be observed in the scatter diagram, the plant units are restricted to specific spacial areas in the diagram. The diagram also illustrates a gradient along the first and second axes which could be related to the soil texture, drainage, soil depth and the presence of calcareous rocks. An ordination was then performed separately on the relevés of the woodland units (Figure 6) and on the relevés of the grassland units (Figure 7). On the first axis of the scatter diagram of the woodland data (Figure 6), the *Rhoo lanceae – Acacion karroo* (1) can be clearly distinguished from the *Acacion eriolobae* (3). It also illustrates a gradient which could be related to soil texture, drainage and soil depth. On the second axis the *Rhoo lanceae – Acacion karroo* could be divided into *Rhoo pyroidis – Acacietum karroo* (1) (on non-calcareous soils) and *Tarchonantho camphorati – Acacietum karroo* (2) (on calcareous soils). Although the plant units are floristically not totally different (Table 1), the ordination results clearly distinguished between the Kalahari Thornveld (Veld Type 16) and the Dry *Cymbopogon – Themeda* Veld (Veld Type 50).

On the first axis of the scatter diagram of the relevés of the grasslands (Figure 7), the *Hermannio depressae – Elionurion mutici* (4) can clearly be distinguished from the *Circio vulgaris – Eragrostidetum planae* (6). A gradient illustrates the relation of the plant units to soil texture and drainage. The second axis distinguishes between the *Hermannio depressae – Elionurion mutici* (4) and *Themeda triandra – Elionurus muticus* Grassland (5).

Conclusions

This is the first comprehensive syntaxonomical account of the grasslands of the Bd and Ea land types in the western Transvaal grassland. New syntaxa described include one order, three alliances, eight associations and two subassociations.

Typical of the vegetation of the western Transvaal grassland, two structural units, namely woodland and grassland, could be identified. The results of the ordinations support the proposed classification and emphasize the habitat gradients associated with plant units. It was also established that there is a floristic relationship between the different veld types (Acocks 1988) but that the Kalahari Thornveld (Veld Type 16) can be clearly distinguished from the Dry *Cymbopogon – Themeda* Veld (Veld Type 50). The relatively low and erratic rainfall of the area doesn't favour agronomy although many farmers have ploughed and planted maize in good rainfall years. The vegetation of the Bd and Ea land types of western Transvaal are best suited for cattle and, to a lesser extent, sheep farming. This classification of vegetation and associated habitat should form a basis for all vegetation-related management planning in the region. These descriptions and ecological interpretations of the plant units of the Bd and Ea land types contribute considerably to the understanding and present knowledge of the western Transvaal grassland.

Acknowledgements

Thea Bezuidenhout is thanked for assistance in the preparation of this manuscript and Jan and Didi du Toit for their hospitality and friendliness towards one of the authors (H.B.) while doing fieldwork.

References

ACOCKS, J.P.H. 1988. Veld types of South Africa. *Mem. bot. Surv. S. Afr.* 57: 1 – 146.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of Phytosiological Nomenclature, 2nd ed. *Vegetatio* 67: 145 – 195.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H. (in prep.). Syntaxonomy and synecology of western Transvaal grasslands, South Africa. Ph.D. dissertation, University of Pretoria, Pretoria.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom – Ventersdorp – Randfontein area, South Africa. *Phytocoenologia* 18: 387 – 403.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991. The vegetation of the Bc land type in the western Transvaal Grassland, South Africa. *Phytocoenologia* 19: 497 – 518.

BOSCH, O.J.H. & JANSE VAN RENSBURG, F.P. 1987. Ecological status of species on grazing gradients on the shallow soils of the western grassland biome in South Africa. *J. Grassl. Soc. South. Afr.* 4: 143 – 147.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve. 1. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 – 529.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom – Fochville – Parys area. *S. Afr. J. Bot.* 55: 199 – 206.

COETZEE, B.J. 1983. Phytosociology, vegetation structure and landscapes of the Central District, Kruger National Park. Dissertationes Botanicae 69. Cramer, Vaduz

DU PREEZ, P.J. & BREDENKAMP, G.J. 1991. Vegetation classes of the southern and eastern Orange Free State (Republic of South Africa) and the highlands of Lesotho. *Navors. Nas. Mus., Bloemfontein* 7: 477 – 525.

GIBBS RUSSELL, G.E., REID, C., VAN ROOY, J. & SMOOK, L. 1985. List of species of southern African plants, 2nd edn., Part 1. *Mem. bot. Surv. S. Afr.* 51: 1 – 152.

GIBBS RUSSELL, G.E., WELMAN, W.G., RETIEF, E., IMMELMAN, K.L. GERMISHUIZEN, G., PIENAAR, B.J., VAN WYK, M. & NICHOLAS, A. 1987. List of species of southern African plants, 2nd edn., Part 2. *Mem. bot. Surv. S. Afr.* 56: 1 – 270.

GUBB, A.A. 1989. An evaluation of Landsat MSS data for ecological land classification. M.Sc. thesis, University of Cape Town, Cape Town.

HARMSE, H.J.vonM. 1967. Soil genesis in the Highveld Region, South Africa. D.Sc. thesis, University of Utrecht, Utrecht.

HILL, M.O. 1979a. TWINSPAN – A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

HILL, M.O. 1979b. DECORANA – A Fortran program for detrended correspondence analysis and reciprocal averaging. Cornell University, New York.

KOOIJ, M.S., BREDENKAMP, G.J. & THERON, G.K. 1990. Classification of the vegetation of the B land type in the northwestern Orange Free State. *S. Afr. J. Bot.* 56: 309 – 318.

KOOIJ, M.S., SCHEEPERS, C.J., BREDENKAMP, G.J. & THERON, G.K. 1991. The vegetation of the Kroonstad area, Orange Free State I: Vlei and bottomland communities. *S. Afr. J. Bot.* 57: 213 – 219.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. agric. nat. Resour. S. Afr.* 4: 1 – 441.

MACVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H. & HARMSE, H.J.vonM. 1977. Soil classification – A binomial system for South Africa. Dept. Agricultural-technical services, Pretoria.

MENTIS, M.T. & HUNTLEY, B.T. 1982. A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog. Rep.* 62: 1 – 29.

MORRIS, J.W. 1973. Automatic classification and ecological profiles of south-western Transvaal Highveld grassland. Ph.D. dissertation, University of Natal, Pietermaritzburg.

MORRIS, J.W. 1976. Automatic classification of the highveld grassland of Lichtenburg, south-western Transvaal. *Bothalia* 12: 267 – 292.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

VAN ROOYEN, N., THERON, G.K. & GROBBELAAR, N. 1981. A floristic description and structural analysis of the plant communities of the Punda Milia – Pafuri – Wambiya area in the Kruger National Park. 1. The hygrophilous communities. *Jl. S. Afr. Bot.* 47: 213 – 246.

WEATHER BUREAU. 1988. Climate of South Africa. Report No. 40, pp. 1 – 475. Government Printer, Pretoria.

4.6 **Syntaxonomy of the vegetation of the Fb land type in the western Transvaal Grassland, South Africa.**

Page

* *In press: South African Journal of Botany*

Syntaxonomy of the vegetation of the Fb land type in the western Transvaal Grassland, South Africa.

H. Bezuidenhout*, G.J. Bredenkamp and G.K. Theron

Department of Botany, University of Pretoria, Pretoria 0002, Republic of South Africa

* To whom correspondence should be addressed: National Parks Board, Scientific Services, P.O. Box 110040, Hadison Park, Kimberley 8306, Republic of South Africa

Relatively little is known about the vegetation of the western Grassland Biome in South Africa. The classification of the vegetation of the Fb land type forms part of a research programme on the synthesis of the vegetation of the western Grassland Biome. Using a numerical classification technique (TWINSPAN) as a first approximation, the classification was refined by applying Braun-Blanquet procedures. The result is a phytosociological table where two new alliances and seven new associations are recognized. The new syntaxa are ecologically interpreted as well as described. Associated gradients in habitat are identified by using an ordination algorithm (DECORANA). This study should contribute to the present knowledge and ecological understanding of the vegetation of the western Transvaal grassland.

Relatief min inligting is oor die plantegroei van die westelike grasveldbioom van Suid-Afrika beskikbaar. Die klassifikasie van die plantegroei van die Fb-landtipe vorm deel van die sintese van die plantegroei van die westelike grasveldbioom. 'n Numeriese tegniek (TWINSPAN) is as 'n eerste klassifikasie van die floristiese data aangewend. Daarna is die Braun-Blanquet-prosedure gevolg om twee nuwe alliansies en sewe nuwe assosiasies in 'n fitososiologiese tabel te identifiseer. Die nuwe sintaksons word ekologies geïnterpreteer en beskryf. Geassosieerde gradiënte in habitat is deur toepassing van 'n ordeningstegniek (DECORANA) geïdentifiseer. Hierdie studie behoort 'n waardevolle bydrae tot die kennis oor die plantegroei en ekologie van die Wes-Transvaal te lewer.

Keywords: Braun-Blanquet, Fb land type, Grassland Biome, Syntaxonomy, Western Transvaal.

Introduction

Mentis & Huntley (1982) as well as Scheepers (1987) stated the necessity to determine the location and extent of the major vegetation types within the Grassland Biome. As part of a phytosociological research programme on the synthesis of the vegetation of the Grassland Biome in South Africa (Bezuidenhout 1988, Turner 1989, Kooij 1990, Breytenbach 1991, Myburgh *et al.* 1992, Eckhardt 1993), the plant communities of the western Grassland Biome is being surveyed and classified. In the western Grassland Biome only Acocks's (1988) broad classification and a few local vegetation studies (Louw 1951, Morris 1973, Van Wyk 1983, Bezuidenhout 1988) have been done. A mosaic of land types occur in the western Grassland Biome (Figure 1). As land types represent an ecologically based stratification of the study area, each land type is separately used to describe the vegetation of the area (Bezuidenhout *in prep*). In this paper a description of the vegetation of the Fb land type in the study area is presented.

The gold-bearing quartzitic rock of the Witwatersrand Supergroup in the Fb land type is of great national importance (Coetzee 1976). Although mining activities have caused destruction and degradation of the vegetation of the Fb land type, large areas with relatively well preserved vegetation can still be found on the rocky hills and ridges in the area. The need to classify and describe this vegetation could therefore not be over emphasized. A habitat and floristic diversity of rocky quartzitic hills are known from other parts of the Grassland Biome (Bredenkamp & Theron 1978, Bredenkamp & Lambrechts 1979, Behr & Bredenkamp 1988). To formulate a management policy, proper land use should be emphasized, and for this purpose a classification of the vegetation is essential (Van Rooyen *et al.* 1981). It will also provide scientific guidelines for conservation priorities. The results should contribute to the ultimate aim of a phytosociological and syntaxonomical synthesis of the South African Grassland Biome.

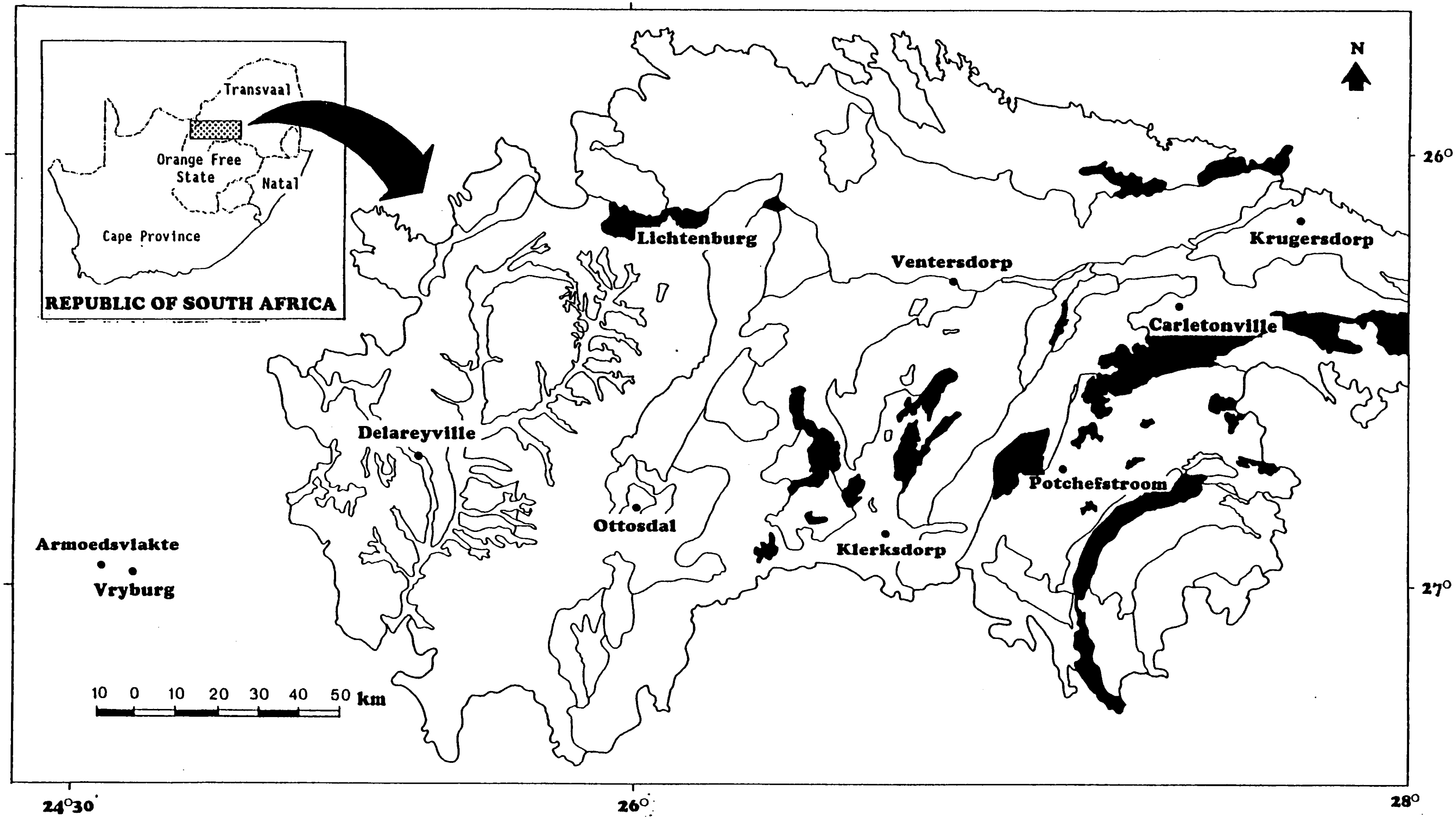


Figure 1: The location of the Fb land type (■) in the western Transvaal, South Africa (Adapted from Land Type Series 1979).

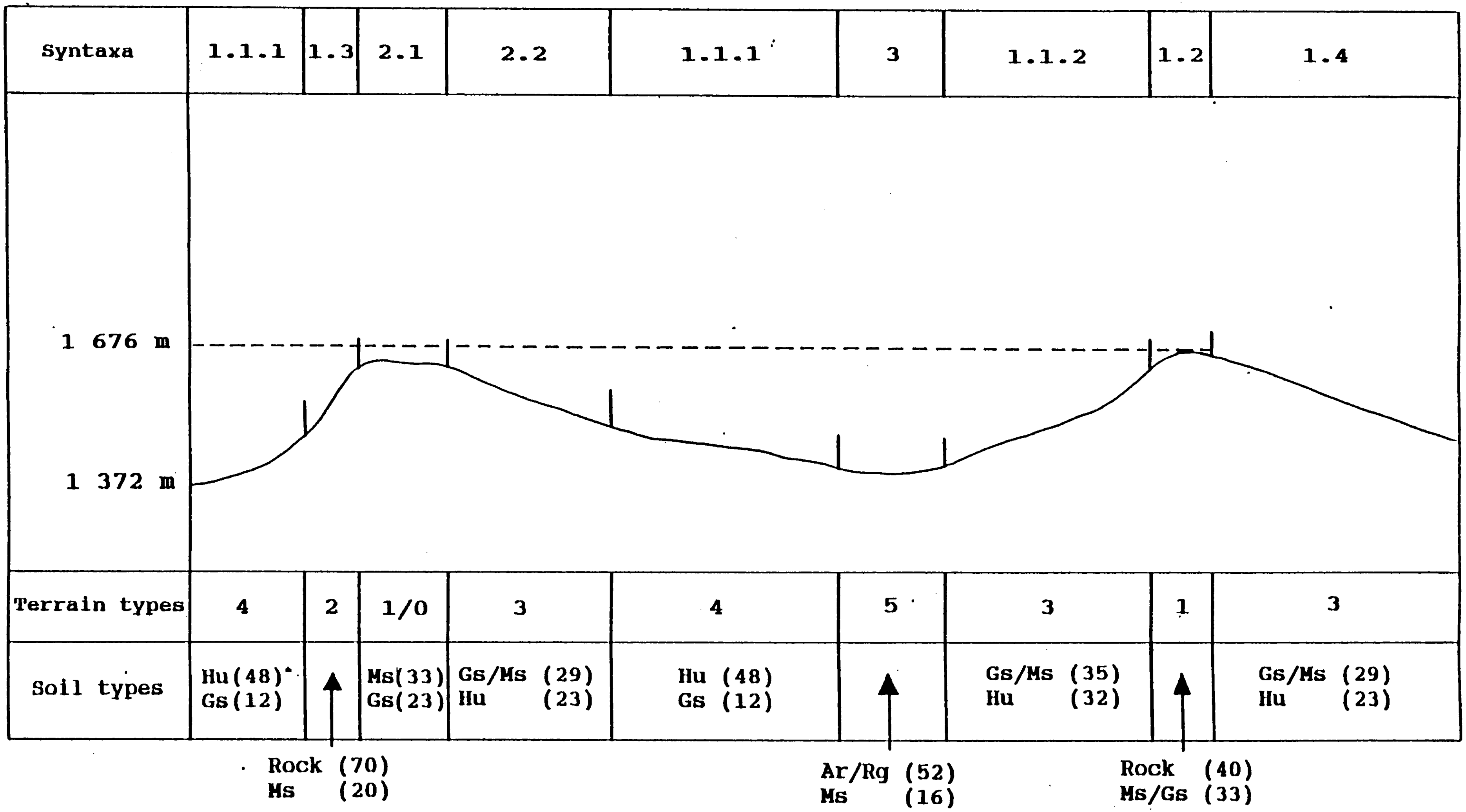
Study area

The study area is situated in the western part of the Highveld Agricultural Region, Transvaal and bounded by latitudes 25° 45′ and 27° 15′ south and longitudes 24° 45′ and 28° 00′east (Figure 1). Most of the Fb land type islands are situated to the eastern part of the study area with isolated parts in the central and western parts of the study area. The well known Gatsrant hill range between Potchefstroom and Carletonville and the outer rim of the Vredefort Dome just south of Potchefstroom, form the main core of the Fb land type in the western Transvaal. The Fb land type covers approximately 178 130 hectares, and although the Land Type Survey Staff (1984) estimated that between 5 % to 10 % is unsuitable for agronomy, very little of the Fb land type has been ploughed. Apart from the fact that mining companies own much of the Fb land type area, one of the main reasons for not ploughing it is that the dominant soil types are relatively shallow (between 100 - 350 mm) and rocky with the soil forms Glenrosa, Mispah and shallow Hutton predominant (Land Type Survey Staff 1984). The soil nomenclature follows the classification of MacVicar *et al.* (1977). The main rock types of the Fb land type are shale, slate and quartzite of the Pretoria Group with interlayered diabase sills and Hekpoort lava. Chert, dolomite and Black Reef quartzite are present in some places. The quartzite usually forms the crests and scarps in the terrain while the footslopes are usually covered by mixed colluvium. The midslopes and drainage lines are on the shales and slate (Land Type Survey Staff 1984). The Fb land type is drained by the tributaries of the Schoonspruit and the Mooi River.

The terrain is mostly high lying and is situated at altitudes of 1 372 m up to 1 676 m above sea level. The Fb land type represents the conspicuous parts in the study area and can easily be recognized while travelling through the western Transvaal. The average summer rainfall in the east exceeds 600 mm, with Potchefstroom receiving 625 mm and Carletonville 670 mm per year. However, in the west the rainfall is erratic and sometimes lower than 450 mm per annum. The mean minimum monthly winter temperatures are sometimes below - 1 °C whilst the mean maximum monthly summer temperatures are as high as 32 °C (Weather Bureau 1986).

Methods

The broad stratification of the study area was based on land type, while terrain type was used within each land type for a more detailed stratification. The term land type is used in a land-use classification system describing a homogeneous terrain with regard to soil pattern and climate (Land Type Survey Staff 1984). The following terrain types were recognised in the Fb land type: Plateau (1/0); Crest (1); Scarp (2); Midslope (3); Footslope (4) and Drainage line (5) (Figure 2). Relevés were compiled in 96 stratified sample plots. Plot sizes were fixed on 16 m^2 for the grassland vegetation and 100 m^2 for the woody vegetation (Bredenkamp & Theron 1978). For every plant species present in the sample plot a cover-abundance value was estimated according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). Height and canopy cover for the tree, shrub and herbaceous layers were additionally recorded in each sample plot, and average values calculated for each plant community. Environmental information such as rock type, terrain type and soil type as well as soil depth and an estimation of rockiness of the soil surface, and also slope inclination were noted (Figures 3 and 4). For analysing the raw floristic data an objective statistical classification technique, TWINSPAN (Hill 1979a), was used complementary to the Braun-Blanquet procedures. The final result of the classification procedure is represented in a phytosociological table (Table 1). An ordination technique, DECORANA (Hill 1979b), was also applied to the floristic data (Figure 4). Taxa names conform to those of Arnold & De Wet (1993). This is the first comprehensive vegetation classification of the entire Fb land type of the western Transvaal grassland and therefore new syntaxa are described and formal syntaxonomy in accordance to the Code of Phytosociological Nomenclature (Barkman *et al.* 1986) is applied to the classification.



* Hu (48): Hutton soil form occurs in 48 % of the terrain type.

Figure 2: The location of the syntaxa on the topographical terrain types within the Fb land type (adapted from Land Type Survey Staff 1984) in the western Transvaal, South Africa (all abbreviations and numbers in text).

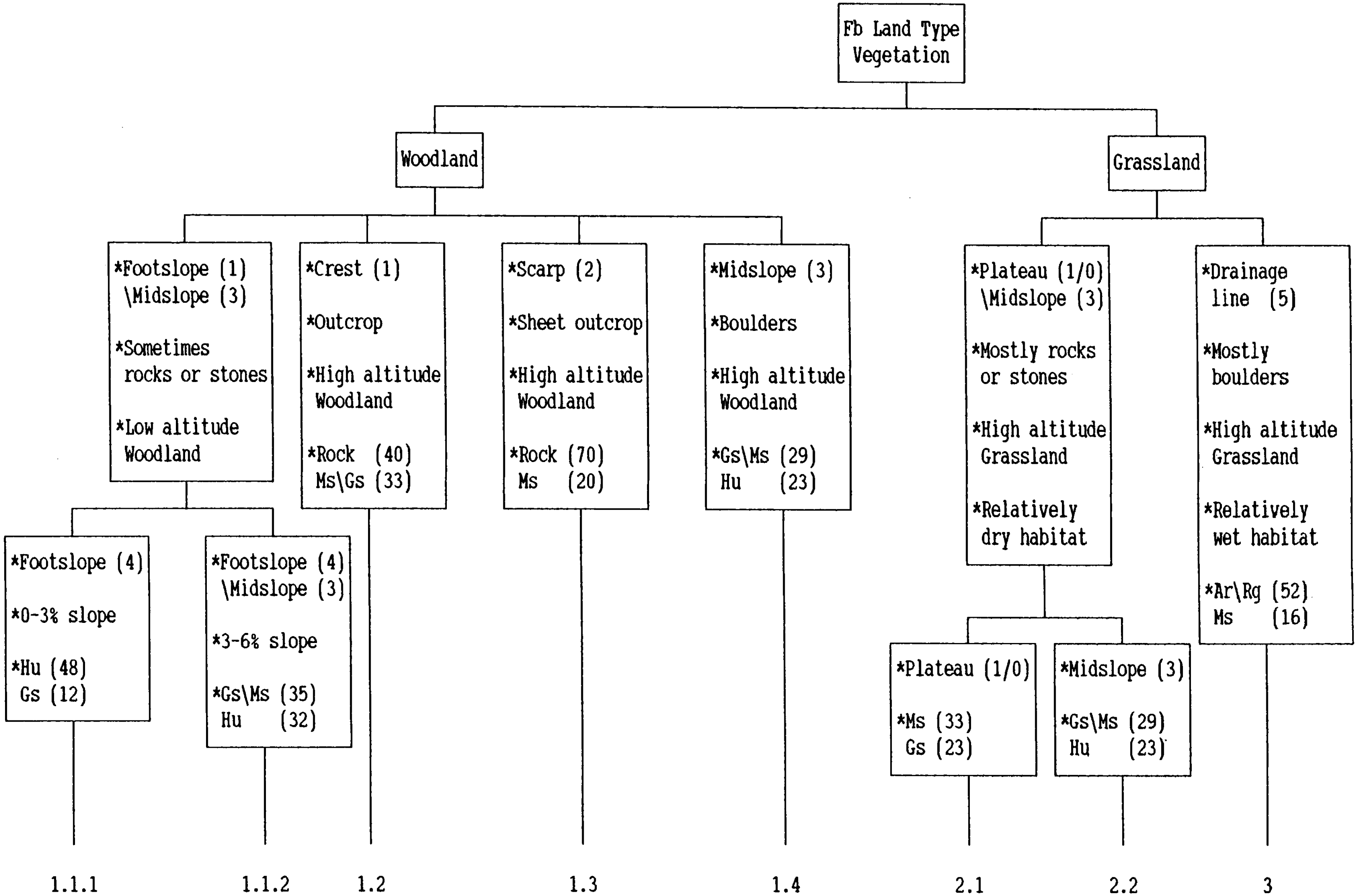


Figure 3: A dendrogram to illustrate the habitat relationships of the syntaxa of the Fb land type in the western Transvaal, South Africa (all abbreviations and numbers explained in text).

Results

Classification

In the phytosociological table (Table 1), two alliances, seven associations and two sub-associations are recognized. The hierarchical classification of these vegetation units is as follows:

1. *Rhoo leptodictyo-Acacion caffrae*

   1.1 *Acacietum karroo-caffrae*
      1.1.1 *Acacietum karroo-caffrae rhoetosum pyroidis*
      1.1.2 *Acacietum karroo-caffrae barlerietosum macrostegiae*

   1.2 *Rhoo rigidae-Acacietum caffrae*
   1.3 *Dombeyo rotundifoliae-Acacietum caffrae*
   1.4 *Proteo caffrae-Acacietum caffrae*

2. *Diheteropogono amplectentis-Schizachyrion sanguinei*
   2.1 *Monocymbio ceresiiformis-Schizachyrietum sanguinei*
   2.2 *Uryletro agropyroidis-Schizachyrietum sanguinei*

3. *Hyparrhenio hirtae-Eragrostidetum planae*

Description of the syntaxa

The vegetation of the Fb land type is strongly associated with the rocky outcrops and hills of the study area. Typical of the vegetation of the Western Transvaal, two broad physiognomic classes, namely woodland and grassland can easily be distinguished (Bezuidenhout & Bredenkamp 1990). The vegetation of the Fb land type differs from the rest of the study area, in so far that woodland predominates in the study area, where grassland is normally the dominant vegetation type (Table 1). In the Fb land type the grassland vegetation occurs as an upland grassland on the high altitude plateaux/midslopes, or as bottomland grassland in narrow drainage lines.

Table 1: A phytosociological table of the vegetation of the Fb land type in the western Transvaal, South Africa (all numbers explained in text).

Syntaxa	1					2		3
	1.1		1.2	1.3	1.4	2.1	2.2	
	1.1.1	1.1.2						
Sample plots	003020000114100 790696777598078 242028579344214	444414211201 010808400970 904256540483	20000000223024 96689795490898 55928096890835	3021 0996 1569	00101100 55050086 34156763	0400200000 9889588565 0791557918	01000110220012055122200 99899995001861644911568 37067357236384667623441	0000000 7669177 4272736
Species group A								
Acacia karroo	43344443444+1+	2 1R232234	+3+	++2	+		+ + ++	
Ziziphus mucronata	+++32+++++ 2+3	2+2 + + 2+	3 +	3 +	+			
Tragus berteronianus	+ ++224+ 1	+ 1++++ +	++ + +				++	+
Digitaria eriantha	1 ++ 2	+ ++ ++ +		++4	++	+	2	+
Celtis africana	+ 3 + +2	+1 + ++ +	+ ++	3+		+	+	
Blepharis angustifolia	++++	+ ++ ++ ++	+			+		
Hibiscus pusillus	+ + + +	+ + + ++	+				+	
Pavonia burchellii	++ + ++	+ + + +		+				
Eragrostis obtusa	+ + +	+ ++					+	
Species group B								
Rhus pyroides	33+22 +++++ +	R ++	+ + ++ +++	+	+ +	+	+ + +	
Sporobolus africanus	+1+2 +	+	+	+	+	+	+ + ++	+
Acacia robusta	+ 2 2		+	+				
Maytenus polyacantha	+ + 2	+	+					
Species group C								
Barleria macrostegia	+ +	+ + + ++					+	
Lantana rugosa	+	++++ +	+					
Chamaesyce hirta		+ + ++	+					
Species group D								
Rhus rigida		+ ++	+2+ +2 +	+	+		+	
Species group E								
Teucrium trifidum	+ ++++++ ++++	++ +++++ + +	++ + +++				+ + +	+ +
Protasparagus africanus	++ ++23+2+ +	+ ++ ++ ++	++ + + ++		+		+ +	+
Clematis brachiata	++ + +	+++++++ + +	++ ++++ +		+	+		
Protasparagus laricinus	+++ + + 2++ +	+ + ++2++	+ + ++					
Grewia flava	+ + 2 + +	++++ 12 +	+ + + + +		+			
Species group F								
Dombeya rotundifolia				4343				
Olea europaea	+		+	+ ++				
Grewia occidentalis	2 +	+	+ +++	42				

Species group G								
Protea caffra			4		+ 33 3+3			
Pavetta zeyheri		+	+ +	++	11++++			
Maytenus tenuispina					+1 2			
Combretum molle					12			
Helichrysum kraussii		+			1+ 1			
Tapiphyllum parvifolium			+	2	+ +		+	
Species group H								
Acacia caffra	+ 2+ + + +1 53	+ 3 2+2 +	3 4444434 4+41	222	1 3+	+		
Rhus leptodictya	+++ + ++2+	+ + + +	++++ + +++ 1	+2++	+ + 2++			
Protasparagus suaveolens	++++++3 22++++	+ +++1++++ +	++ ++++ + ++	+	+ +		+ +	
Ehretia rigida	+ + ++ 2 +3	++ +++++ +	+ 2+ + + + ++	+ ++	+ +			
Eustachys paspaloides	+ + + +22	+ + +	+ 2+2 +++++++	++	++ +		+	
Maytenus heterophylla	+++ ++	++++++ +++ +	3 2 +++ +	++++	++		+	
Euclea crispa	+2 + + + +	++ +++ +	++ +3 +++ +	++	3			
Zanthoxylum capense	+2 + 2+	1 + +	+ +++++2 +	22++	++++	+	+	
Species group I								
Acrotome hispida	+		+		+	+++ ++	+	
Crassula lanceolata		+				+++	+	
Monocymbium ceresiiforme						++ 2	+ +	
Microchloa caffra		+	+			++ +	2 +	
Cheilanthes hirta	+	+	+	+ +		+ ++		
Sphenostylis angustifolia			++			+++	+ +	
Species group J								
Justicia anagalloides	++	+	+		+ +		++ + +++ + +++ ++	
Stoebe vulgaris			+		+ +	++	+ ++ 1+4++ + + +	+ +
Senecio coronatus	+		++ +			+ +	++++ + + ++	
Pentanisia angustifolia						+	+++ + +++ +	
Polygala hottentotta		+			+	+ +	+ + + ++ + +	+
Lotononis foliosa					+	+ +	++ ++ + +	
Eragrostis superba	+		+				+ + ++ ++	
Geigeria burkei						+	+ +++ + +	
Alloteropsis semialata							2 ++ ++	
Cyanotis speciosa			+			+ +	+ + + + +	
Hermannia lancifolia					+		+ + + + +	
Oryletrum agropyroides						++	+ 2 2 2	
Digitaria monodactyla						+	2 + 1+	
Tephrosia semiglabra						+	+ ++ +	+
Indigofera rhytidocarpa			+ +				++ +	
Indigofera hedyantha			+			+	+ ++ +	+
Graderia scabra						+	+ + + +	
Leucas capensis	+		+ +		+ +	+	+ + + +	+ +
Hypericum aethiopicum				+			+ + +	
Parinari capensis						+	+ + +	
Gazania krebsiana	+						+ + +	
Stachys spathulata	+			3			+ + +	

Species group K

Species	Relevé entries
Schizachyrium sanguineum	+ + + + + +2 3+ 2+32 4+ + 12
Diheteropogon amplectens	+ + + +1+2 + 22 + 2 ++
Aristida diffusa	+ + +++2 + ++ + + + 1 + 4 2
Lightfootia denticulata	+ + +++ ++ ++ + + + ++++
Tristachya leucothrix	+2+ + + ++ 2
Sporobolus pectinatus	1 + + ++

Species group L

Species	Relevé entries
Loudetia simplex	+132 +2+ +2+++2+++4
Indigofera comosa	+ + ++ + + + + ++++ + + +
Sporobolus fimbriatus	+ + + + + + + + + + +
Mundulea sericea	+ 3 + + +

Species group M

Species	Relevé entries
Diospyros lycioides	+ + ++ + 22 + + + + +12 + + + 2+ + +
Vangueria infausta	++ R +++ +2+ 2 + 2 ++ ++ + 2
Rhus magalismontana	+ +++ +++ ++++ 3+ +++ + +
Pellaea calomelanos	++ + + ++ + ++ + + +

Species group N

Species	Relevé entries
Bulbostylis burchellii	+ + ++++ + ++ +++ + ++ ++ + +
Tephrosia longipes	+ + ++ + +++++ + + + +
Becium obovatum	+ + + + + ++ + + ++ + + + + ++

Species group O

Species	Relevé entries
Brachiaria serrata	+ + ++ +++ +++ + + ++ 1++ ++ ++++++++ +++ ++ ++
Trachypogon spicatus	++ +2 3+ + + + 3+ +3 ++2+++++++ ++ +1++++ + +
Melinis repens	+ + + +++++ + ++ ++ + + + + + ++ +++ 2+ +++ + +
Andropogon schirensis	+ 32 + +3+ ++++ ++ ++22+2 2+ + + + 3 + 2 +
Senecio venosus	+ +++ + + + 1 + +++ +++ +++++ +++ ++++++
Dicoma anomala	+ + ++ + +++ + ++++ + ++ + ++ ++ + + ++ ++
Trichoneura grandiglumis	++ + + + + + + + + + + +++ + + + + ++ ++ +
Gnidia capitata	+ + + + + + + ++ + + + ++ ++++ ++ + ++ + +
Acalypha angustifolia	+ + + ++ ++ + + ++ +++ ++++ + +++
Elephanthorrhiza elephantina	+ + ++++ + ++++++++ + + ++ +
Melinis nerviglumis	+ + ++ 1 + + + + + +++
Plexipus hederaceus	+ + + ++ + + 12+ + + ++
Triraphis andropogonoides	+ + 44 + + ++ 3 + ++
Chamaecrista mimosoides	+ + + + + + + + ++ + +

Species group P

Species	Relevé entries
Hyparrhenia hirta	+ + + + ++ + + + ++ 33 3 +2
Eragrostis plana	+ + ++ ++2
Verbena bonariensis	+++
Setaria nigrirostris	+ ++
Oenothera tetraptera	+ + +

Species group Q

Eragrostis racemosa	+	++	++ + + + + +	+	+ + + +	+1++++232+	22 +3+++2+ 2+ +1++++3++	+ + +
Heteropogon contortus	+	++	+++		+ +	+ 2+2	2++++ +++ + ++++ +2	++
Cymbopogon excavatus			++ + + ++		+ ++	+ 2 ++	2 + 1+++++	+ +
Helichrysum nudifolium	+		++ + +			+++ +	++++++ + ++++	+3++ +
Lactuca serriola			++ +			+ ++	++ ++ ++ + ++++	+++
Anthospermum hispidulum	+ +		++ +	1++2	+ +	+ +	++++++++++ + ++	+ ++
Eragrostis gummiflua			+3+	2	+ + +		+ + +	+++ +

Species group R

Eragrostis curvula	+ + +4 +32+++	2+1 +++++++	+ +3+++ 3 ++++	+	++++23	+ ++2+	+ + + ++1++++ 1 ++ 2+	2+5+23+
Elionurus muticus	2	+ ++++ +	4++ +2+1++++++		+++1 +++	++ ++++++	323+22+2+22+3+2 +34+3++	+ +
Themeda triandra	2 + ++ + ++	2++ ++22	2+++ +++2 3++		+ ++	2 + 1 +	+2++++3 2+2 +22+122+2+2	2+ 23++
Aristida congesta	++ + 2 +++2 4	+ + + +1 +	++++ 4++++ +++		+ ++ 2	+ + +	+ + ++++ 2	++33
Vernonia oligocephala	++ + +++	+ ++++ +	++ + ++ +++ +			+	++ ++++ + ++ ++ +++	+
Setaria sphacelata	2+ +++ + ++	111+ +++ 2 +	++ 2++22232+	+	+	++	++++++ + +23+++1+ +2	+ ++++
Cynodon dactylon	3 42+3++ 1+	+ + +++ +++	++1	+		+	++ ++ + + +	++++ ++
Felicia muricata	++ +++ ++++	+++ ++ ++++	+ + +	+	+	+ +	++ + +	+++
Aloe greatheadii	+ +++++ ++	+++++	++++++++ +	+	+ +		++ + + +	+
Aristida canescens	2 + ++	+ +++4++	++ 3+ 3++ +			3 + +	+ 2 ++	+ + +3
Ziziphus zeyheriana	+++++ ++ +	+ 2+++ 3+	+++ ++ +				+ + + + + +	+
Hermannia depressa	+ +++ +	+ ++++	+ ++				+++ + + ++ + + ++	++++
Lippia scaberrima	++ ++ +++	+ +++	++ + ++			+	+ + + + ++	+
Crabbea acaulis	++	+++ + +	+ +		+		+ + +++++ +++	+++
Scabiosa columbaria	+ + + ++	+		+		++ + +	+ + + + + + +	+ ++
Helichrysum rugulosum	+ +	+ +	+ ++				+ ++ + + + + + +	+ ++
Crabbea angustifolia	+ + + +	+ +	+ + +			+	++++ + + + ++ +	+
Sida dregei	+ +++ + +	+ ++	+ + + +				+ + +	+
Cymbopogon plurinodis	+ +	+ 2 + +	+ +3 1		++ +3	+ +	+ +2++ ++ + +	+
Eragrostis chloromelas	3	+	+ + +			2 +	+ +4	+
Solanum panduriforme	+	+ ++ + +	+ +	+	+	+	++ + ++ +	+
Ipomoea obscura	+		+ + + + +	+ ++			++ + +	
Commelina africana		+	+ + +	++	++ ++	++ +	+	
Monsonia angustifolia	+	+ ++	+ ++		+	+	+	+
Hibiscus trionum	+ ++ +	++ +	+				+ +	+ +
Raphionacme hirsuta	+	+ +	++ + +			+	+ + + + +	
Eragrostis capensis		+ + ++ +	+	+3	+	+	+ ++ +	
Eragrostis lehmanniana	+ +	+ + +			+		+ ++	+
Panicum coloratum	+ 3	+ + +++ +				+	+ + + + +	
Dianthus mooiensis	+		+ + +	+	+	+ + +	+ + +	
Rhynchosia venulosa	+	+	++ +		++		+	+
Corchorus asplenifolius		+ ++	+ + +		+		+ ++	+
Turbina oblongata	+	+	+ +		+		+	++
Solanum incanum	+	+	+			++	+ + +	
Kyphocarpa angustifolia	+		+				+	
Ledebouria marginata	+			++		+	+ + +	
Indigofera holubii			+			+ +		
Phyllanthus incurvus			+ +			++	++	
Mariscus indecorus		+	+ +		+		+ + +	
Phyllanthus parvulus	+	+	++		+ +	+		
Pogonarthria squarrosa	+	+	++	+	+ +	++		

Species group R (continued)

Aristida stipitata		+	+		+		+	+
Leonotis ocymifolia					+	++		
Gomphrena celosioides	+ +		+ +		+	+ +		+
Oxalis species	+	+	+ +				+	+ +
Solanum capensis		+ +	+ + +			+	+	+
Bewsia biflora			+			+ +	+	
Osyris lanceolata					++	2		
Pygmaeothamnus zeyheri					++	+ +	+ +	
Zornia glochidiata			+		+ +	+ +	+	
Walafrida densiflora			+			+	+	++ +
Indigofera filipes				+	+	+	+ +	
Euclea undulata	+ +	+	+					
Salvia runcinata	+						+	+ +
Talinum caffrum	++		+ +				+	
Schkuhria pinnata	+ + + +		+			+	+	
Acacia mearnsii							+	
Rhynchosia adenodes	+		+ ++					
Eragrostis biflora			+				+	
Pollichia campestris		+ +	+ +	+				
Cyperus species					+	++		+ +
Berkheya species			+			+	+ +	++
Panicum natalense					+ +	+	+	
Cussonia paniculata	+	+	+ +	+	+		+	
Ipomoea bathycolpos	+	+ +	+					

1. *Rhoo leptodictyo-Acacion caffrae* all. nov.

Nomenclatorial Type: relevé 98
This alliance represents a large part of the vegetation of the Fb land type and is characterized by species group H (Table 1). The diagnostic species are the trees *Acacia caffra*, *Rhus leptodictya* and the shrubs *Ehretia rigida*, *Maytenus heterophylla*, *Euclea crispa* and *Zanthoxylum capense*. The small shrubby *Protasparagus suaveolens* and the grass *Eustachys paspaloides* are also diagnostic species of the *Rhoo leptodictyo-Acacion caffrae*. The *Rhoo leptodictyo-Acacion caffrae* occurs on the slopes of the hills and ridges. This alliance is represented by 53 relevés and four associations are recognised.

1.1 *Acacietum karroo-caffrae* ass. nov.

Nomenclatorial Type: relevé 292
The *Acacietum karroo-caffrae* is found on the footslopes and midslopes (terrain units 3 and 4) of the rocky outcrops and hills of the Fb land type (Figures 2 and 3). This association represents the relatively low altitude woodland. Related vegetation is present in some of the other land types in the study area (Bezuidenhout *in prep*). There may be rocks and stones on the soil surface, but the rock cover is normally less than 10 % (Figure 4). The diagnostic tree species *Acacia karroo*, *Ziziphus mucronata* and *Celtis africana* dominate this association. Other diagnostic species (Table 1; species group A) which also characterize the association are the grass species *Digitaria eriantha*, *Tragus berteronianus* and *Eragrostis obtusa* as well as the pioneer forbs *Hibiscus pusillus*, *Blepharis angustifolia* and *Pavonia burchellii*. This vegetation is excellent for cattle and sheep farming and is often subjected to overgrazing, resulting in degradation and the subsequent presence of many pioneer species. Two sub-associations can be identified within this association.

1.1.1 *Acacietum karroo-caffrae rhoetosum pyroidis* subass. nov.

Nomenclatorial Type: relevé 292
This sub-association is strongly associated with the footslopes of the rocky outcrops and hills of the Fb land type (Figure 2). It occurs on slopes between 0 - 3 % and the soil is deeper than 0,3 m. The Hutton (Hu) and Glenrosa (Gs) soil forms are the dominant forms in this sub-association (Figure 3). Less than 10 % of the soil surface is covered by rocks and stones (Figure 4). The tree *Acacia robusta* and the shrubs *Rhus pyriodes* and *Maytenus polyacantha* and the grass *Sporobolus africanus* are the diagnostic species (Table 1; species group B) which characterize the *Acacietum karroo-caffrae rhoetosum pyroidis*. Species from species groups A (diagnostic for the association), E and H (diagnostic for the alliance) as well as most of the more common species from species group R (Table 1) are present in this sub-association. An average of 30 species was recorded per sample plot.

The tree stratum is well developed and is 5,25 m tall with a canopy cover of 25,5 %. The shrub stratum is 2,24 m tall and has a canopy cover of 19,2 % while the herbaceous layer is 0,71 m tall with a fairly scanty canopy cover of 29,2 %.

1.1.2 *Acacietum karroo-caffrae barlerietosum macrostegiae* subass. nov.

Nomenclatorial Type: relevé 245
The *Acacietum karroo-caffrae barlerietosum macrostegiae* is found on the midslopes and sometimes on the footslopes where the slope is between 3 % and 6 % (Figure 2). The soils are fairly shallow, representing the Mispah (Ms), Glenrosa (Gs) and Hutton (Hu) soil forms. No tree species are diagnostic for this sub-association but the diagnostic species (Table 1; species group C) are the inconspicuous, though mostly perennial forbs *Barleria macrostegia*, *Chamaesyce hirta* and the small shrub *Lantana rugosa*. Other species which are also present in this sub-association are species from groups A (diagnostic for the association), E, H (diagnostic for the alliance) and the common species from species group R (Table 1). An average of 28 species per sample plot was noted.

The tree stratum is well developed and is 4,97 m tall with a canopy cover of 14,7 %. The shrub stratum is 2,01 m tall with a canopy cover of 25,6 % while the herbaceous layer which is not very tall (average of 0,57 m) is relatively well developed with a canopy cover of 37,5 %.

1.2 *Rhoo rigidae-Acacietum caffrae* ass. nov.

Nomenclatorial Type: relevé 98

The *Rhoo rigidae-Acacietum caffrae* is associated with the crest of the hills and rocky outcrops in the Fb land type (Figure 2). The soil surface is very rocky, with Mispah (Ms) and Glenrosa (Gs) soil forms also present in this relatively high altitude woodland (Figure 3). Although only one species, the dwarf shrub *Rhus rigida* (Table 1; species group D), was identified as diagnostic for this community, the vegetation is interpreted as to represent an association, as this specific species combination is typical for this particular habitat in the Fb land type. The presence of species group O (Table 1) in this association indicates that this vegetation is floristically related to the high lying grasslands. Several grasses such as *Andropogon schirensis*, *Trachypogon spicatus* and *Triraphis andropogonoides*, which are typical of the relatively high lying grassland areas in the Fb land type are prominent in this association. The species of species groups E, H (diagnostic for the alliance) and R are also present in this association (Table 1). An average of 28 species was noted per sample plot.

The tree stratum, which is dominated by *Acacia caffra* is well developed, 5,43 m tall and has a canopy cover of 13,5 %. The shrub stratum is also well developed and is 2,19 m tall with a canopy cover of 18,1 %. The herbaceous layer is 0,83 m tall, well developed and has a canopy cover of 46,4 %.

A related community was described by Bezuidenhout & Bredenkamp (1991) in the Bc land type.

1.3 *Dombeyo rotundifoliae-Acacietum caffrae* ass. nov.

Nomenclatorial Type: relevé 99
This relatively high lying association occurs on the cooler and moister, but extremely rocky (70 % rock on the soil surface) scarp of the Fb land type (Figure 2). The limited soil present in this association, is exclusively represented by the shallow (< 0,2 m deep) Mispah (Ms) soil form (Land Type Survey Staff 1984). The tree species *Dombeya rotundifolia, Olea europaea* subsp. *africana* and the shrub *Grewia occidentalis* are the diagnostic species (Table 1; species group F). Species from species group H (diagnostic for the alliance) (Table 1) are also prominent in this association. An average of 30 species per sample plot was recorded.

The tree stratum is well developed and is 6 m tall and has a canopy cover of 25 %. Apart from the diagnostic trees which are present in this association, *Acacia caffra* (Table 1; species group H) is also prominent. The shrub stratum is 1,97 m tall with a canopy cover of 31,3 % and is dominated by the diagnostic shrub *Grewia occidentalis*. Relatively few species of the normally common grasses and forbs are present in this association, which is an indication of the dominance of the woody species. The herbaceous layer is 0,95 m tall and has a canopy cover of 30,5 %.

The alien invaders *Acacia mearnsii* (Black wattle) (Henderson *et al.* 1987) and *Eucalyptus* species encroach the *Dombeyo rotundifoliae-Acacietum caffrae*.

A related community was also described in the Faan Meintjes Nature Reserve (Bredenkamp & Bezuidenhout 1990).

1.4 *Proteo caffrae-Acacietum caffrae* ass. nov.

Nomenclatorial Type: relevé 63
The *Proteo caffrae-Acacietum caffrae* occurs on the relatively high altitude midslopes of the Fb land type (Figure 2). Big boulders on the soil surface are being associated with this association (Figure 3). The soil which is relatively shallow (< 0,3 m) is represented by the Glenrosa (Gs) and Mispah (Ms) soil forms (Land Type Survey Staff 1984). The slope of this habitat is less than that of the *Dombeyo rotundifoliae-Acacietum caffrae* (1.2) and steeper than that

of the *Acacietum karroo-caffrae barlerietosum macrostegiae* (1.1.2) (Figure 2). Species groups L, M, N, O and Q (Table 1) indicate the strong floristic relationship between the *Proteo caffrae-Acacietum caffrae* and *Monocymbio ceresiiformis-Schizachyrietum sanguinei* (2.1). When the soil is too shallow for the *Proteo caffrae-Acacietum caffrae* as well as the absence of big boulders, the *Monocymbio ceresiiformis-Schizachyrietum sanguinei* (2.1) might occur on this terrain type (Figure 3). The trees *Protea caffra* and *Combretum molle* and the shrubs *Pavetta zeyheri*, *Maytenus tenuispina* and *Tapiphyllum parvifolium* and the shrub-like forb *Helichrysum kraussii* are the diagnostic species for this association (Table 1; species group G). An average of 32 species per sample plot was noted.

The tree stratum is 5,03 m tall and has a canopy cover of 28,5 % while the shrub stratum is poorly developed, being 2,30 m tall with a canopy cover of 12,5 %. The herbaceous layer is well developed and is 0,92 m tall and has a canopy cover of 47,5 %.

2. *Diheteropogono amplectentis-Schizachyrion sanguinei* all. nov.

Nomenclatorial Type: relevé 487
This alliance occurs on the relatively high lying plateaux and midslopes of the Fb land type (Figure 3). The shallow soil (< 0,3 m) has more than 10 % rocks and stones on the surface (Figure 4). This habitat is drier than that of the *Hyparrhenio hirtae-Eragrostidetum planae*. This high altitude grassland is characterized by species group K (Table 1). The diagnostic species are the grass species *Schizachyrium sanguineum*, *Diheteropogon amplectens*, *Aristida diffusa*, *Tristachya leucothrix* and *Sporobolus pectinatus* as well as the inconspicuous forb *Lightfootia denticulata*. This alliance is represented by 33 relevés and two associations can be distinguished.

2.1 *Monocymbio ceresiiformis-Schizachyrietum sanguinei* ass. nov.

Nomenclatorial Type:: relevé 487
The *Monocymbio ceresiiformis-Schizachyrietum sanguinei* is strongly associated with the high lying plateaux of the Fb land type (Figure

2). The soil of this habitat is shallow (< 0,3 m) and very rocky with quarzite outcrops scattered about. The dominant soil forms are the Mispah (Ms) and Glenrosa (Gs) forms (Land Type Survey Staff 1984). The diagnostic species are the grasses *Monocymbium ceresiiforme* and *Microchloa caffra*, the conspicuous forb *Sphenostylis angustifolia,* the inconspicuous forb *Acrotome hispida*, the fern *Cheilanthes hirta* and the small succulent *Crassula lanceolata* subsp. *transvaalensis* (Table 1; species group I). Species from species groups K (diagnostic for the alliance), L, M, N, O, Q and R (Table 1) are also present in this association. An average of 33 species per sample plot was noted.

A tree stratum is absent and a scanty low shrubby layer is present in only one sample plot. The herbaceous layer is well developed and has a canopy cover of 44,3 % and is 0,76 m tall.

A related community was described by Bezuidenhout (1988) in the Mooi River catchment area, Transvaal.

2.2 *Uryletro agropyroidis-Schizachyrietum sanguinei* ass. nov.

Nomenclatorial Type: relevé 547

This association occurs on the midslopes of the Fb land type. The dominant soil forms present in this association are the Glenrosa (Gs), Mispah (Ms) and Hutton (Hu) forms. Large boulders are absent on the soil surface but more than 10 % of the soil surface is covered with rocks and stones. The prominent diagnostic species of this association are the grasses *Alloteropsis semialata*, *Uryletrum agropyroides* and *Digitaria monodactyla* together with the forbs *Justicia anagalloides*, *Senecio coronatus*, *Pentanisia angustifolia*, *Polygala hottentotta* and the small bushy shrub *Stoebe vulgaris* (Table 1; species group J). The species from species groups I, K (diagnostic for the alliance), N, O, Q and R (Table 1) may also occur in this association. The vegetation is mostly dominated by grass species *Themeda triandra* and *Elionurus muticus* (Table 1; species group R). An average of 37 species per sample plot was recorded.

The tree stratum is absent and the shrub stratum is poorly developed with a canopy cover of 9,5 % and is 1,65 m tall. The herbaceous layer is well developed with a canopy cover of 57,7 %

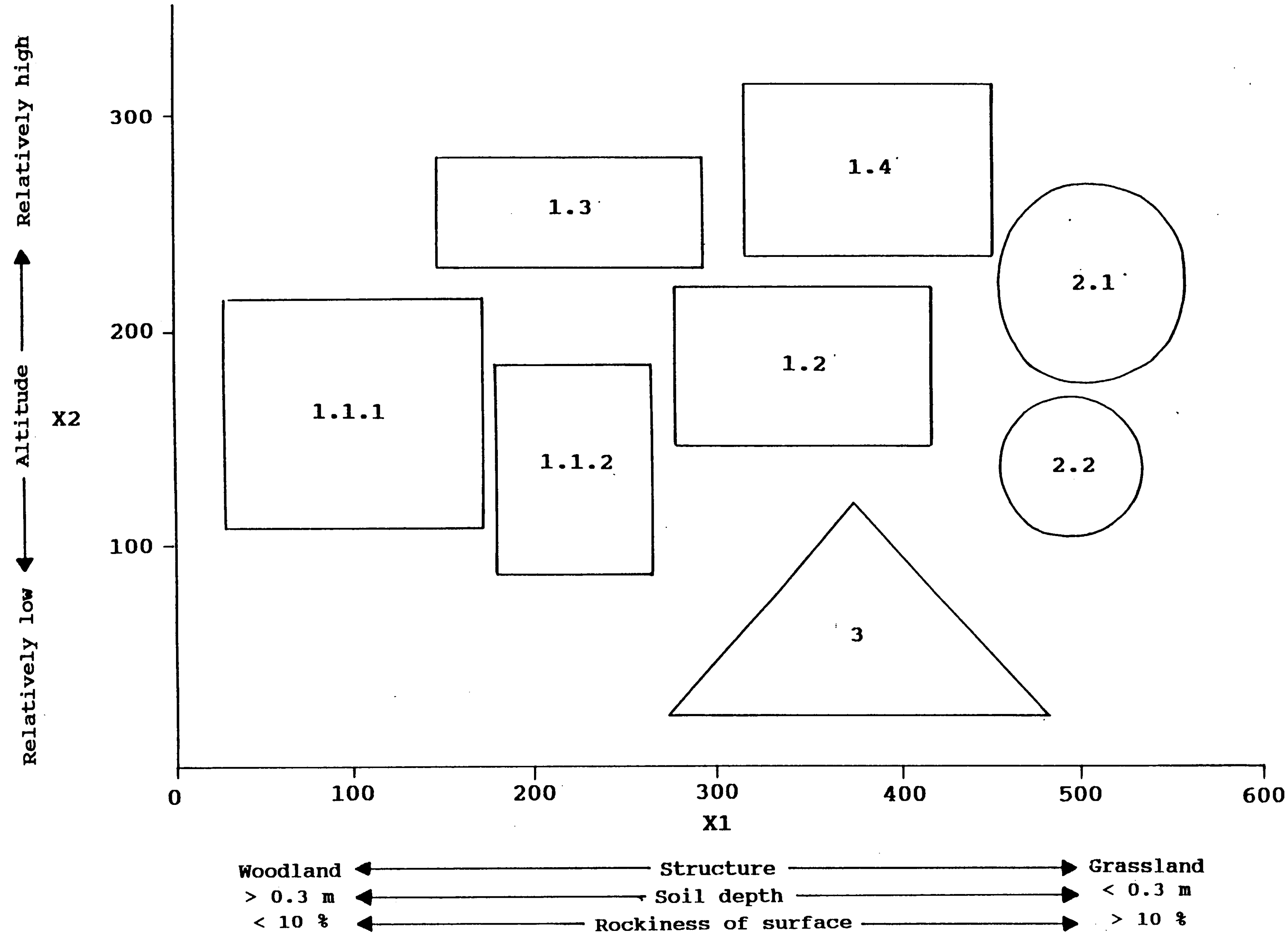


Figure 4: The relative positions of the syntaxa (all numbers explained in text) along the first two axes of the ordination of the Fb land type in the western Transvaal, South Africa.

and is 0,68 m tall.

A related community was described by Bezuidenhout (1988) in the Mooi River catchment area, Transvaal.

3. *Hyparrhenio hirtae-Eragrostidetum planae* ass nov.

Nomenclatorial Type: relevé 76
This association is characteristic of the drainage lines of the Fb land type. More than 10 % rocks and boulders occur on the soil surface of this relatively low lying grassland. While occurring in water courses it is wetter than the *Diheteropogono amplectentis-Schizachyrion sanguinei* (2) and the dominant soil forms are the Rensburg (Rg), Arcadia (Ar) and Mispah (Ms) forms (Land Type Survey Staff 1984). The soil depth varies from 0,1 to 0,6 m. The diagnostic species are the grasses *Hyparrhenia hirta*, *Eragrostis plana* and *Setaria nigrirostris* and the forbs *Verbena bonariensis* and *Oenothera tetraptera* (Table 1; species group P). Species from species groups Q and R (Table 1) are also present in this association. An average of 17 species per sample plot was noted.

The tree and shrub strata are absent. The herbaceous layer has a canopy cover of 60 % and is 0,7 m tall.

Ordination

In the scatter diagram the distribution of the syntaxa along the first and second axes of the Decorana ordination is given (Figure 4). Although no distinct discontinuity can be observed, the plant communities are restricted to specific spatial areas in the diagram. Along the first axis the grassland syntaxa are situated to the right side of the diagram while the woodland syntaxa occur to the central and left sides of the diagram. Also illustrated on the first axis is a gradient which can be related to soil depth and rockiness of the soil surface. The second axis illustrates a gradient which may be related to altitude (Figure 4). This result confirms the result of the classification, and is not discussed further.

Conclusions

This is the first comprehensive syntaxonomical account of the grasslands of the Fb land type in the western Transvaal grassland. New syntaxa described include two alliances, seven associations and two sub-associations.

According to Acocks (1988) the Bankenveld veld type was an open savanna with *Acacia caffra*. The presence of *Acacia caffra*, *Celtis africana* and *Protea caffra* and other bushveld taxa indicate a strong affinity to the Sour Bushveld and the Sourish Mixed Bushveld. However this woodland occurs on rocky outcrops and hills and is unlikely to be found in the plains. However, the *Acacia karroo* woodland may occur in the plains. The plains are dominated by grassland and when fire and bad management practices have taken its toll, it will often only change in species composition but not necessarily in physionomic structure, thus remaining a grassland community. In exceptional cases *Acacia karroo* encroachment may occur on overgrazed grassland vegetation. As far as agriculture is concerned the vegetation of the Fb land type is not able to support good farming prospects. However, due to great habitat and floristic diversity and for aesthetical reasons, the landscape of the Fb land type deserves to be conserved. The Faan Meintjes Nature Reserve, Suikerbosrand Nature Reserve and Transvaal Protea Garden can serve as examples where small parts of these Nature Reserves are situated in the Fb land type (Bredenkamp & Bezuidenhout 1990, Bredenkamp & Theron 1978, Behr & Bredenkamp 1988).

Acknowledgements

Mrs. D. Bezuidenhout is thanked for assistance in the preparation of the manuscript. The Foundation for Research Development, Council for Scientific and Industrial Research is thanked for financial assistance.

References

ACOCKS, J.P.H. 1988. Veld types of South Africa. *Mem. Bot. Surv. S. Afr.* 57: 1 - 146.

ARNOLD, T.H. & DE WET, B.C. 1993. Plants of Southern Africa: Names and distribution. *Mem. bot. Surv. S. Afr.* 62: 1 - 825.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of Phytosociological Nomenclature, 2nd edition. *Vegetatio* 67: 145 - 195.

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanic Garden. *S. Afr. J. Bot.* 54: 525 - 533.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H. (*in prep.*). Syntaxonomy and synecology of the western Transvaal grasslands, South Africa. Ph.D. dissertation, University of Pretoria, Pretoria.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* 18: 387 - 403.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991. The vegetation of the Bc land type in the western Transvaal Grassland, South Africa. *Phytocoenologia* 19: 497 - 518.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. 1990. The vegetation of the Faan Meintjes Nature Reserve, Transvaal. *S. Afr. J. Bot.* 56: 54 - 64.

BREDENKAMP, G.J. & LAMBRECHTS, A.V.W. 1979. A check list of the floristic plants and ferns of the Suikerbosrand Nature Reserve. *Jl S. Afr. Bot.* 45: 25 - 47.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve. 1. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 - 529.

BREYTENBACH, P.J.J. 1991. Die fitososiologie van die Villiers-Grootvlei-omgewing. M.Sc. thesis, University of Pretoria, Pretoria.

COETZEE, C.B. (Red.) 1976. Delfstowwe van die Republiek van Suid-Afrika. 5 edition Handbook 7. Department of Mineral and Energy Affairs. Government Printer, Pretoria.

ECKHARDT, H.C. 1993. A synecological study of the vegetation of the north-eastern Orange Free State. M. Sc. thesis. University of Pretoria, Pretoria.

HENDERSON, M., FOURIE, D.M.C., WELLS, M.J., HENDERSON, L. 1987. Declared weeds and alien invader plants in South Africa. Department of Agriculture and Water Supply. Government Printer, Pretoria.

HILL, M.O. 1979a. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

HILL, M.O. 1979b. DECORANA - A Fortran program for detrended correspondence analysis and reciprocal averaging. Cornell University, New York.

KOOIJ, M.S. 1990. A phytosociological study of the north-western Orange Free State. M.Sc. thesis, University of Pretoria, Pretoria.

LAND TYPE SERIES. 1979. 2626 Wes-Rand. Prepared by the Soil and Irrigation Research Institute, Pretoria. 1:250 000. Government Printer, Pretoria.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. agric. nat. Resour. S. Afr.* 4: 1 - 441.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. bot. Surv. S. Afr.* 24: 1 - 105.

MACVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H. & HARMSE, H.J. VON M. 1977. Soil classification - A binomial system for South Africa. Department of Agriculture and Technical Services, Pretoria.

MENTIS, M.T. & HUNTLEY, B.J. 1982. A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog.* 62: 1 - 29.

MORRIS, J.W. 1973. Automatic classification and ecological profiles of south-western Transvaal Highveld grassland. Ph.D. dissertation, University of Natal, Pietermaritzburg.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. New York: Wiley.

MYBURGH, W.J, BREYTENBACH, P.J.J., THERON, G.K. & BREDENKAMP, G.J. 1992. Die fitososiologie van die Bankenveld in die Grootvlei-omgewing, Suid-Transvaal. *Bothalia* 22: 245 - 254.

SCHEEPERS, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on classification and mapping. Ecosystems Programmes Occasional Report Series No. 16, CSIR, Pretoria.

TURNER, B.J. 1989. A phytosociological study of the south-eastern Transvaal Highveld grasslands. M.Sc. thesis, University of Pretoria, Pretoria.

VAN WYK, S. 1983. 'n Plantekologiese studie van die Abe Bialey-natuurreservaat. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

VAN ROOYEN, N., THERON, G.K. & GROBBELAAR, N. 1981. A floristic description and structural analysis of the plant communities of the Punda Milia-Pafuri-Wambiya area in the Kruger National Park. 1. The hygrophilous communities. *Jl S. Afr. Bot.* 47: 213 - 246.

WEATHER BUREAU. 1986. Climate of South Africa. WB 40: 1 - 475. Government Printer, Pretoria.

4.7 The vegetation of the western Transvaal dolomitic and chert grassland, South Africa.

* *Submitted*: *South African Journal of Botany*

The vegetation of the western Transvaal dolomitic and chert grassland, South Africa.

H. Bezuidenhout*, G.J. Bredenkamp and G.K. Theron

Department of Botany, University of Pretoria, Pretoria, 0002, Republic of South Africa.

* To whom correspondence should be addressed: National Parks Board, Scientific Services, P.O. Box 110040, Hadison Park, Kimberley 8306, Republic of South Africa.

Some of the data for this research were collected while employed by the Department of Agricultural Development, Grassland Research Centre, Private Bag X05, Lynn East, 0039 Republic of South Africa.

Relatively little is known about the vegetation of the western Grassland Biome in South Africa. The classification of the dolomitic and chert grassland in the western Transvaal (Fa land type) forms part of a research programme on the syntaxonomic and synecological synthesis of the vegetation of the western Grassland Biome. Using a numerical classification technique (TWINSPAN) as a first approximation, the classification was refined by applying Braun-Blanquet procedures. The result is a phytosociological table from which two new alliances, six new associations, two new sub-associations and two new communities without syntaxonomic rank are recognized. The new syntaxa are ecologically interpreted as well as described. Associated gradients in habitat are identified by using an ordination algorithm (DECORANA). This study should contribute to the present knowledge and ecological understanding of the vegetation of the western Transvaal.

Relatief min inligting is oor die plantegroei van die westelike grasveldbioom van Suid-Afrika beskikbaar. Die klassifikasie van die plantegroei van die dolomitiese en chert grasveld in die Wes-Transvaal (Fa landtipe) vorm deel van die sintaksonomiese en sinekologiese sintese van die plantegroei van die westelike grasveldbioom. 'n Numeriese tegniek (TWINSPAN) is as eerste klassifikasie van die floristiese data aangewend. Daarna is die Braun-Blanquet-prosedure gevolg om twee nuwe alliansies, ses nuwe assosiasies, twee nuwe subassosiasies en twee nuwe gemeenskappe sonder range in 'n fitososiologiese tabel te identifiseer. Die nuwe sintaksons word ekologies geïnterpreteer en beskryf. Geassosieerde gradiënte in habitat is deur toepassing van 'n ordeningsalgoritme (DECORANA) geïdentifiseer. Hierdie studie behoort 'n waardevolle bydrae tot die ekologiese kennis oor die plantegroei van die Wes-Transvaal te lewer.

Keywords: Braun-Blanquet procedures, Dolomitic and chert grassland, Fa land type, Grassland Biome, Vegetation classification.

Introduction

Mentis & Huntley (1982) as well as Scheepers (1987) stated the necessity to determine the location and extent of the major vegetation types and subtypes within the Grassland Biome. As part of a phytosociological research programme on the syntaxonomic synthesis of the vegetation of the Grassland Biome in South Africa several studies have been carried out (Bezuidenhout 1988, Turner 1989, Kooij 1990, Myburgh 1990, Breytenbach 1991, du Preez 1991, Eckhardt 1993). A mosaic of land types occur in the western Grassland Biome (Figure 1). As land types represent an ecologically based stratification of the study area, each land type is separately used to describe the vegetation of the western Transvaal grassland (Bezuidenhout *in prep*). In this paper a description of the vegetation of the Fa land type in the study area is presented. A broad, regional account of the vegetation of the *inter alia* Fa land type is given by Acocks (1988) and a few local vegetation studies from the Potchefstroom area (Louw 1951), Lichtenburg area (Morris 1973), Abe Bailey Nature Reserve (Van Wyk 1983) and the Mooi River catchment area (Bezuidenhout 1988) have been done. A part of the dolomitic or Klipveld vegetation was described by Bezuidenhout & Bredenkamp (1990). In the Jack Scott Nature Reserve, which is situated adjacent to the north-eastern boundary of the study area, the dolomitic vegetation was also investigated (Coetzee 1974, Scogings & Theron 1990).

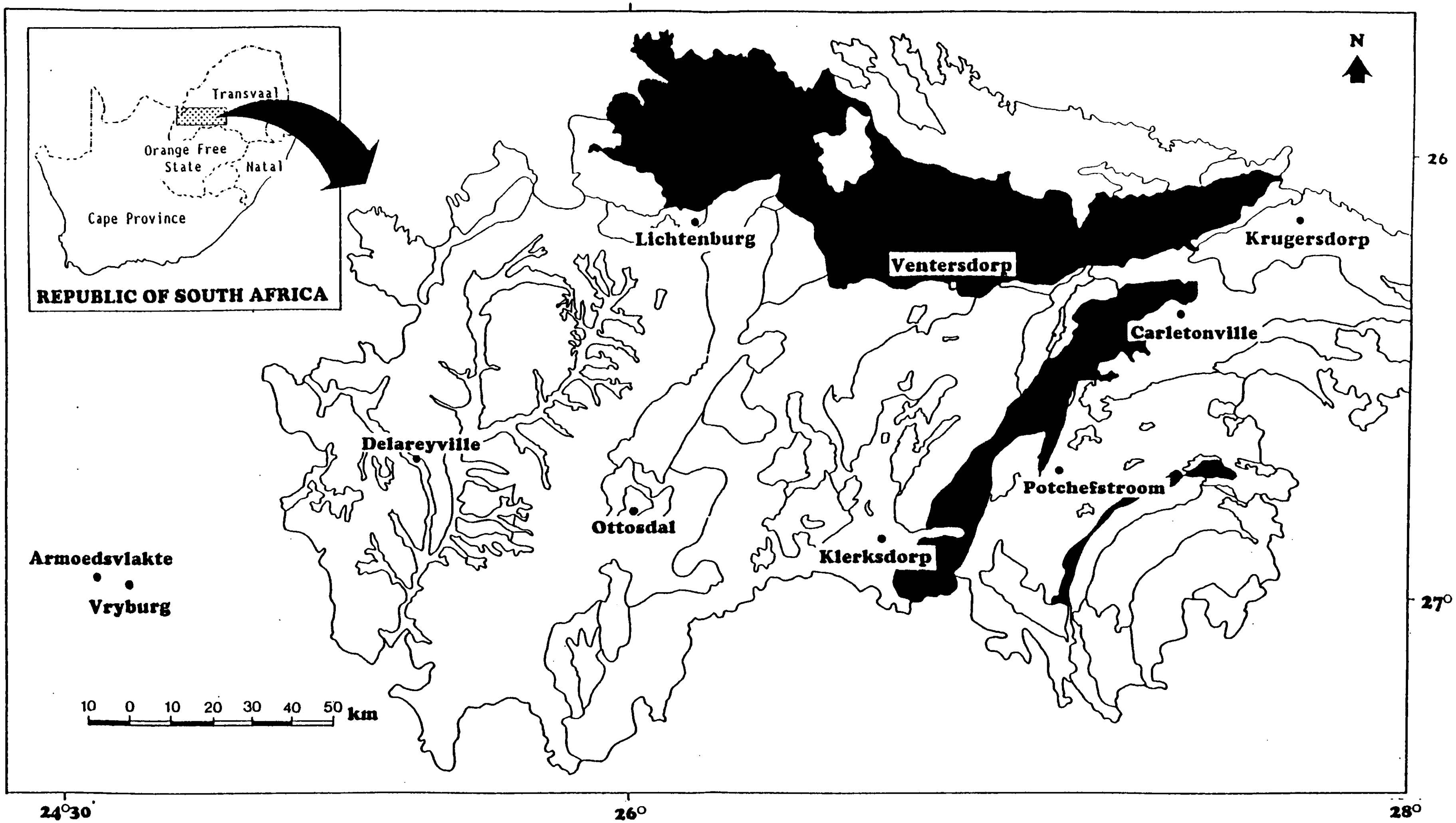


Figure 1: The location of the Fa land type (■) in the western Transvaal, South Africa (Adapted from Land Type Survey Staff 1984).

To formulate a management policy, proper land use should be emphasized, and for this purpose a classification of the vegetation is essential (Van Rooyen, *et al.* 1981). It will also provide scientific guidelines for the identification of conservation priorities. This is a comprehensive vegetation classification of the dolomitic and chert area which includes the entire Fa land type in the western Transvaal. This report forms part of the synthesis of the vegetation of the western Grassland Biome of South Africa and the results should contribute significantly to the ultimate aim of a phytosociological and syntaxonomical synthesis of the western Grassland Biome.

Study area

The study area is situated in the western part of the Highveld Agricultural Region in the Transvaal and is bounded by latitudes 25° 45′ and 27° 15′ south and longitudes 24° 45′ and 28° 00′east (Figure 1). The dolomitic and chert grassland, encompassing the Fa land type is situated in the northern, eastern, as well as in the southern parts of the study area (Figure 1). The Fa land type covers approximately 557 320 hectares of land, and the Land Type Survey Staff (1984) estimated that 35 % is unavailable for agronomy. More than 50 % of the main soil types are relatively shallow (between 50 and 150 mm) and rocky (dolomitic and chert) with the dominant soil forms Mispah, Glenrosa and shallow Hutton (Land Type Survey Staff 1984).

The vegetation is distributed in a complex mosaic pattern and is not dominated by a single or few species. It rather represents a mosaic of many co-dominants (Louw 1951). According to the Acocks (1988) classification, the largest part of the Fa land type vegetation is represented by the western variations of the Bankenveld (Veld type 61a) while the remaining parts are represented by the *Cymbopogon-Themeda* veld (Veld type 48b).

The main rock types which underly the Fa land type are dolomite and chert of the Chuniespoort Group (Transvaal Sequence). The slightly undulating plains are dissected by prominent rocky chert ridges (Land Type Survey Staff 1984).

The Fa land type is drained by the Schoonspruit and the Mooi River and their tributaries. The sources of both river systems are springs which originate from the dolomite water reservoir in the northern central part of the Fa land type (Du Toit 1954).

The terrain is situated at altitudes of 1 356 m to 1 450 m above sea-level and in two climatic regions, according to the Köppen climate classification system, namely a cool dry steppe with summer rains and a warm temperate climate with summer rains. The rainfall exceeds 600 mm per year (Lichtenburg 601 mm, Potchefstroom 625 mm and Carletonville 670 mm) which is relatively high for the study area (Bezuidenhout *in prep.*). The summer temperatures are high, with the mean maximum monthly temperatures exceeding 32 °C during October to January, while the mean minimum monthly temperatures are below -1 °C during May to September. The winters are severely frosty (Weather Bureau 1986).

Methods

Within the Fa land type, which was used as a first stratification unit in the investigation of the western Transvaal grasslands, terrain types were used for subsequent finer stratification. The term land type is used in a land-use classification system describing a homogeneous terrain with regard to soil pattern and climate (Land Type Survey Staff 1984). The following terrain types were recognized in the Fa land type: Plateau (1); Midslope (3); Footslope (4a), Floodplain (4b) and Drainage line (5) (Figure 2). Relevés were compiled in 91 stratified sample plots. Plot sizes were fixed on 16 m² for the grassland vegetation and 100 m² for the woody vegetation (Bredenkamp & Theron 1978). For every plant species present in the sample plot a cover-abundance value was estimated according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). Height and canopy cover for the tree, shrub and herbaceous layers were additionally recorded in each sample plot, and average values calculated for each plant community. Environmental information such as rock type, terrain type and soil type as well as soil depth and an estimation of rockiness of the soil surface were noted (Figure 3). The soil nomenclature follows the classification of MacVicar *et al.* (1977). For analyzing the floristic data an objective statistical classification technique,

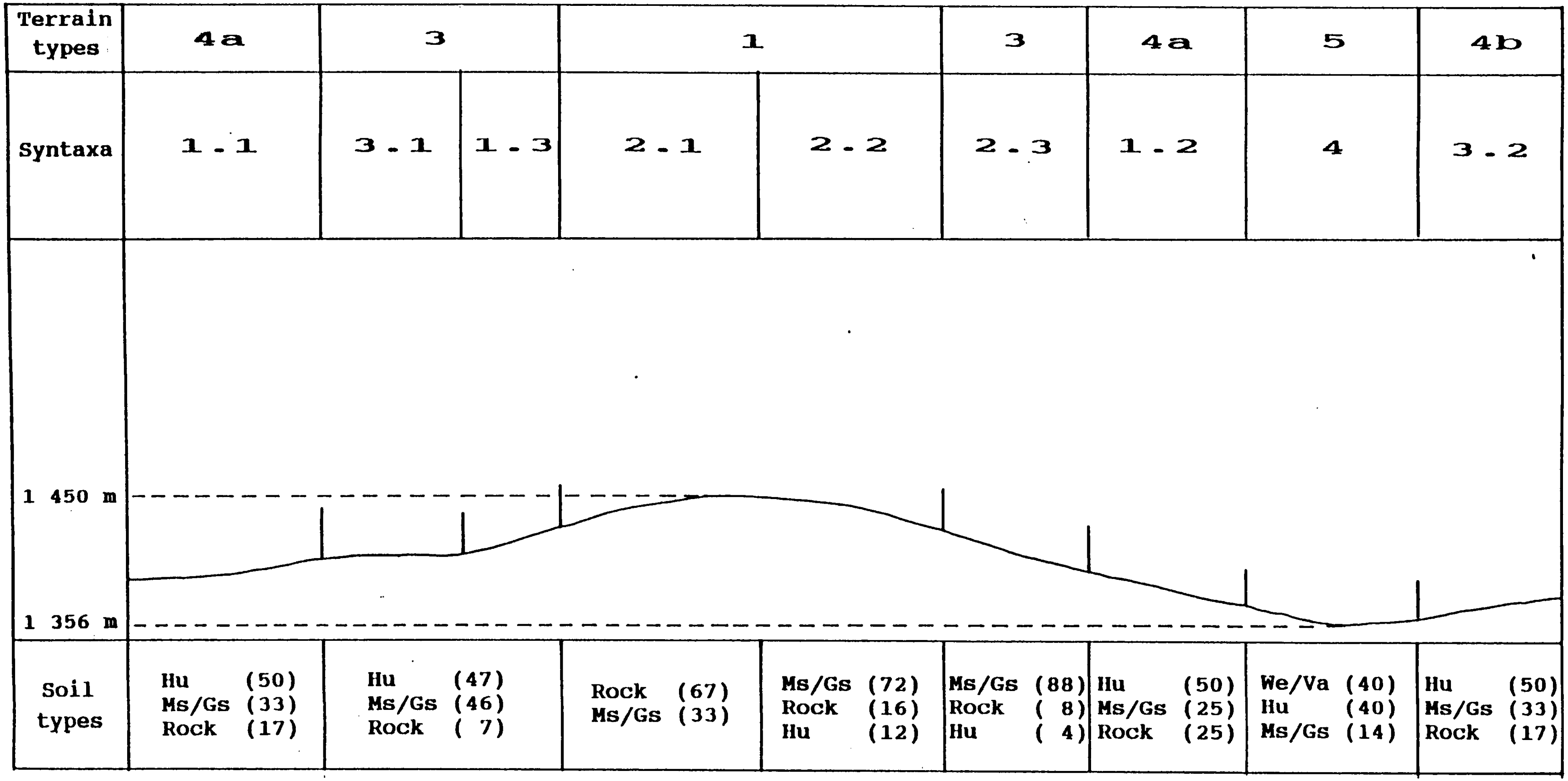


Figure 2: The location of the syntaxa on the topographical terrain types within the dolomitic and chert Grassland in the western Transvaal, South Africa (all abbreviations and numbers in text)(Adapted from Land Type Survey Staff 1984).

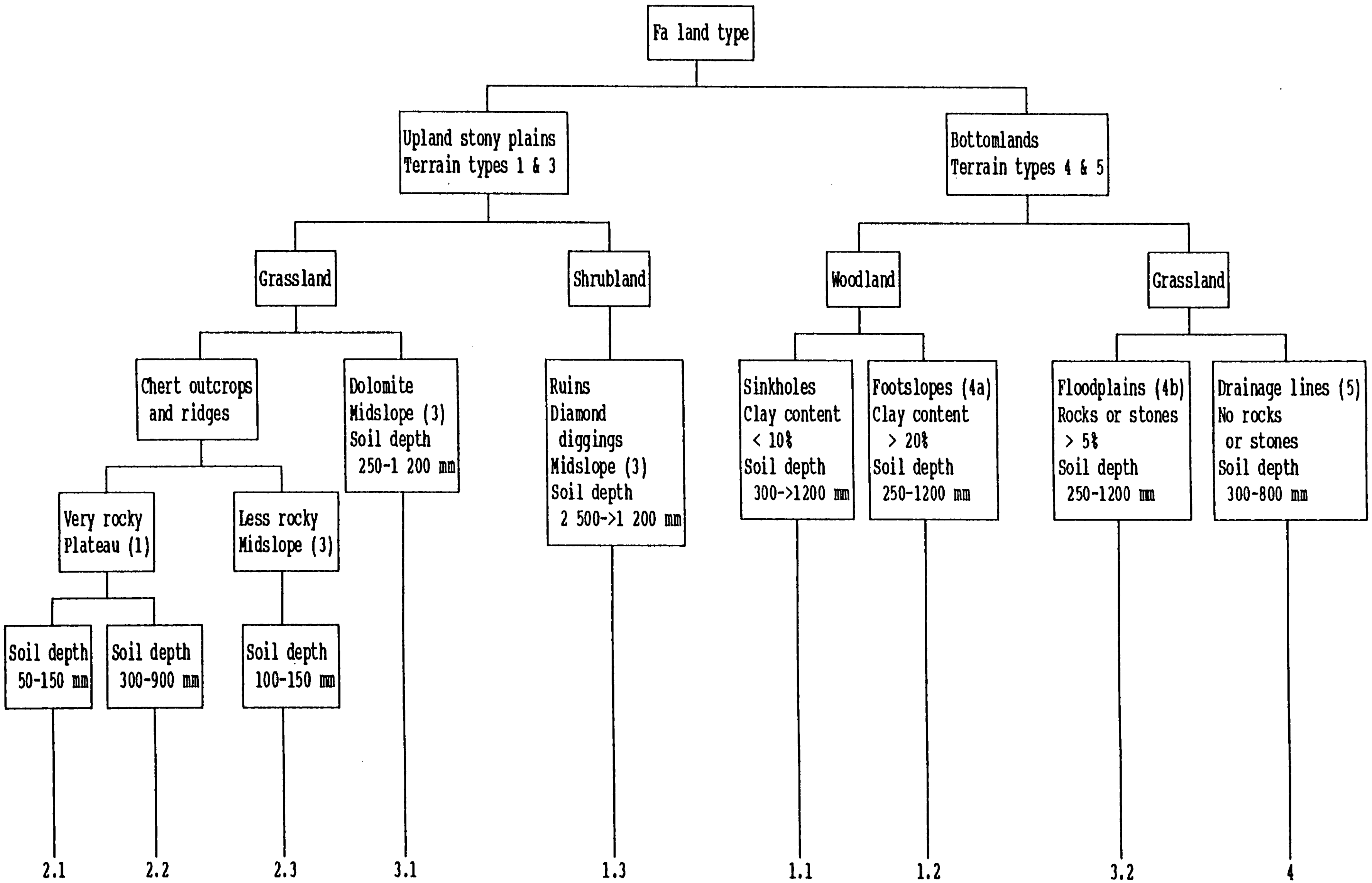


Figure 3: A dendrogram to illustrate the habitat relationships of the syntaxa, of the dolomitic and chert Grassland in the western Transvaal, South Africa (all abbreviations and numbers in text).

TWINSPAN (Hill 1979a), was used and the result was refined by Braun-Blanquet procedures. The final result of the classification procedure is represented in a phytosociological table (Table 1). An ordination technique, DECORANA (Hill 1979b), was also applied to the floristic data to illustrate floristic relationships between plant communities to detect possible gradients in and between communities and to detect possible habitat gradients associated with vegetation gradients (Figure 4). Taxa names conform to those of Gibbs Russell *et al.* (1985, 1987). New syntaxa are described and formal syntaxonomy, in accordance to the Code of Phytosociological Nomenclature (Barkman *et al.* 1986), is applied to the classification.

Results

Classification

In the phytosociological table, two alliances, six associations, two sub-associations and two communities without syntaxonomic rank are recognized (Table 1). No syntaxonomic rank is formally assigned to the latter two communities because too little information is available about them, and their syntaxonomic position is still uncertain. The hierarchical classification of the syntaxa is as follows:

1. *Grewio flavae-Rhoion pyroidis*
   1.1 *Rhoo lanceae-Acacietum eriolobae*
   1.2 *Zizipho mucronatae-Acacietum karroo*
   1.3 *Digitaria eriantha-Rhus pyroides* Shrubveld (community without syntaxonomic rank)
2. *Trachypogono spicati-Diheteropogonion amplectentis*
   2.1 *Loudetio simplicis-Diheteropogonetum amplectentis*
   2.2 *Alloteropsido semialatae-Tristachyetum leucothricis*
   2.3 *Cymbopogon excavatus-Diheteropogon amplectens* Grassland (community without syntaxonomic rank)

Table 1: A phytosociological table of the vegetation of the western Transvaal dolomitic and chert Grassland, South Africa (all numbers in text).

Sample numbers	441666242 004888405 210132931	555451114 222338444 345461344	1111111 2288948 0229120	5555555450144 3423232330544 3820958469961 5	1121224 7909013 6972109	4411222 4323010 0317875	111111 222233 578989	2224455011111141111112224 327342323355894666689035 74 0955317856077064567880904 2	011222 224017 961663
Syntaxa numbers	1			2			3		4
	1.1	1.2	1.3	2.1	2.2	2.3	3.2	3.3	4
Species group A									
Acacia erioloba	++4+1+5 4								
Rhus lancea	22+222 2	+				+			
Pavonia burchellii	+++ +	+							
Eragrostis biflora	2 4						+		
Eragrostis capensis	+2 + 1			+				+ ++ + +	
Lantana rugosa	+ +	+ +							
Setaria verticillata	4								
Species group B									
Acacia karroo		1221+322+	+ +	+					+
Ziziphus mucronata		+111++++	+					+	
Sporobolus fimbriatus		211			+		++		
Tarchonanthus camphoratus		+++							
Acacia hereroensis		12							
Acacia caffra		2+							
Species group C									
Maytenus heterophylla	+ + + +	++ +	+	+					
Protasparagus africanus	+ + +	+ + 1			+		+	+	
Ehretia rigida	1+ +	+ + +							
Brachiaria nigropedata	++	++							
Species group D									
Rhus pyroides	3+ ++ +	++1+++ ++	+++4+22		+	+	+	2 +	+
Diospyros lycioides	1+3++ +++	+++ +	2+	2	++	+		+	
Protasparagus suaveolens	+12++ +++	+ + +++1	+ ++++	+ +					
Grewia flava	+ ++1+1+	+ + +++ +	++++ +	+ 1		+	+		
Protasparagus laricinus	++ + +	++++ +++	+ + +++				++		+
Celtis africana	+ +++ 12	++1++ R	+ +						

Species group E

Loudetia simplex	+ +			11+1 +1 2 + 22	3				
Ophrestia oblongifolia				++++++ +				+ + + + +	
Andropogon schirensis		+		+ + 1+ +				+ +	
Bewsia biflora			+	+ + + +	+				
Digitaria tricholaenoides		+		+ + ++	+			+ +	
Parinari capensis				1+ + +					
Chaetacanthus burchellii				+ ++					
Helichrysum miconiifolium				++ +					
Rhus magalismontana			+	+ + 2	+				
Indigofera sanguinea				++ +					
Kohautia amatymbica				+ ++					
Monocymbium ceresiiforme				+1		+		+	
Gnidia species		+		+ +					
Cucumis hirsutus				+ +					
Hypoxis species				+ +					
Indigofera species			+	+ +					

Species group F

Dianthus mooiensis			+	+ +	++++ +	+++	+	+	
Panicum coloratum	+			++	+++++	+		+ + +	4
Alloteropsis semialata				+	2+2				+

Species group G

Tristachya leucothrix			+	++ + +++ 2++	++ +2+1			+ +	
Sporobolus pectinatus		+		+ + + ++	+ +++++	+		+	
Ipomoea ommaneyi				+ + + + +	++++	+		+ +	
Pentanisia angustifolia			+ +	+ + + ++	+++ +	+			
Pearsonia cajanifolia				+ + +	++			+	

Species group H

Diheteropogon amplectens			4	1 ++1++ ++ ++	+ + +	1 ++++	+ +	+ + +	+
Bulbostylis burchellii	+		+	+ + + +++	++++ ++	+++		+ +	
Schizachyrium sanguineum	+	+	+	+2+ +1	+	+ 3+	+ +	+	

Species group I

Eragrostis gummiflua		+	+ +	+ +		+	+ +	+3+ + 4+ ++ + ++	
Chamaesyce hirta		+	+++			+	++++	+ ++ + + +++	++
Helichrysum nudifolium			+ +	+	++++	+	++	++ ++ + ++++ ++1	++ +
Dicoma capensis		+	+	+ +			+ ++	+ + + + +	
Ziziphus zeyheriana		+	+ +	+ +			+ + +	+ + + ++ ++ + + +	

Species group J

Aristida canescens	++	2		+ +		+	++2	+ + +	+
Kyphocarpa angustifolia	+ +		+	+	+	+	+++ +	+ + +	
Indigofera comosa		+	+ +		+ ++		+ +++	+ + +	+
Solanum capense	+	+++	+	+	+	+ +	++++	+ + +	
Helichrysum caespititium			+ +	+	+	+	+ ++++	+ + +	

Species group K

Salvia radula		+	+ + +			+		+++ ++ +++ ++++++++	
Solanum panduriforme	+	+ ++	+ + +		+		+	+ +++ + ++ ++	
Tragus berteronianus		+				+		+ + + 2 ++	+
Helichrysum rugulosum			+ ++	+		+	+	+ + ++ + +++	++
Tylosema esculentum		++	+				+	+ + ++++	
Helichrysum coriaceum			++		+	+	++	+ + + ++ +	
Ipomoea obscura	+		+ +					+ + + ++ + +	+

Species group L

Eragrostis racemosa			+ +	+ +++++ ++++	+++++	+ +++		+ + 1 + +++ ++++ +	
Crabbea angustifolia		+ +	++ +	++++ + ++	+ +	++	+++ ++	+++ ++++++++++++	+
Trichoneura grandiglumis		+ +	+	++++++ + +	+ +++	++++ +	++++ +	2 + + + + +	
Acalypha angustata	++		+ +	+ + + + + +++	+++	+ + +	+ +	++ + + + ++ +	+
Aristida diffusa	1		++	+ 1 1 +++2+		+		++ ++ +2 ++ + ++ +	+
Cymbopogon excavatus	+ +		2 +	+ + ++++ +		11+ +		+ ++1	+
Senecio coronatus		+	++	+ ++ + +	+++	+	+	+ +++ ++	+
Hibiscus trionum	+	+	+++		++	+	++ +	+ +++ + +	+
Becium grandiflorum			+ +	++ +++ +	+ ++	+ + +		++ + +	+
Thesium utile	+	+	++	++	+ ++	+ +	+	+ + + + +	+
Tephrosia longipes		+	+	++	+ + +	+	+ +	++ +	

Species group M

Brachiaria serrata	++	+ +	+ +	++++++ ++ +++	2+++	++++	+	+ ++++ + + +++++++ +	
Heteropogon contortus	1	+ +	++ ++	+ ++++ + 1+	+++		2 +	+ ++1 +++ + ++++	
Senecio venosus		+ +	+ ++	+++ ++ + + +	+++ ++	+ +++	++	++ + + +++	+
Cyanotis speciosa	+	+ +	+++ +	++ ++ +	++ + +	+	+ +	+ ++ + + + + + + +	
Pygmaeothamnus zeyheri	+	+ +	+ + +	+ ++ + +	+ ++ +	++		+ + + + + +++	
Felicia muricata	+	+ +	+		++		++	+ + + + + +++	+
Dicoma anomala	+	+ + +	+ +	+ ++ ++++ + ++	+ +	+++	+ +	+ +	
Justicia anagalloides	++	+ ++	+ ++++	+++++++ ++	++++++	+++	++++	++++ ++ +++ +++++++ +	
Eragrostis lehmanniana		213 2+	+2 4	+ +	+ +++	+ +	4	+ + 2 + +	++
Raphionacme hirsuta		+ ++	+ + +	+ + ++	+	++ +	+++ ++	++ + + ++ + ++ +	
Eragrostis superba	+	+ +++	+ + +	+ +		+ +++		++ ++2 2 ++	+

Species group N

Chamaecrista mimosoides	+ + ++	+	+++ ++	++ ++ +	++ +++	+++	+++++	+ +++ + + +++ +++ +	
Plexipus hederaceus	+ +++ +	+ +	++ ++	+ ++ ++ +++	+ +	+++	+ +	+ + + + ++ +++	
Barleria macrostegia	+ ++++	+ + ++	++	+ + ++ + +		++	+++++	++++ +++ ++++ ++ +++	
Eustachys paspaloides	++ +	+ ++ +	+ ++ 3	+ +++	+	2	+++	22+ + +++ ++2+++	
Elephantorrhiza elephantina	++ +	+	+	+ + + + ++	+ +	++++	+ +	++ +++ + ++ +++ + +	
Trachypogon spicatus	++ +	+	++	11+21 + 1+ 2+	+ +	++	+	++ ++ + + ++	+
Commelina africana	+ ++ + +		+ +	++ +	+ +++	++	+	+ ++	
Mariscus indecorus	+ ++	+	+++ +	+ + + +	++	+	+	+ +++++ ++ ++	

Species group O

Hyparrhenia hirta		+				+	+	4	125+42
Verbena bonariensis						+		+	++++
Eragrostis plana					+ ++			+ ++ +	2++
Scabiosa columbaria			+ +			+		+ + + +	+++
Chloris pycnothrix									+++
Paspalum dilatatum								+	+3

Species group P

Eragrostis curvula	11+221+1	1 + +23+	+ 2+++	+ 1 ++1+ +++11	++2++2	21+++42	3++22+	2+3211 +3+322 +++++ 3+++	++++ +
Elionurus muticus	++ + + +	++++	2 +2+	+ ++++1+1+2 +	22 +2++	+2++2	+++++	+ ++++++ +++ 2++2+3+++	+ +
Themeda triandra	2 +22+ 3	+ + +2+++	++ ++	+++ + 1+	++ ++++	+ ++	2 +++	+1111++5+ 2 2++23224+252	++ +
Aristida congesta	+ 21+++	+++ + 4+	++ +	+ + 1 1+ + +	+ +	+2++ +	++ 3++	+ ++11++++++ + +++++	+++ +4
Digitaria eriantha	2+ + 2 2	1++ + ++1	4+ 2	1 1++++ +	++++	++	3 +	++1++1+++++++ + +2	1++
Anthospermum hispidulum	+ ++ +	+ +	+++++	+ +++ ++ +	+ ++++	++++	+++++	++ + + +++ + + ++ ++	++++
Vernonia oligocephala	++ +	+	+ + +++	+ ++ +		+	++ + +	++ +++++++++++++ + +	+ +
Triraphis andropogonoides	+++1	+++ ++	+	1 ++++ ++		++	++2+32	+2 ++ ++ + +	+
Melinis repens	+ +	+ + +	+++ +	+ + + ++++ +	+ +++	+ ++	2++ +	+ + + 2 +	+ +
Cymbopogon plurinodis	+1 +	2+	+ + 2	+	+ +	+	+3+2	++ ++ + +++ +2++ ++ + 1	++
Cynodon dactylon	1	1+++	+ + +		++ +	+ + +	++ +	+ + + + + + + +++32	+ +++
Corchorus asplenifolius	+	+ + + +	++ +	+ ++		++	++ +	++ ++ ++ + + +++	+ +
Setaria sphacelata	++ + 3++		2	++	+ ++	+ +	+	++++ + 12 + ++1	+ +2
Lactuca serriola			+	+ + +	+ +++	+	+ +	+ + +++ ++++ + +++	++ +
Crabbea acaulis		+	+ +	+ ++		+	+	+ ++ +++ ++ + + +	++++
Sida dregei	+++ ++ +	+	+++ +				++	+ + + ++++	+ ++
Hermannia depressa	+		+ ++	+ ++			++ +	++ + + ++++ + +	++
Oxygonum dregeanum			+	+ + + + +++	+++	+ ++		++ + + + + +	
Pogonarthria squarrosa	++	+ +	+	++ ++		1 +	++	+ + ++ ++	++
Schkuhria pinnata	+ + +	1	+	+	++ +	+	+	+ + + ++	+++
Stoebe vulgaris	R		+	+ + +	+	+ 2		+++ ++ ++ + +	++
Solanum incanum	+	+ +	+ +	+ +	+ +	+	+ + +	+ + + +	+ +
Turbina oblongata	++ +	+	+	+	+	++	+	+ + +++ ++ +	
Blepharis angusta	++ +	+ ++	+ +	+ +			++	+ + + +++	
Walafrida densiflora	++		+ +		+ ++		+ ++	+ +++ +	+ ++
Rhynchosia nervosa	+ + +	+	+ +	+ + +	++ +	+		+ + +	
Polygala hottentotta	+ + +			+	++ +	+	+	+ ++ + +++	+
Pollichia campestris	+	+ + ++	+ +		+ ++		++	+ + +	+
Lightfootia denticulata	+		+ +	+ + +	++	+	+	+ + + + +	
Sphenostylis angustifolia			+		++++	++++	+	+ + +	
Gnidia capitata	+ +		+ +	+	+ +	+		+ ++ + +	+
Lippia scaberrima		+ +	+	+		++	+	+ ++ + +	+

Species group P (continued)

Ipomoea bathycolpos	++ +	+ +	+ +	+		+ +	+ +	+	
Monsonia angustifolia		+ + +				+ +	+	+ + + + +	++
Oxalis species	+ +	+	+ ++	+		+	+	+ +	+
Geigeria burkei			+ ++	+	++	+		+++ + +	
Hermannia lancifolia				+ ++		+ +	+ ++	+ + +	
Gomphrena celosioides		++++	+	+		+	+	+ + +	
Helichrysum callicomum			+	+	+ +	+ +		+ + + +	

Species with an occurrence of < 10 have been omitted.

3. *Cymbopogono plurinodis-Eragrostidetum gummifluae*

3.1 *Cymbopogono plurinodis-Eragrostidetum gummifluae aristidetosum canescentis*

3.2 *Cymbopogono plurinodis-Eragrostidetum gummifluae eragrostidetosum superbae*

4. *Paspalo dilatati-Hyparrhenietum hirtae*

Description of the syntaxa

In the vegetation of the dolomitic and chert grassland in the Western Transvaal (Fa land type), two broad physiognomic classes, namely woodland and grassland can easily be distinguished (Table 1, Figure 4). The hierarchical classification of the vegetation stresses the correlation between habitat and communities in the Fa land type, as was also noted by Scogings & Theron (1990) in the Jack Scott Nature Reserve, as well as the relationships between communities (Figure 3). The vegetation is often overgrazed and burned as indicated by the presence of pioneer grasses such as *Aristida congesta*, *Cynodon dactylon*, *Eragrostis superba* and *Melinis repens* (Table 1; species group P)

1. ***Grewio flavae-Rhoion pyroidis*** **all.nov.**

Nomenclatorial Type: relevé 189
This alliance represents the woody vegetation of the Fa land type and is characterized by species group D (Table 1). The diagnostic species are the tree *Celtis africana* and the shrubs *Rhus pyroides*, *Grewia flava*, *Diospyros lycioides* and the two small shrubby species *Protasparagus suaveolens* and *P. laricinus*. Two associations and one community without syntaxonomic rank can easily be recognized. A total of 25 relevés represents this woody vegetation of the Fa land type.

1.1 ***Rhoo lanceae-Acacietum eriolobae*** **ass. nov.**

Nomenclatorial Type: relevé 140
The *Rhoo lanceae-Acacietum eriolobae* is usually associated with the slightly undulating bottomlands of the Fa land type (Figure 3) and

can be observed while travelling from Potchefstroom to Klerksdorp (Figure 1). This association is situated in the south-western area of the Fa land type near Klerksdorp. Sinkholes are characteristically present in this habitat which is underlain by dolomite. The soil is normally shallow (< 300 mm) and clayey but the sinkholes, which are mostly filled by deep (> 1 200 mm) aeolian sand have a clay content less than 10 %. The dominant soil forms are Hutton (Hu) (50 % of this terrain type), Mispah (Ms) and Glenrosa (Gs) (together 33 % of the terrain type) and also dolomite outcrops (17 % of the terrain type)(Figure 2). The trees *Acacia erioloba* and *Rhus lancea*, the shrub *Lantana rugosa* and the forb *Pavonia burchellii* and the grasses *Setaria verticillata*, *Eragrostis biflora* and *E. capensis* are the diagnostic species (Table 1; species group A). *Acacia erioloba* is normally restricted to the deep sandy soils in the old sinkholes. Species from species groups C, D (diagnostic for the alliance), N and the more common, widely distributed species from species group P (Table 1) are present in this association. An average of 31 species was recorded per sample plot.

The tree stratum is well developed and is 6,5 m tall with a canopy cover of 24,7 %. The shrub stratum is 1,8 m tall and has a canopy cover of 9,6 % while the herbaceous layer is 0,5 m tall with a canopy cover of 54,4 %.

Aesthetically this association is associated with one of the most scenic landscapes in the western Grassland Biome and certainly deserves high conservation priority.

1.2 ***Zizipho mucronatae-Acacietum karroo*** **ass. nov.**

Nomenclatorial Type: relevé 523

This association is not prominent in the Fa land type but it occurs on the footslopes (4a) and sometimes may encroach into the floodplains (4b) where it holds a subordinate position in the floristic composition, as was also mentioned by Bredenkamp & Bezuidenhout (1990). This encroachment is usually the result of overgrazing or other forms of disturbance of the vegetation (Friedel 1987). The soils are relatively deep (250 - 1 200 mm) and clayey (clay content > 20%) with the Hutton (Hu) (50 % of the terrain type), Mispah (Ms) and Glenrosa (Gs) (25 % of the terrain type) soil forms being dominant. The diagnostic species are the three *Acacia* tree species namely *A. karroo*, *A. hereroensis* and *A. caffra* as well as *Ziziphus mucronata*, while the shrub *Tarchonanthus camphoratus* and the grass *Sporobolus fimbriatus* are also diagnostic for this association (Table 1; species group B). The species of species groups C, D (diagnostic for the alliance), M, N and P are also present in this association (Table 1). An average of 32 species was noted per sample plot.

The tree stratum, which is dominated by *Acacia karroo*, is 5,9 m tall and has a canopy cover of 22,8 % while the shrub stratum is 2,2 m tall with a canopy cover of 26,9 %. The herbaceous layer is 0,6 m tall and has a canopy cover of 48,9 %.

Similar communities were described on different geological strata (Bezuidenhout *et al.* 1988, Bredenkamp *et al.* 1989, Bezuidenhout & Bredenkamp 1991) and also on dolomite (Bezuidenhout & Bredenkamp 1990), but these communities have never been ranked syntaxonomically.

1.3 ***Digitaria eriantha-Rhus pyroides*** **Shrubveld** (community without syntaxonomic rank)

This community is usually associated with ruins and debris of old diamond diggings situated on the midslope (3) of the Fa land type, along archaic river beds. Surface rock usually comprises old diamond mine debris. The soils were disturbed and overturned as a result of the diggings and therefore, soil depth varies between 250 and > 1 200 mm. The clay content also varies from 13 to 30 %. This habitat leads to a relatively high diversity in floristic composition. This community is classified under the *Grewio flavae-Rhoion pyroidis*, and although no syntaxonomic rank is assigned to this shrubveld it is suggested that it may represent an association. There are no diagnostic species for this community but the strong presence of species group D (Table 1) (diagnostic for the alliance) characterizes this community. Species of species groups L, M, N and P (Table 1) are also present in this community. An average of 43 species per sample plot was recorded.

The tree stratum is poorly developed and is 4,4 m tall with a canopy cover of 10 %. The shrub stratum is 2,4 m tall with a canopy cover of 14,9 % while the well developed herbaceous layer is 0,8 m tall and has a canopy cover of 56,4 %.

A similar community was identified by Bezuidenhout & Bredenkamp (1990).

2. *Trachypogono spicati-Diheteropogonion amplectentis all. nov.*

Nomenclatorial Type: relevé 533

This alliance occurs on the relatively flat or slightly undulating stony plains of the upland areas. The soil of this alliance is shallow (50 - 150 mm) and generally very rocky with the exception of the *Alloteropsido semialatae-Tristachyetum leucothricis* whose soil is deeper (300 - 900 mm). Two grass species namely *Diheteropogon amplectens* and *Schizachyrium sanguineum*, and the grass-like forb *Bulbostylis burchellii* are the diagnostic species for this alliance (Table 1; species group H). These species are typical for the relatively dry upland, sandy or rocky, well drained areas and do not occur on the floodplains or on other relatively wet, clayey, poorly drained bottomlands situations. This was also noted by Van Wyk & Bredenkamp (1986), Bredenkamp & Bezuidenhout (1990), Scogings & Theron (1990) and Bezuidenhout & Bredenkamp (1991). This alliance is represented by 28 relevés and two associations. One community without syntaxonomic rank is also recognized.

2.1 ***Loudetio simplicis-Diheteropogonetum amplectentis*** **ass. nov.**

Nomenclatorial Type: relevé 533

The Loudetio simplicis-Diheteropogonetum amplectentis is strongly associated with the rocky chert outcrops and ridges on the plateau (1) of the Fa land type's undulating landscape (Figures 2 and 3). The limited shallow soil (50 - 150 mm) with a low clay content (< 10%) present in this association is predominated by chert outcrops (67 % of the terrain type) and the Mispah (Ms) and Glenrosa (Gs) (33 % of the terrain type) soil forms. Less than 10 % of the soil surface is covered by scattered rocks. Diagnostic species of this association include the prominent grass species *Loudetia simplex*, *Andropogon schirensis*, *Bewsia biflora* and *Monocymbium ceresiiforme* all associated with rocky areas and the dwarf shrubs *Rhus magalismontana* and *Parinari capensis* as well as the conspicuous forbs *Ophrestia oblongifolia* and *Helichrysum miconiifolium* (Table 1; species group E). Species from species groups G, H (diagnostic for the alliance), and the widespread species of species groups L, M, N and P (Table 1) may also occur in this association. An average of 37 species per sample plot was recorded.

The tree stratum is absent and the shrub stratum is poorly developed 1,0 m tall with a canopy cover of only 7,4 %. The shrub stratum, with *Protea welwitschii* being prominent is conspicuous in the central northern areas of the Fa land type, adjacent to the Sourish Mixed Bushveld (Veld type 19) (Acocks 1988). The herbaceous layer has a canopy cover of 55,7 % and is 0,8 m tall.

2.2 ***Alloteropsido semialatae–Tristachyetum leucothricis*** ass. nov.

Nomenclatorial Type: relevé 176

This grassland association occurs on the relatively high altitude plateaux (1) and differs from the *Loudetio simplicis-Diheteropogonetum amplectentis* in so far that the soil is deeper (300 - 900 mm) and has a higher clay content (> 10 %). The dominant soil types present in this association are the Mispah (Ms) and Glenrosa (Gs) (72 % of the terrain type) and the Hutton (Hu) (12 % of the terrain type) forms (Figure 2). Large rocks cover 10 - 70 % of the soil surface. The diagnostic species for this association are the grasses *Panicum coloratum* and *Alloteropsis semialata* and the inconspicuous forb *Dianthus mooiensis* (Table 1; species group F). The species of species groups G, H (diagnostic for the alliance), and widespread species of species groups L, M, N and P are also present in this association (Table 1). An average of 40 species was noted per sample plot.

The tree stratum is absent and a scanty shrub stratum may be present with a canopy cover of 5 % and being 1,8 m tall. The herbaceous layer with *Tristachya leucothrix* and *Alloteropsis semialata* the prominent grasses, is 0,7 m tall and has a canopy cover of 47,9 %.

Similar communities were identified by Van Wyk & Bredenkamp (1986) and Bezuidenhout & Bredenkamp (1990) but no formal syntaxonomical rank was assigned.

2.3 *Cymbopogon excavatus-Diheteropogon amplectens* Grassland (community without syntaxonomic rank)

This grassland community is also associated with the high lying areas in the Fa land type (Figure 2). It is found on the midslopes (3) but is situated downslope, below the *Alloteropsido semialatae-Tristachyetum leucothricis* (2.2)(Figure 3). Mispah (Ms), Glenrosa (Gs) (88 % of the terrain type) and Hutton (Hu) (4 % of the terrain type) soil forms are dominant in this community. Less than 10 % of the soil surface is covered with rocks and stones. No syntaxonomic rank is assigned to this grassland because too little is known about the syntaxonomic position of this community. There are no diagnostic species for this community but the presence of the diagnostic species for the alliance (species group H) and the absence of species groups D (diagnostic for *Grewio flavae-Rhoion pyroidis*) and I (diagnostic for *Cymbopogono plurinodis-Eragrostidetum gummifluae*) suggest that this community should be classified under the *Trachypogono spicati-Diheteropogonion amplectentis* (Table 1). Widespread species from species groups L, M, N and P (Table 1) are present in this community. An average of 32 species was recorded per sample plot.

The tree and shrub strata are absent but the herbaceous layer is well developed, 0,8 m tall and has a canopy cover of 57,1 %.

Old cultivated areas left to recuperate are also found in this grassland.

3. ***Cymbopogono plurinodis-Eragrostidetum gummifluae*** **ass nov.**

Nomenclatorial Type: relevé 135

This association occurs on the midslopes (3) and the bottomland floodplains (4b) of the Fa land type (Figures 2 and 3). The soils are relatively deep (250 - 1 200 mm) and has a clay content of between 13 - 30 %. The pioneer grass species *Eragrostis gummiflua* and the dwarf shrub *Ziziphus zeyheriana* as well as the conspicuous forbs *Helichrysum nudifolium* and *Dicoma capensis*, together with the inconspicuous forb *Chamaesyce hirta* are diagnostic for this association (Table 1; species group I). The vegetation is often subjected to overgrazing, resulting in degradation and the subsequent presence of many pioneer species. Two sub-associations can be identified.

3.1 ***Cymbopogono plurinodis-Eragrostidetum gummifluae* aristidetosum canescentis subass. nov.**

Nomenclatorial Type: relevé 125
The *Cymbopogono plurinodis-Eragrostidetum gummifluae aristidetosum canescentis* is associated with bottomlands but relatively high lying, rocky, lower midslopes (3) just above the floodplains of the Fa land type. There may be outcrops of dolomitic rock and sometimes rock sheets occur just beneath the soil surface in which case the soil is shallow (< 250 mm). Normally the soil is deeper than 250 mm with the Hutton (Hu) (47 % of the terrain type), Mispah (Ms) and Glenrosa (Gs) (46 % of the terrain type) soil forms predominant in this sub-association (Figure 2). The diagnostic species are the pioneer grass species *Aristida canescens* and the conspicuous pioneer forbs *Kyphocarpa angustifolia, Solanum capense* and the dwarf shrub *Indigofera comosa*. The inconspicuous matforming forb *Helichrysum caespititium* (Table 1; species group J) is also diagnostic. Species from species groups I (diagnostic for the association), L, M, N and the more common species from species group P are also present in this sub-association (Table 1). An average of 44 species were noted per sample plot.

The tree and shrub strata are absent. The herbaceous layer is degraded 0,7 m tall, with a canopy cover of 35 %.

3.2 ***Cymbopogono plurinodis-Eragrostidetum gummifluae eragrostidetosum superbae* subass. nov.**

Nomenclatorial Type: relevé 135
This sub-association is found in the low lying floodplains (4b) of the Fa land type (Figure 2). The soil (250 - 1 200 mm deep) has

more than 5 % rocks and stones on the surface. The dominant soil forms are the Hutton (Hu) (50 % of the terrain type), Mispah (Ms) and Glenrosa (Gs) (33 % of the terrain type). The diagnostic species are the pioneer grass *Tragus berteronianus* and the forbs *Salvia radula*, *Solanum panduriforme*, *Helichrysum rugulosum*, *Tylosema esculentum*, *Helichrysum coriaceum* and *Ipomoea obscura* (Table 1; species group K). Other species from species groups I (diagnostic for the association), L, M, N and P are also present in this sub-association (Table 1). An average of 36 species was recorded per sample plot.

The tree stratum is absent and a poorly developed shrub stratum is locally present, with a canopy cover of 8 % and is 1,83 m tall. The well developed herbaceous layer is 0,77 m tall and has a canopy cover of 62 %.

4. ***Paspalo dilatati-Hyparrhenietum hirtae*** **ass. nov.**

Nomenclatorial Type: relevé 141

The *Paspalo dilatati-Hyparrhenietum hirtae* is strongly associated with the low lying drainage lines (5) in the Fa land type. These seasonally wet bottomlands have soils with a higher clay content (>25 % clay) than those of the upland areas. No or very little rock or stone occur on the soil surface. The dominant soil forms present in this association are Westleigh (We), Valsrivier (Va) (40 % of the terrain type) and Hutton (Hu) (40 % of the terrain type) (Figure 2). The diagnostic species are the perennial grasses *Hyparrhenia hirta*, *Chloris pycnothrix*, *Eragrostis plana* and *Paspalum dilatatum* and the conspicuous forbs *Verbena bonariensis* and *Scabiosa columbaria* (Table 1; species group O). The only other species present are the more common species of species group P (Table 1). An average of 26 species was noted per sample plot.

A tree stratum is absent and the 1,7 m tall shrub layer covers less than 10 % of the area. The herbaceous layer is well developed, with a canopy cover of 56,7 % and is 1,0 m tall.

This habitat is fairly unstable due to seasonal flooding and subsequent desiccation which, together with the frequent overgrazing of these sites, cause the advanced state of degradation of the vegetation.

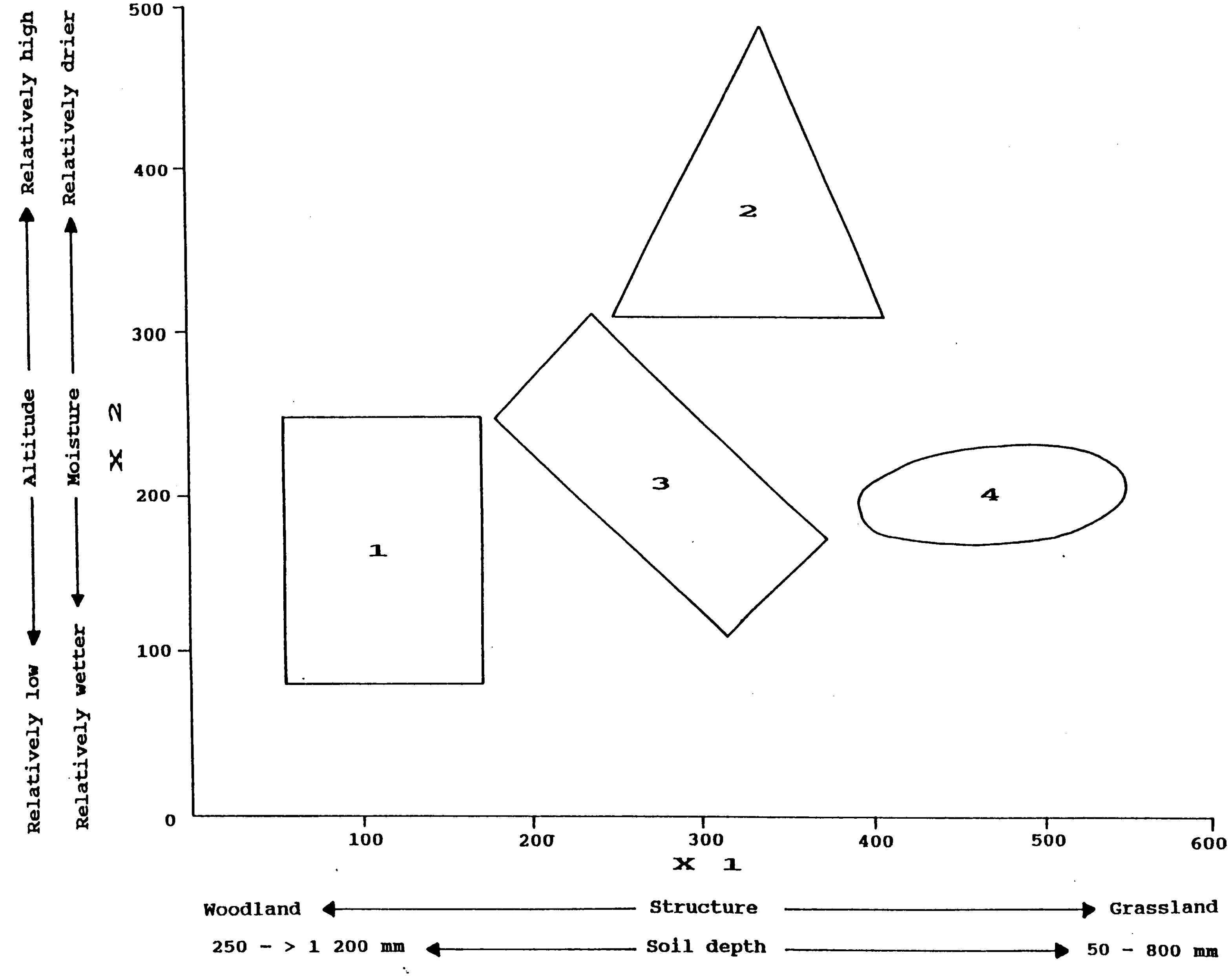


Figure 4: The relative positions of the major syntaxa (numbers refer to text) along the first two axes of the ordination of the dolomitic and chert Grassland in the western Transvaal, South Africa (all abbreviations explained in text).

A similar community was described by Bezuidenhout & Bredenkamp (1990).

Ordination

In the scatter diagram the distribution of the major syntaxa along the first and second axes of the ordination is given (Figure 4). Although no distinct discontinuity occurs, the syntaxa are restricted to specific spacial areas in the ordination diagram. It is possible to circumscribe the different syntaxa but the distinct discontinuity between them are hampered by the presence of a strong group of common species (Table 1; species group P). The presence of these common species are ascribed to the compiling of the data in a relatively homogenous land type.

Along the first axis the woodland syntaxa (1) occur to the left of the diagram while the grassland syntaxa (2 and 3) occur in the centre with the wetland syntaxa (4) to the right of the diagram. Along the second axis a gradient is illustrated which may be related to altitude and moisture (Figure 4). This trend confirms the result of the classification, and is not discussed further.

Conclusions

This is the first comprehensive syntaxonomical account of the vegetation of the dolomitic and chert region (Fa land type) in the western Transvaal Grassland Biome. New syntaxa described include two alliances, six associations and two sub-associations with two communities without syntaxonomical status.

The floristic and habitat diversity of the Fa land type, especially the *Rhoo lanceae-Acacietum eriolobae* should have high conservation priority. Small nature reserves such as the Abe Bailey Nature Reserve (1 887 ha) (Van Wyk 1983) and a part of the Jack Scott Nature Reserve (2 100 ha) (Coetzee 1974) are at present the only known protected vegetation in the Fa land type. It is alarming that only 4 000 ha (0,72 %) of this vegetation is being formally conserved. The presence of pioneer species in species groups L, M and N (Table 1) indicates that this vegetation is in a state of degradation. The main factors being the relatively low rainfall of the area over the past ten years and the continuous overgrazing of the natural vegetation by domestic stock. This classification of vegetation and associated habitat should form a basis for all vegetation related management planning as well as establishing priorities for conservation of land. This description of the Fa land type contributes considerably to the understanding and present knowledge of the western Transvaal grassland.

Acknowledgement

Mrs. D. Bezuidenhout is thanked for assistance in the preparation of the manuscript.

References

ACOCKS, J.P.H. 1988. Veld types of South Africa. *Mem. Bot. Surv. S. Afr.* 57: 1 - 146.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of Phytosociological Nomenclature, 2nd edition. *Vegetatio* 67: 145 - 195.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H. *in prep*. Syntaxonomy and synecology of western Transvaal grasslands, South Africa. Ph.D. dissertation, University of Pretoria, Pretoria.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydsk. Natuurwet. & Tegn.* 7: 4 - 9.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* 18: 387 - 403.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991. The vegetation of the Bc land type in the western Transvaal Grassland, South Africa. *Phytocoenologia* 19: 497 - 518.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. 1990. The vegetation of the Faan Meintjes Nature Reserve, Transvaal. *S. Afr. J. Bot.* 56: 54 - 64.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area. *S. Afr. J. Bot.* 55: 199 - 206.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve. 1. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 - 529.

BREYTENBACH, P.J.J. 1991. Die fitososiologie van die Villiers-Grootvlei-omgewing. M.Sc. thesis, University of Pretoria, Pretoria.

COETZEE, B.J. 1974. A phytosociological classification of the vegetation of the Jack Scott Nature Reserve. *Bothalia* 11: 329 - 347.

DU PREEZ, P.J. 1991. A syntaxonomical and synecological study of the vegetation of the southern and eastern Orange Free State and related areas with special reference to Korannaberg. D. Sc. dissertation. University of the Orange Free State, Bloemfontein.

DU TOIT, A.C. 1954. The geology of South Africa. Oliver & Boyd, Edinburgh.

ECKHARDT, H.C. 1993. A synecological study of the vegetation of the north-eastern Orange Free State. M. Sc. thesis. University of Pretoria, Pretoria.

FRIEDEL, M.H. 1987. A preliminary investigation of the woody plant increase in the western Transvaal and implications for veld assessment. *J. Grassl. Soc. South Afr.* 4: 25 - 30.

GIBBS RUSSELL, G.E., REID, C., VAN ROOY, J. & SMOOK, L. 1985. List of species of southern African plants. 2nd edn. Part 1. *Mem. Bot. Surv. S. Afr.* 51: 1 - 152.

GIBBS RUSSELL, G.E., WELMAN, W.G., RETIEF, E., IMMELMAN, K.L., GERMISHUIZEN, G., PIENAAR, B.J., VAN WYK, M. & NICHOLAS, A. 1987. List of species of southern African plants. 2nd edn. Part 2. *Mem. Bot. Surv. S. Afr.* 56: 1 - 270.

HILL, M.O. 1979a. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

HILL, M.O. 1979b. DECORANA - A Fortran program for detrended correspondence analysis and reciprocal averaging. Cornell University, New York.

KOOIJ, M.S. 1990. A phytosociological study of the vegetation of the north-western Orange Free State. M. Sc. thesis. University of Pretoria, Pretoria.

LAND TYPES SERIES. 1979. 2626 Wes-Rand. Prepared by the Soil and Irrigation Research Institute, Pretoria. 1:250 000. Government Printer, Pretoria.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. agric. nat. Resour. S. Afr.* 4: 1 - 441.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. Bot. Surv. S. Afr.* 24: 1 - 105.

MACVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H. & HARMSE, H.J. VON M. 1977. Soil classification - A binomial system for South Africa. Department Agricultural-technical services, Pretoria.

MENTIS, M.T. & HUNTLEY, B.J. 1982. A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog.* 62: 1 - 29.

MORRIS, J.W. 1973. Automatic classification and ecological profiles of south-western Transvaal Highveld grassland. Ph.D. dissertation, University of Natal, Pietermaritzburg.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

MYBURGH, W.J. 1990. 'n Plantsosiologiese studie van die Bankenveld en die vleigebiede in die Grootvlei-distrik, Suid Transvaal. B.Sc. (Hons.), University of Pretoria, Pretoria.

SCHEEPERS, J.C. 1986. Grassland Biome Project: Proceedings of the workshop on the classification and mapping. Ecosystems Programmes Occasional Report Series No 16, CSIR, Pretoria.

SCOGINGS, P.F. & THERON, G.K. 1990. An application of multivariate analysis techniques to dry-weight-rank data from a Bankenveld nature reserve. *S. Afr. J. Bot.* 56: 648 - 653.

TURNER, B.J. 1989. A phytosociological study of the south-eastern Transvaal Highveld grasslands. M.Sc. thesis, University of Pretoria, Pretoria.

VAN WYK, S. 1983. 'n Plantekologiese studie van die Abe Bialey-natuurreservaat. M. Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

VAN WYK, S. & BREDENKAMP, G.J. 1986. 'n Braun-Blanquet-klassifikasie van die plantegroei van die Abe Bailey-Natuurreservaat. *S. Afr. J. Bot.* 52: 321 - 331.

VAN ROOYEN, N., THERON, G.K. & GROBBELAAR, N. 1981. A floristic description and structural analysis of the plant communities of the Punda Milia-Pafuri-Wambiya area in the Kruger National Park. 1. The hygrophilous communities. *Jl. S. Afr. Bot.* 47: 213 - 246.

WEATHER BUREAU. 1986. Climate of South Africa. WB 40: 1 - 475. Government Printer, Pretoria.

4.8 The vegetation syntaxa of the Ba land type in the western Transvaal Grassland, South Africa.

Page

* *Submitted: South African Journal of Botany*

The vegetation syntaxa of the Ba land type in the western Transvaal Grassland, South Africa.

H. Bezuidenhout*, G.J. Bredenkamp and G.K. Theron

Department of Botany, University of Pretoria, Pretoria 0002, Republic of South Africa.

* To whom correspondence should be addressed: National Parks Board, Scientific Services, P.O. Box 110040, Hadison Park, Kimberley 8306, Republic of South Africa.

Some of the data for this research were collected while employed by the Department of Agricultural Development, Grassland Research Centre, Private Bag X05, Lynn East 0039 Republic of South Africa.

Relatively little is known about the vegetation of the western Grassland Biome in South Africa. The classification of the vegetation of the Ba land type forms part of a research programme on the synthesis of the vegetation of the western Grassland Biome. The numerical classification technique (TWINSPAN) was refined by applying Braun-Blanquet procedures. The result is a phytosociological table where one new order, three new alliances, nine new associations and four new subassociations are recognized. The new syntaxa are ecologically interpreted as well as described. Associated gradients in habitat are identified by using an ordination algorithm (DECORANA). This study should contribute to the present knowledge and ecological understanding of the vegetation of the western Transvaal grassland.

Relatief min inligting is oor die plantegroei van die westelike grasveldbioom van Suid-Afrika beskikbaar. Die klassifikasie van die plantegroei van die Ba landtipe vorm deel van die sintese van die plantegroei van die westelike grasveldbioom. Die numeriese klassifikasie deur TWINSPAN verkry is met behulp van Braun-Blanquetprosedures verfyn. Een nuwe orde, drie nuwe alliansies, nege nuwe assosiasies en vier nuwe subassosiasies is in 'n fitososiologiese tabel geïdentifiseer. Die nuwe sintaksons word ekologies geïnterpreteer en beskryf. Geassosieerde gradiënte in habitat is deur toepassing van 'n ordeningstegniek (DECORANA) geïdentifiseer. Hierdie studie behoort 'n waardevolle bydrae tot die kennis oor die plantegroei en ekologie van die Wes-Transvaal te lewer.

Keywords: Braun-Blanquet procedures, Ba land type, Grassland Biome, Syntaxa, Western Transvaal.

Introduction

The vegetation of the Ba land type of the western Transvaal occurs in the Grassland Biome (Rutherford & Westfall 1986). The importance of the Grassland Biome is stated very clearly in the Department of Agriculture and Water Supply's (1987) programme which indicates the importance of the region for the production of maize, wheat, meat, wool and dairy products. In order to formulate a management policy for agricultural land-use as well as for conservation, a classification of the vegetation is essential (Van Rooyen *et al.* 1981). Mentis & Huntley (1982) stated the necessity to determine the location and extent of the major vegetation types within the Grassland Biome. As part of a phytosociological research programme on the synthesis of vegetation studies of the Grassland Biome in South Africa several investigations were carried out (Bezuidenhout 1988, Kooij *et al.* 1990, du Preez & Bredenkamp 1991, Breytenbach *et al.* 1992, Myburgh *et al.* 1992, Bloem *et al.* 1993, Eckhardt *et al.* 1993, Fuls *et al.* 1993, Smit *et al.* 1993).

The only broad, regional account of the vegetation of the area representing the Ba land type, is given by Acocks (1988). Smaller local studies, such as those of Louw (1951; Potchefstroom area), Bezuidenhout (1988; Mooi River catchment area), Bezuidenhout *et al.* (1988; Vredefort dome) Bredenkamp & Bezuidenhout (1990; Faan Meintjes Nature Reserve) and Bezuidenhout & Bredenkamp (1991; Ba land type of the Mooi River catchment area) have been carried out, but so far no attempt has been made to compile a syntaxonomic synthesis of the vegetation of the Ba land type of the western Transvaal. Therefore, this is the first comprehensive vegetation

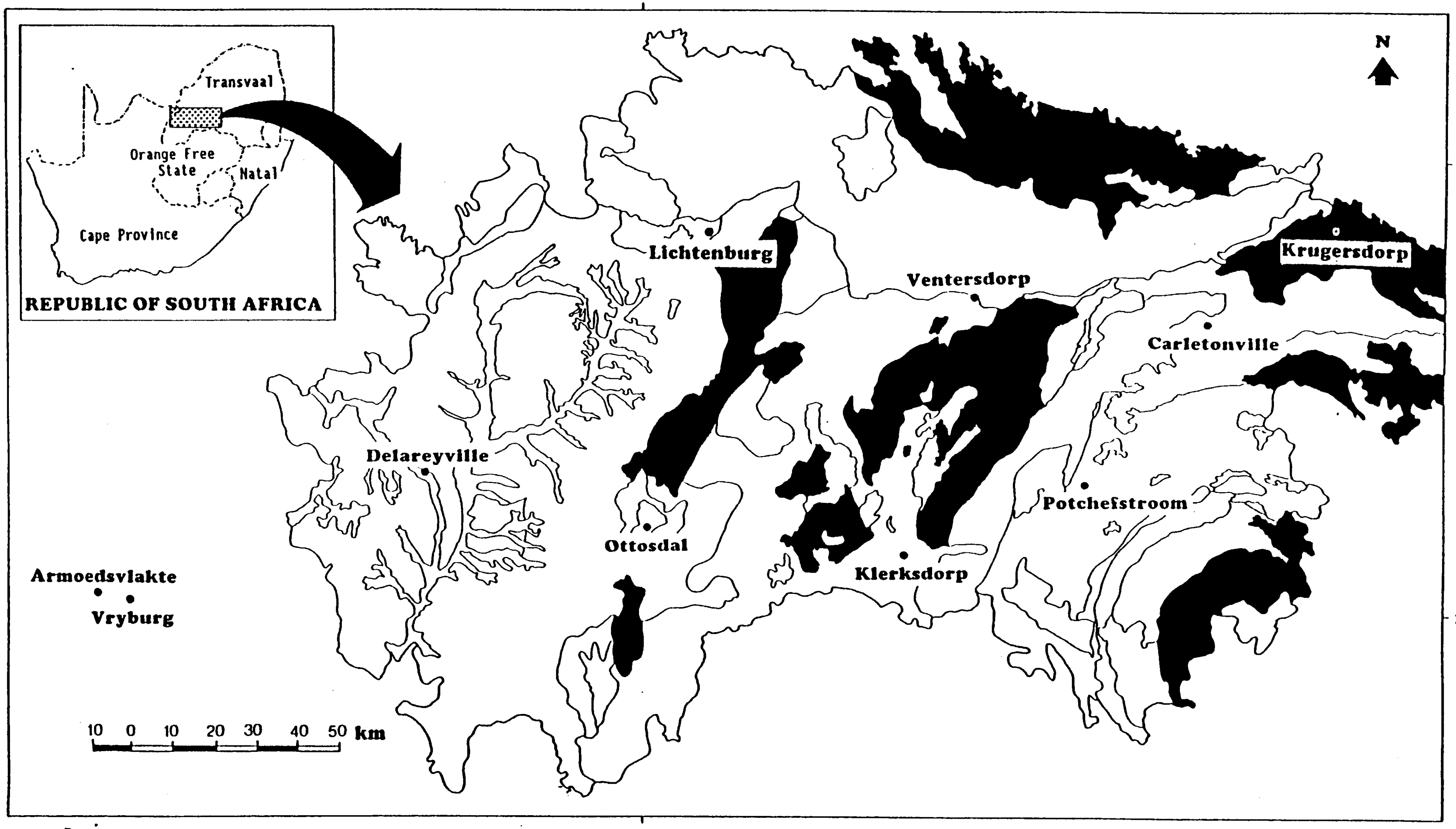


Figure 1: The location of the Ba land type (■) in the western Transvaal, South Africa (Adapted from Land Type Survey Staff 1984).

classification of the entire Ba land type of the study area. A mosaic of land types occur in the western Grassland Biome (Figure 1). As land types represent an ecologically based stratification of the study area, each land type is separately used to describe the vegetation of the area (Bezuidenhout *in prep*). New syntaxa are described and formal syntaxonomy, in accordance to the Code of Phytosociological Nomenclature (Barkman *et al*. 1986), is applied to the classification. This report forms part of the synthesis of the vegetation of the western Grassland Biome of South Africa and the results should contribute significantly to the ultimate aim of a phytosociological and syntaxonomical synthesis of the western Grassland Biome.

Study area

The study area is situated in the western part of the Highveld Agricultural Region in the Transvaal and is bounded by latitudes 25° 45′ and 27° 15′ south and longitudes 24° 45′ and 28° 00′east (Figure 1). The Ba land type is situated in the northern, central, eastern, as well as in the southern parts of the study area (Figure 1). The Ba land type covers approximately 624 810 hectares of land, and the Land Type Survey Staff (1984) estimated that 2.9 % (18 119 ha) is unsuitable for agronomy.

The vegetation is distributed in a complex mosaic pattern, as a result of the pressure by the current farming practices and is not dominated by a single or a few species (Louw 1951). The largest part of the Ba land type vegetation is situated in the western and central variations of the Bankenveld (Veld type 61a,b) while the rest is in the *Cymbopogon*-*Themeda* veld (Veld type 48b) (Acocks 1988).

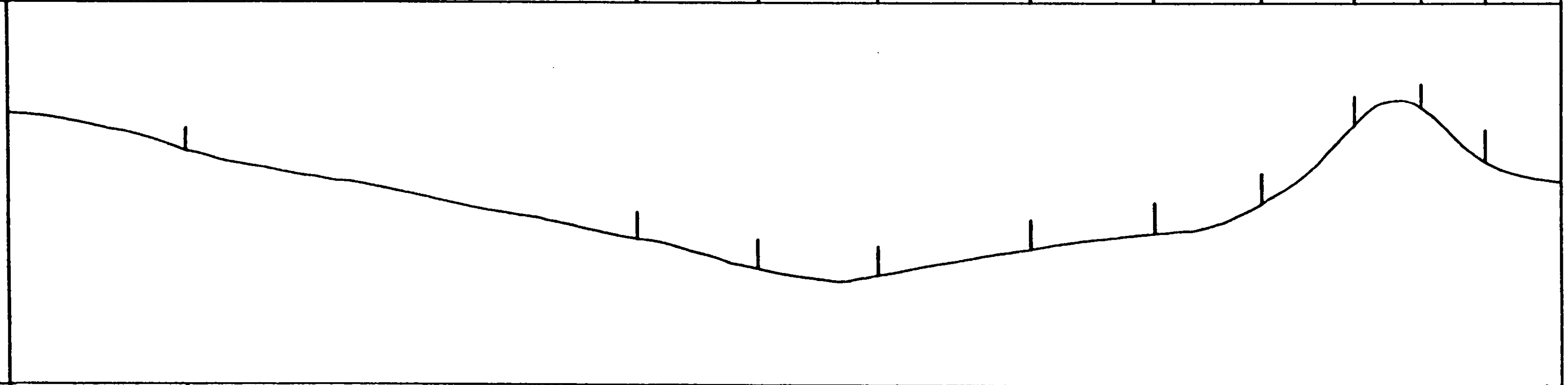
The Ba land type is mainly underlain by Witwatersrand quartzites, shales and slates and Ventersdorp lavas of the Ventersdorp Supergroup and Transvaal Sequence. Also part of the Ba land type is the core of the Vredefort Dome in the south eastern part of the study area (Figure 1). The core consists of Basement Complex granite. The soils of the Ba land type are relatively deep (> 900 mm) but varies considerably in soil type and also in the clay content (B-horizon 3 - 50 %) (Figures 3 & 4).

The terrain is situated at altitudes of 1 356 m to 1 450 m above sea-level and two climatic regions, according to the Köppen climate classification system, namely a cool dry steppe with summer rains, and a warm temperate climate with summer rains, are present in the study area (Schulze & McGee 1978). The rainfall exceeds 600 mm per year (Lichtenburg 601 mm, Potchefstroom 625 mm and Carletonville 670 mm). The summer temperatures are high, with the mean maximum monthly temperature exceeding 32 °C during October to January, while the mean minimum monthly temperature are below -1 °C during May to September. The winters are severely frosty (Weather Bureau 1986). The Ba land type is drained by the Schoonspruit and the Mooi River and their tributaries. A more detailed account of the physical environment is given by Bezuidenhout (*in prep.*).

Methods

The first stratification of the study area was based on land type, while terrain type was used within each land type for a more detailed stratification. Reports on the vegetation of the Bc, Bd and Ea, Fb and Fa land types of the area are given by Bezuidenhout & Bredenkamp (1991a), Bezuidenhout *et al.* (1993, *in press*, *in prep.*) The term land type is used in a land-use classification system describing an area with a "marked degree of uniformity with respect to terrain form, soil pattern and climate" (Land Type Survey Staff 1984). The following terrain types were recognized in the Ba land type: Crest ((1) - 30 % of the land type); Scarp ((2) - 2 % of the land type); Midslope ((3) - 48 % of the land type); Footslope ((3a) - 2 % of the land type); Bottomland flats ((4) - 8 % of the land type) and Drainage lines ((5) - 10 % of the land type) (Figure 2). Relevés were compiled in 97 stratified sample plots. Plot sizes were fixed on 16 m² for the grassland vegetation and 100 m² for the woody vegetation (Bredenkamp & Theron 1978). For every plant species present in the sample plot a cover-abundance value was estimated according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). Height and canopy cover for the tree, shrub and herbaceous layers were additionally recorded in each sample plot, and average values calculated for each plant community. Environmental information such as rock type, terrain

Terrain type	3	3	4	5	4	3	3	2	1	2	3



Syntaxa	1.3	4.1	4.3	5	1.1	4.2	1.2	2.1	2.2	3.1	3.2
Slope	0 - 2 %	2 - 6 %	2 - 3 %	0 - 1 %	3 - 8 %	2 - 3 %	2 - 6 %	>100%	0 - 5 %	>100 %	2 - 3 %
Soil-rock complex	Hu (37) Rock (27) Ms (26)	Hu (47) Ms (11) Av (10)	Va (33) We (20) Gc (10)	↑	Gc (30) Lo (23) Fw (22)	Hu (47) Ms (11) Av (10)		•	••	•••	••••

Rg
Wo
Ar
\> (90)

• Rock (90)
Ms (10)

•• Ms (23)
Gc (20)
Hu (19)

••• Ms (35)
Gs (22)
Hu (14)

•••• Rock (60)
Ms (30)
Gs (10)

Figure 2: The location of the syntaxa on the topographical terrain types within the Ba land type in the western Transvaal, South Africa (all abbreviations and numbers in text)(Adapted from Land Type Survey Staff 1984).

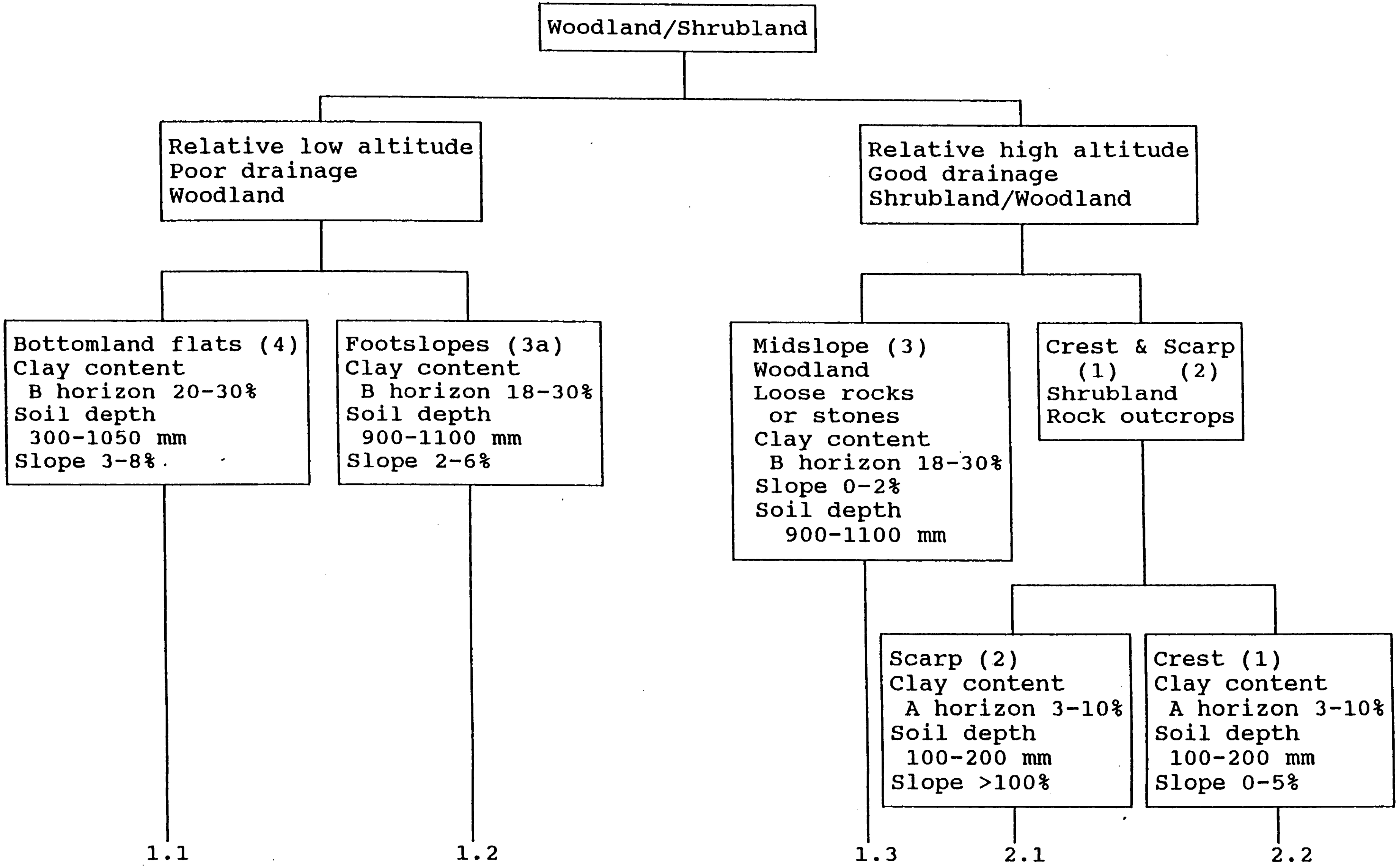


Figure 3: A dendrogram to illustrate the habitat relationships of the woodland and shrubland syntaxa, of the Ba land type in the western Transvaal, South Africa (all abbreviations and numbers in text).

type, slope, soil type, clay content as well as soil depth and an estimation of rockiness of the soil surface were noted (Figures 3 & 4). For analyzing the raw floristic data, an objective statistical classification technique, TWINSPAN (Hill 1979) was used, complementary to the Braun-Blanquet procedures. The final result of the classification procedure is represented in a phytosociological table (Table 1). Taxa names conform to those of Arnold & De Wet (1993). The soil nomenclature follows the classification of MacVicar *et al.* (1977).

Results

Classification

In the phytosociological table, one order, three alliances, nine associations, four sub-associations and one community without a syntaxonomic rank are recognized (Table 1). No syntaxonomic rank is formally assigned to this community because too little information is available. The hierarchical classification of these vegetation units is as follows:

A. Unspecified order (to indicate that the following syntaxa are not classified under any of the recognized orders (Coetzee 1983))
- 1. *Protasparago africani - Acacion karroo*
  - 1.1 *Protasparago suaveolentis - Acacietum karroo*
  - 1.2 *Eragrostido curvulae - Acacietum karroo*
  - 1.3 *Rhoo lanceae - Acacietum caffrae*

B. *Loudetio simplicis - Schizachyrietalia sanguinei*
- 2. *Schizachyrio sanguinei - Vanguerion infaustae*
  - 2.1 *Zanthoxylo capensis - Vanguerietum infaustae*
  - 2.2 *Pavetto zeyheri - Vanguerietum infaustae*
- 3. *Schizachyrio sanguinei - Pogonarthrion squarrosae*
  - 3.1 *Alloteropsido semialatae - Pogonarthrietum squarrosae*
  - 3.2 *Aristido stipitatae - Pogonarthrietum squarrosae*

Table 1: A phytosociological table of the vegetation of the Ba land type in the western Transvaal, South Africa (all syntaxa numbers in text).

Sample plots	11222	12455	22244	2226	12166	5555144	2222222456	22224444455551166666	22222466	145666222266	222222	1145564555
	58459	51701	24877	3336	36356	4544788	0222346311	34790089911448816661	22457066	394126772811	334235	3831469111
	54028	91975	71078	1278	11290	3049398	4568622738	44876731228053572799	12667834	032406693156	583433	3689110167
Syntaxa	1			2		3		4			5	
	1.1	1.2	1.3	2.1	2.2	3.1	3.2	4.1	4.2	4.3	5.1	5.2
Species group A												
Rhus lancea			++ ++									
Acacia hebeclada			++R+				+					
Acacia erioloba			3+					R				
Species group B												
Acacia karroo	44 +4	2++ +	+ 3+	+++	+			R				
Rhus pyroides	+++2	2+ ++	+ ++	++++	+							
Protasparagus africanus	+ +3	+ +	++++	+++								
Acacia caffra	++	3 2	4+5+2	4								
Teucrium trifidum	+++++	++ ++	++++	+			+			+		
Species group C												
Zanthoxylum capense		+		+++1	+							
Pellaea calomelanos		+		++++	+	+						
Mundulea sericea				++1	+		+					
Euclea undulata				+++								
Leonotis ocymifolia				++ +								
Commelina africana		+		+++	+		++ + +	+		++		
Euclea crispa			+	++	+							
Phyllanthus parvulus				+ +		+	+	+				
Rhus rigida				+ +				+				
Vernonia galpinii				++			+					
Rhynchosia venulosa				+ +			+	+				
Sporobolus pectinatus				++	+	+	+ +	+		+		
Species group D												
Pavetta zeyheri				+ +	2+12							
Becium angustifolium				+	+++		+ +					+
Species group E												
Vangueria infausta				+++	+ +11							
Rhus magalismontana		+		+2+	+ +		2 3					
Tapiphyllum parvifolium				24+	+ +							
Ziziphus mucronata		+		+1	+ 1							
Indigofera comosa				++	+2		++ + ++	+ +		+ +		
Rhus leptodictya				++	+1			+				
Dombeya rotundifolia				2	+							
Olea europaea				+	1							
Cheilanthes hirta				+	+		+					

Species group F

Alloteropsis semialata						++++	+		2			
Monocymbium ceresiiforme						+++ R						
Panicum natalense						+ ++ +						
Pentanisia angustifolia						+ +++		+ ++				
Crassula lanceolata						+ +++		+ +	+	+		
Digitaria tricholaenoides			+			1 + +	+	+			+	
Sphenostylis angustifolia					+	+ + +						
Hypoxis rigidula						++ +						
Pearsonia cajanifolia		+				++		++ +				
Bewsia biflora						+ +	+	+		+		
Digitaria monodactyla						+ +						

Species group G

Ryphocarpa angustifolia			+	++		+	++ ++ + +	+ + +	++	+ +		
Pygmaeothamnus zeyheri							+ + 2 ++	+ +			+	
Aristida stipitata			+	+			+++ ++	+ +	+	+ + + +		
Acrotome hispida			+			+	+2++	++ +				
Zornia glochidiata		+				+	++ +++ +	+ + +		+		
Tephrosia lupinifolia					+		+ + +					
Tephrosia longipes		+			+ +	+	+ + +	+				

Species group H

Pogonarthria squarrosa			++			+ +++ +	+ + + ++	+ + +		+		
Tristachya leucothrix						+++ +R	32 +	+				
Parinari capensis						++	+ +	+				
Cleome rubella					+	+ ++	+++					

Species group I

Schizachyrium sanguineum			+	+ +	2 +21	+ 1	+ + 2 1	+				
Loudetia simplex				43	+2+	3 +2 +	+ +					
Bulbostylis burchellii				++	++ ++	+ ++ +	++ +++ ++	+ R				

Species group J

Becium grandiflorum	+ + +			++ +	+	+ +++	+	+ ++		+	+	+
Pavonia burchellii	++++			+++								
Clematis brachiata	+++		+	++	+			+				
Acacia robusta	+2		+	+ +				+				
Tarchonanthus camphoratus	2			+								

Species group K

Grewia flava	+ 34+		+3+	+++				R				
Maytenus heterophylla	+++		+ ++	++++	++							
Celtis africana	+++	+	+ +	++++	+							
Aloe species	++	+	+++	+++			+ +	+ + +			+	
Ehretia rigida	+	+	+ ++	+ ++	1		+					

Species group L												
Diospyros lycioides	+2++	2+	+33 +	++++	242++	+	++ + +			+		
Protasparagus suaveolens	++2+3	+++	+++++	+++	+ + +			+	+	+		
Protasparagus laricinus	+++++	++++	+ +1+	+	+++ +		+ +	+			+	
Sporobolus africanus	+4 4	1	++ 1		2+	+		+ +	+	2		
Species group M												
Aristida canescens			++ +	+	+		+	+ +	+ 2 2+	+ +		
Sporobolus discosporus							+ +	++	+ +++	+ +	+	
Eragrostis superba	+	+	+					+	+ +3	+ +		
Microchloa caffra			+			+			++			
Species group N												
Cymbopogon plurinodis			+ ++	+ 2		1	+	2+22++1 + + ++	+ + 2+ +	+++ + +	+ +	+
Helichrysum rugulosum	++	+ +			+	+		++++ + ++ +++++ +	+ + + +	++++ + + +	+	+ ++
Scabiosa columbaria	++ +	+					+	+++ + + + ++ +	+ + +		++	++
Barleria macrostegia		+	+++		+		+	+++ + + +	+++ ++ +	+ + +++		
Turbina oblongata		+		+ +	+	+	+	+++ + + +	+	+		+
Polygala hottentotta	+	+		+ +	+			++ ++ +	++ +++	+ + + +	+	+
Species group O												
Tephrosia burchellii							++	+++ + + +	+	+ + +	+	+
Plexipus hederaceus							2+++ +	+++ + + ++	++	+		
Species group P												
Eragrostis racemosa	+				+	1+++++1	++ +++ +1	++ + +++ +++ 2+	+	+		
Trachypogon spicatus	+			+	2	++1++1	+ + + +	+ ++ ++ +++ 1	1			
Dicoma anomala		+		+	+	++	++ +++ ++	+++ ++++ +++ + +	+	+	+	
Andropogon schirensis				+++		++ +	+ +++ +	+ 1 + + +		+		
Senecio venosus	++	+				+++ ++	+ ++ +	+ + + +++				
Chamaecrista mimosoides						+ +	+ ++ + +	+ + ++ +				
Hermannia lancifolia		+				+ + +	+ + +	+ 2 +		+ +		
Diheteropogon amplectens					+ 2+	1++ +	++	++ +		+		
Gnidia capitata		+ +	+		+	+ + +	+ + +	+++ + + +	+	+		
Rhynchosia nervosa					+	+ +	+ + ++	+ + + +		+		
Acalypha angustata	+	+		+		+ +	+ +	+ ++++ + +	+	+ +	+	
Senecio coronatus					+	++	+ ++	++++ +			+	+
Aristida diffusa					+ +	++	+ + +	++ + +++ +		+ +	+ ++	
Species group Q												
Elionurus muticus	+	+		+1	++ ++	1 11221	+3 ++++1+	++23+2111 111 + ++1+	+ 21 +	++ ++++	+	+
Triraphis andropogonoides		+	+++	++	11		+ ++	3++ + +	+++ 1	+++ + +		
Trichoneura grandiglumis					+ +++	+	++ 2+++ +	++++ + ++ +++++	++2++++	+ +		
Brachiaria serrata	+				++	++++	++ 22+++2	++ ++++ +++ +1++++	+ +	+ +	+	
Crabbea angustifolia	+		+ +			++ +	++ +	+ ++++ + +++ +	+ +++	++		+
Heteropogon contortus		+		+	+ +	+ ++	3+ ++	+ 2+ + + +		+ +	+	+ +
Species group R												
Eragrostis plana								+			43223+	5223332221
Falckia oblonga								+			+++3+	++ ++ +

Species group S												
Paspalum dilatatum											++	+
Verbena bonariensis											+++ +	+
Species group T												
Cirsium vulgare												++++
Oxalis species	+	+										+++ +
Species group U												
Themeda triandra	2++	1+	+222	2	+1	+ 11+11	+ + ++2+ 2	2++11+31 431 22+232	2 +++2+2	543+1245++11	2+2333	++111+3243
Eragrostis curvula	22 +	2311	+2211	++1	+2 +	+11+ 2	+34++ 231+	+ ++2+++1211+3+ 1+11	++2 +++	+11+21 3+	+ ++++	2+ 121211+
Setaria sphacelata	+3+		2+++	++	+	+	+ 3+2++++	+ +++++ + + +++1	+ + +++	+ ++++2 ++	323++2	++11+++++
Aristida congesta	+ +	21	++ ++	++	+ 3 +	+ ++ 1	++ + +++1	+ + + +++ + ++++	4422++++	+ 1+ + ++++	++	+ 1 +
Cynodon dactylon	++ +	2++++	++++2		+++	+ +	+ ++	++ + + ++++	+++ +	3R 1 3+2++2	++++ +	+++1
Digitaria eriantha	2 2	+	3 +	+ ++	+	+ +	+ + +	2+ 1 + ++	+++ +++	1 333321	2 2+++	+++ + ++
Lactuca serriola		++	++		+	+++	+ ++ ++	++++ + ++ ++ +	+ + + ++	++++ + ++++	+++ +	++ +
Vernonia oligocephala	+ +	+	++			+ +	++	+ ++++++ ++++ +++	+ +	++ +++ + +	+	+
Ziziphus zeyheriana	+ +++	++++	+++ +	+	+ +	+		+ +++ ++ + ++	++ ++ +	+ + +		+ +
Hermannia depressa	++ +	++ +	+ ++			+		+ +++ ++ +++++ +	+ ++ +	+++ + ++	+	+
Justicia anagalloides	++ +	+	+	+	1+	+ ++ +	2 ++	+ + + + + ++ +	+ + +	++ + +	+	
Felicia muricata	++++	+ ++	+ +	++	+		+	++ ++ +++ +	++ ++	+ + +	+ +	+ +
Anthospermum hispidulum	+ +	+ +			++	+	+++ +++	++++ + +	+ + ++ +	++ + +	++	
Helichrysum nudifolium	+		+		+ +++	++	+ ++ +	++++ + ++ ++	+	++ +	+ +++	
Eragrostis gummiflua		+	+ +	++	+ 1+		+++ ++ 2	2 + 1+	+++3	+ +2 2		+1
Stoebe vulgaris		++			++	+ 1+	+ +	+ +++ + ++ +	+ +++	+ +3	+	++ +
Crabbea acaulis	+ + +	+	++ +	+	+			+ + + + +	+ +++++	+ + + +	+ + +	+
Schkuhria pinnata	+ +	+ +	+ +		+		++ + +	+ +	++ +	+ ++++	+ ++++	+
Melinis repens		++ +	+	+2+	2++++	+ +	+ + ++++	++ + + +	+			+
Mariscus indecorus	+		+++		+	++	+ +++++	+++ +	+ ++ +	+ ++		+
Gomphrena celosioides	++	+ +	++	+	+		++ + +	++ + + + + +		+ +	+ ++ +	+
Hyparrhenia hirta		+ 1+	+	1	R+	+ ++ R+	+ 1	+ 23 +		+		+++1 +
Lippia scaberrima	+	+ ++	++	+	+++			+ + + + + ++ +	+ + +	R +		+
Blepharis angusta	+	+	++ +				++ +	++ + ++ + +	++ + ++	+	+	
Cyanotis speciosa	+	+	++	+		+ ++++	+ ++	+++ + + +	+ +	+		
Sida dregei	+ +	+	++	++			++ +	+++ ++ + +		+ + +		+ +
Monsonia angustifolia	+	+						++ ++ +	+++ +	+ + + +	+ ++	+ ++
Corchorus asplenifolius		+	+ +		+		+	+ ++ + + +++	+ ++ +	+	+	+ +
Hibiscus pusillus	+ +++		+++					+	+++ ++++	++++	+	
Berkheya radula									++	+++ + +	+++++	+++ ++1+
Walafrida densiflora		++	+	+	+	+ +++	+	+	+	+ +++	++	+
Eragrostis capensis	+		2 2		++			++	++ ++ +	+ 3+		+++ +
Cymbopogon excavatus	2	1		+ 1	+	+ +	+ +	+ + 2 +	+	1 ++	+	
Hibiscus trionum	+	+	+				+ +	++	+ +	+ +++ +	++ ++	
Solanum panduriforme	+	+ +	+++	++			++ +	+ +++ ++	+			
Eragrostis lehmanniana	+ ++		+		2		+ + +	+ + + +	+ + +	2	+	+
Ipomoea obscura	+++			+			+ +	++++ + + +	+ +	+	+	
Raphionacme hirsuta	+	+ +	+		+	+	++	+ ++ + +	+ + + +			
Panicum coloratum		+				+	+	+ ++	+ +	+ +1 + +	+ +	+
Lightfootia denticulata		+				+	++ + +	+++ + +		+ + +	+	+
Eragrostis obtusa	+ +	++	+++					+	+ +	2+ +		+
Tephrosia semiglabra						+	+ ++ +	+ ++ +	+	+ + +		
Chamaesyce hirta							+ +	+++	+ +	+ +	+ +	+ +
Tragus berteronianus		+ +	+++					+ +	+2+ +	+	+	
Eustachys paspaloides	+	+	++ +	+	+			++	+ +	2 +		
Solanum capensis	+	+ +	+			+	++ +	+ +	+			

C. Unspecified orders (to indicate that the following syntaxa are not classified under any of the recognized orders (Coetzee 1983))
   4. *Elionurio mutici - Cymbopogonetum plurinodis*
      4.1 *Elionurio mutici - Cymbopogonetum plurinodis eragrostidetosum racemosae*
      4.2 *Elionurio mutici - Cymbopogonetum plurinodis aristidetosum canescentis*
      4.3 *Themeda triandra - Cymbopogon plurinodis* Grassland (community without syntaxonomic rank)
   5. *Falckio oblongae - Eragrostidetum planae*
      5.1 *Falckio oblongae - Eragrostidetum planae verbenetosum bonariensis*
      5.2 *Falckio oblongae - Eragrostidetum planae cirsetosum vulgaris*

Description of the syntaxa

The vegetation of the Ba land type of the Western Transvaal can typically be divided into broad physiognomic classes (Edwards 1983) namely woodland, shrubland (not so common in the study area but prominent in the vegetation of the Ba land type) and grassland (Bezuidenhout & Bredenkamp 1990; Bezuidenhout & Bredenkamp 1991; Kooij *et al.* 1990; Bezuidenhout *et al.* 1993) (Figures 3 & 4). Species of species group U (Table 1) are generally found in all of the major vegetation units and are dominated by the perennial grasses *Themeda triandra*, *Eragrostis curvula*, *Aristida congesta*, *Cynodon dactylon*, *Digitaria eriantha* and *Setaria sphacelata*. Non-diagnostic species with a frequency of less than 10 are omitted from Table 1.

1. *Protasparago africani - Acacion karroo* all. nov.

Nomenclatorial Type: relevé 184
This alliance, which represents all of the woodland of the Ba land type, is characterized by species group B (Table 1) and the diagnostic species are the tree species *Acacia karroo* and *A. caffra*

as well as the shrub *Rhus pyriodes* and the bushy forb, *Protasparagus africanus* and the perennial forb *Teucrium trifidum*. The diagnostic woody species as well as the woody species listed in species groups K and L (Table 1) as well as the general grass species mentioned above, are the dominant species of the alliance. The habitat of this woodland alliance represents a variation of altitudes, soil types and terrain types (Figure 3). The *Protasparago africani - Acacion karroo* is represented by 15 relevés and three associations are easily recognized.

1.1 *Protasparago suaveolentis - Acacietum karroo* ass. nov.

Nomenclatorial Type: relevé 184
This association occurs in the bottomland flats (4 in Figure 2) in competition with the *Themeda triandra - Cymbopogon plurinodis* Grassland. The reason for the woodland invading the area of the grassland can be partly ascribed to overgrazing and the resulting bush encroachment, but the soil type of the woodland often differs from that of the grassland (Figure 2). The dominant soil forms of the association, are the Glencoe (Gc - 30 % of the terrain type), Longlands (Lo - 23 % of the terrain type) and Fernwood (Fw - 22 % of the terrain type). The soil is typically 300 - 1 050 mm deep, with a clay content in the B-horizon of 20 - 30 % (Land Type Survey Staff 1984). The terrain has a slope of 3 - 8 % with relatively poor drainage (Figure 3).

Differential species identified, also occurring in the *Zanthoxylo capensis - Vanguerietum infaustae* (2.1), include the woody *Acacia robusta* and *Tarchonanthus camphoratus*, the liana *Clematis brachiata* and the forbs *Becium grandiflorum* and *Pavonia burchellii* (Table 1, species group J). An average of 34 species per sample plot was recorded.

The well developed tree stratum is 6.5 m tall and the canopy cover is 35 % while the shrub stratum is 2.24 m tall with a canopy cover of 24 %. The woody component includes the trees *Acacia karroo* and *A. robusta* and the shrubs *Grewia flava*, *Rhus pyroides* and *Tarchonanthus camphoratus* with the three shrub-like species, *Protasparagus africanus*, *P. laricinus* and *P. suaveolens* also prominent. The herbaceous layer is poorly developed and is 0.7 m tall with a canopy cover of only 40 %. The perennial grasses *Sporobolus africanus*, *Eragrostis curvula* and *Digitaria eriantha* are prominent whilst the perennial forbs *Teucrium trifidum* and *Pavonia burchellii* are also prominent. The presence of relatively palatable grasses (Van Oudtshoorn 1991) in this area indicates the good grazing potential of this association. Related communities were also described by Bezuidenhout & Bredenkamp (1990), Bezuidenhout & Bredenkamp (1991), Bezuidenhout & Bredenkamp (1991a), Bezuidenhout *et al.* (1993).

1.2 Eragrostido curvulae - Acacietum karroo ass. nov.

Nomenclatorial Type: relevé 159

The *Eragrostido curvulae - Acacietum karroo* is one of the easiest recognizable plant communities in the Western Transvaal. It associates strongly with the footslopes (3a in Figure 2) of the hills of the Ba land type where it forms large patches of thorny microphyllous bushveld. The soil forms that represent this association are the Hutton (Hu - 47 % of the terrain type), Mispah (Ms - 11 % of the terrain type) and the Avalon (Av - 10 % of the terrain type) (Land Type Survey Staff 1984). The soil depth is 900 - 1 100 mm with a clay content of 18 - 30 % in the B-horizon (Figure 3).

No diagnostic species were identified but the presence of species groups B (diagnostic of the alliance), L and U (common species) and the absence of species groups J and K characterize this association (Table 1). An average of 31 species per sample plot was noted.

The tree stratum, with a canopy cover of 14.5 % and a height of 5 m is represented by the trees *Acacia caffra* and *A. karroo*. The prominent shrubs in the shrub stratum are *Rhus pyroides, Diospyros lycioides* and the shrubby *Protasparagus laricinus* with a canopy cover of 14.5 % and a height of 2.6 m. The poorly developed herbaceous layer is 0.4 m tall and has a canopy cover of 38.8 %. The only prominent forb is *Teucrium trifidum,* while the perennial grasses *Eragrostis curvula*, *Cynodon dactylon* and *Melinis repens* are also prominent. The palatable component of the grass sward is the cause of selective overgrazing of this vegetation often resulting in considerable degradation of the herbaceous layer and also bush encroachments (Bredenkamp & Bezuidenhout 1990). The presence of the dwarf shrub *Ziziphus zeyheriana*, the pioneer grasses *Aristida congesta* and *Melinis repens* and the relatively low canopy cover of the stratums are an indication of the poor condition and state of degradation of this vegetation. Related communities were mentioned by Bredenkamp *et al*. (1989), Bezuidenhout & Bredenkamp (1991a) and Bezuidenhout *et al*. (1993).

1.3 *Rhoo lanceae - Acacietum caffrae* ass. nov.

Nomenclatorial Type: relevé 241
This association is found high up on the midslopes (3 in Figure 2) of the Ba land type in the Western Transvaal. This relatively high lying woodland associates with deep (900 - 1 100 mm) and well drained soils. The dominant soil-rock complex are Hutton (Hu - 37 % of terrain type), Rock (27 % of the terrain type) and Mispah (26 % of the terrain type) (Land Type Survey Staff 1984). On this relatively flat terrain (slope 0 - 2 %), loose rocks and stones are scattered on the soil surface (less than 10 %) (Figure 3).

The diagnostic species of this association are listed in species group A (Table 1) which includes the two trees *Rhus lancea* and *Acacia erioloba* and the shrub *A. hebeclada*. Species groups B (diagnostic for the alliance), K, L and the common species of species group U are also present in this association (Table 1). An average of 38 species per sample plot was recorded.

The tree stratum is relatively well developed with a canopy cover of 18 % and is 7.7 m tall. Apart from the diagnostic trees, *Acacia caffra* is also prominent in this stratum. The shrub stratum is 2 m tall with a canopy cover of 18 %. Prominent shrubs are *Acacia hebeclada*, *Rhus pyroides*, *Grewia flava*, *Maytenus heterophylla*, *Ehretia rigida*, *Diospyros lycioides* and the two shrubby species *Protasparagus suaveolens* and *P. laricinus*. The herbaceous layer with the perennial forb *Teucrium trifidum*, the dwarf shrub *Ziziphus zeyheriana* and perennial grasses *Sporobolus africanus*, *Themeda triandra*, *Eragrostis curvula*, *Aristida congesta*, *Cynodon dactylon* and *Setaria sphacelata* prominent, is 0.6 m tall with a canopy cover of 47 %.

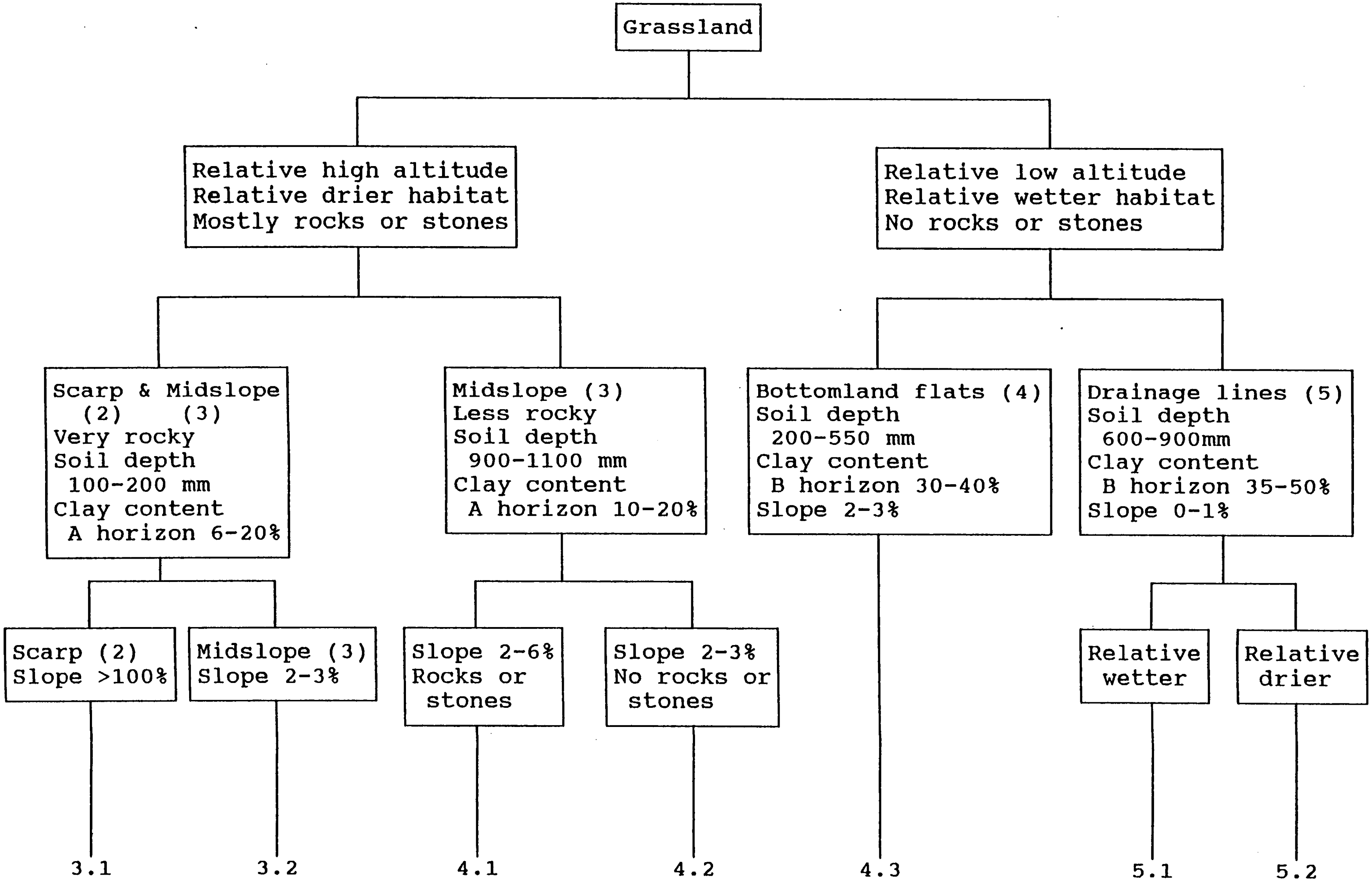


Figure 4: A dendrogram to illustrate the habitat relationships of the grassland syntaxa, of the Ba land type in the western Transvaal, South Africa (all abbreviations and numbers in text).

B. *Loudetio simplicis - Schizachyrietalia sanguinei* ord. nov.

The *Loudetio simplicis - Schizachyrietalia sanguinei* is characterized by the diagnostic perennial grasses *Schizachyrium sanguineum* and *Loudetia simplex* and the perennial grass-like forb *Bulbostylis burchellii* (Table 1, species group I). This order represents the relative high lying shrub- and grassland syntaxa on plateaux and rocky slopes within the Ba land type of the western Transvaal (Figure 2). This order consist of two alliances, each of them with two associations and is represented by 26 relevés.

2. *Schizachyrio sanguinei - Vanguerion infaustae* all. nov.

Nomenclatorial Type: relevé 660
The shrubland syntaxa of the Ba land type are strongly related to the crests (1) and scarps (2) of the hills which are normally well drained (Figure 2). Rock outcrops are also predominant in this terrain type. The alliance is characterized by species group E (Table 1) and the diagnostic species are the trees *Ziziphus mucronata*, *Rhus leptodictya*, *Dombeya rotundifolia* and *Olea europaea* subsp. *africana*, and the shrubs *Vangueria infausta*, *Tapiphyllum parvifolium* and the dwarf shrub *Rhus magalismontana*
and the conspicuous perennial forb *Indigofera comosa* as well as the fern *Cheilanthes hirta* are also diagnostic for this alliance. This alliance is represented by 9 relevés consisting of two associations.

2.1 *Zanthoxylo capensis - Vanguerietum infaustae* ass. nov.

Nomenclatorial Type: relevé 231
The *Zanthoxylo capensis - Vanguerietum infaustae* is restricted to the almost vertical scarps (2 in Figure 2) of the quartzitic hills with slopes of about 100 % in the Ba land type. The predominant soil-rock complex consists of rock (90 % of the terrain type) and the Mispah soil form (Ms - 10 % of the terrain type). The Mispah soil form has a clay content of 3 - 10 % in the A-horizon and is 100 - 200 mm deep (Land Type Survey Staff 1984) (Figure 3).

The diagnostic species which characterize this association include the shrubs *Zanthoxylum capense*, *Mundulea sericea*, *Euclea undulata*, *E. crispa* and the dwarf shrub *Rhus rigida* as well as the perennial forbs *Leonotis ocymifolia*, *Commelina africana*, *Phyllanthus parvulus*, *Vernonia galpinii* and *Rhynchosia venulosa*, with the perennial grass *Sporobolus pectinatus* and the fern *Pellaea calomelanos* also present (Table 1, species group C). Other species from species group E (diagnostic for the alliance), I (diagnostic for the order), J, K, L and U (common species) are also present in this association (Table 1). Species group B (Table 1) (diagnostic for *Protasparago africani - Acacion karroo*) is also present but could be seen as outliers from the adjacent *Protasparago africani - Acacion karroo* and are not typical of this association. An average of 45 species was recorded per sample plot.

The tree stratum is poorly developed with a canopy cover of 5 % and a height of 7 m. Trees like *Acacia caffra*, *A. karroo* and *Celtis africana* are not so typical of this association but were noted in some of the sample plots. However other trees like *Ziziphus mucronata*, *Rhus leptodictya*, *Dombeya rotundifolia* and *Olea europaea* subsp. *africana* are typical of this association. The diagnostic shrubs species for the association and the alliance, as well as *Maytenus heterophylla* and *Diospyros lycioides* are prominent. The shrub stratum is 2.2 m tall and has a canopy cover of 13.7 %. The herbaceous layer is 0.9 m tall with a canopy cover of 22.5 %. The prominent species are the perennial grasses *Loudetia simplex* and *Eragrostis curvula* with no prominent forbs. Related communities were described by Bezuidenhout & Bredenkamp (1991), Bezuidenhout & Bredenkamp (1991a) and by Bredenkamp & Bezuidenhout (1990).

2.2 *Pavetto zeyheri - Vanguerietum infaustae* ass. nov.

Nomenclatorial Type: relevé 660

This shrubland association is typical of the alliance and limited to the crests (1) of the hills of the Ba land type (Figures 2 & 3). The slope is less than 5 % and the dominant soil forms are Mispah (Ms - 23 % of the terrain type), Glencoe (Gc - 20 % of the terrain type) and Hutton (Hu - 19 % of the terrain type) (Figure 2). The shallow (100 - 200 mm deep) soils have a 3 - 10 % clay content in the A-horizon (Land Type Survey Staff 1984).

The diagnostic species are the shrub *Pavetta zeyheri* and the perennial forb *Becium angustifolium* (Table 1, species group D). Other species of species groups E (diagnostic for the alliance), I (diagnostic for the order), L, Q and U (common species) are also present in this association. An average of 37 species per sample plot was recorded.

The tree stratum is 4.25 m tall and has a canopy cover of 8 % with *Ziziphus mucronata*, *Rhus leptodictya* and *Olea europaea* subsp. *africana* the prominent trees. The shrub stratum, with *Pavetta zeyheri*, *Vangueria infausta* and *Diospyros lycioides* prominent, has a canopy cover of 20 % and is 2.8 m tall. The herbaceous layer is 0.7 m tall with a canopy cover of 50 %. The prominent perennial grasses are *Schizachyrium sanguineum*, *Loudetia simplex*, *Triraphis andropogonoides* and *Melinis repens*. The conspicuous forb *Indigofera comosa* and the perennial forb *Helichrysum nudifolium* are prominent in this association. A related community was described by Bezuidenhout & Bredenkamp (1991a).

3. *Schizachyrio sanguinei - Pogonarthrion squarrosae* all. nov.

Nomenclatorial Type: relevé 549

This relatively high lying grassland alliance is found on the scarps (2) and midslopes (3) of the hills of the Ba land type (Figures 2 & 4). More than 10 % of the soil surface is covered by rocks and stones. The soil depth of *Schizachyrio sanguinei - Pogonarthrion squarrosae* is much shallower (100 - 200 mm) than *Elionurio mutici - Cymbopogonetum plurinodis* (4) (900 - 1 100 mm) (Figure 4).

The following species are diagnostic for this alliance: the dwarf shrub *Parinari capensis*, the perennial grasses *Tristachya leucothrix* and *Pogonarthria squarrosa* and the conspicuous, when in flower, annual forb *Cleome rubella*. Most of the prominent grasses have a low grazing value and therefore, this alliance has a low grazing capacity (Gibbs Russell *et al*. 1990; Van Oudtshoorn 1991). This alliance is represented by 17 relevés and two associations are distinguished.

3.1 *Alloteropsido semialatae - Pogonarthrietum squarrosae* ass. nov.

Nomenclatorial Type: relevé 549
The *Alloteropsido semialatae - Pogonarthrietum squarrosae* is typical of the alliance and is associated with the scarp (2 in Figure 2) in the Ba land type with a 50 - 70 % slope (Figure 4). The soil-rock complex differs also from that of the *Zanthoxylo capensis - Vanguerietum infaustae* (2.1) in that there is more soil present in this association. Rock (60 % of the terrain type), Mispah (Ms - 30 % of the terrain type) and Glenrosa (Gs - 10 % of the terrain type) is dominant in the soil-rock complex of this association (Figure 2) (Land Type Survey Staff 1984).

The diagnostic species are the conspicuous perennial grasses *Alloteropsis semialata*, *Monocymbium ceresiiforme*, *Panicum natalense* and *Bewsia biflora* and the inconspicuous perennial grasses *Digitaria tricholaenoides* and *D. monodactyla*. The conspicuous perennial forbs *Pentanisia angustifolia*, *Sphenostylis angustifolia*, *Pearsonia cajanifolia* and *Hypoxis rigidula,* when in flower (Van Wyk & Malan 1988), as well as the inconspicuous weakly perennial succulent *Crassula lanceolata* subsp. *transvaalensis* are also diagnostic for the association (Table 1, species group F). Other species from species groups H (diagnostic for the alliance), I (diagnostic for the order), P, Q and U (common species) (Table 1) are also present in the association. An average of 35 species was recorded per sample plot.

Both tree and shrub strata are absent. The herbaceous layer is well developed with a canopy cover of 65 % and the height varies from 0.4 - 0.7 m. Other than the diagnostic species, the prominent perennial grasses occurring in this association are *Eragrostis racemosa*, *Trachypogon spicatus*, *Diheteropogon amplectens*, *Elionurus muticus*, *Themeda triandra* and *Eragrostis curvula*.

3.2 *Aristido stipitatae - Pogonarthrietum squarrosae* ass. nov.

Nomenclatorial Type: relevé 242
This association occurs on the midslopes (3 in Figure 2) with shallow (100 - 200 mm) soils (Figure 4). The dominant soil forms on 2 - 3 % slopes are Mispah (Ms - 35 % of the terrain type), Glenrosa (Gs - 22 % of the terrain type) and Hutton (Hu - 14 % of the terrain type) (Figure 2). The *Aristido stipitatae - Pogonarthrietum squarrosae* is associated with more than 45 % stones or rocks on the soil surface.

The association is characterized by species group G (Table 1) which includes the diagnostic perennial grass *Aristida stipitata* subsp. *graciliflora* and the perennial dwarf shrub *Pygmaeothamnus zeyheri* var. *zeyheri* and the perennial forbs *Kyphocarpa angustifolia*, *Acrotome hispida*, *Tephrosia longipes* subsp. *longipes*, *T. lupinifolia* and the annual forb *Zornia glochidiata*. Other species from species groups H (diagnostic for the alliance), I (diagnostic for the order), O, P, Q and U (common species) (Table 1) are also present in this association. An average of 41 species was noted per sample plot.

The tree stratum is absent with a poorly developed shrub stratum which is 1 m tall and has a canopy cover of 10 %. The prominent shrub, if present, is *Diospyros lycioides*. The herbaceous layer is 0.69 m tall with a canopy cover of 49.5 %. The prominent grass species are *Tristachya leucothrix*, *Schizachyrium sanguineum*, *Elionurus muticus*, *Brachiaria serrata*, *Eragrostis curvula* and *Setaria sphacelata* as well as the prominent forbs *Pygmaeothamnus zeyheri* var. *zeyheri*, *Acrotome hispida* and *Plexipus hederaceus* for the association.

4. *Elionurio mutici - Cymbopogonetum plurinodis* ass. nov.

Nomenclatorial Type: relevé 297
This grassland association occurs over a wide variety of habitats and is found on the midslopes (3) and bottomland flats (4) of the Ba land type (Figures 2 & 4). The soil is deeper (900 - 1 100) and the habitat is less rocky than that of *Schizachyrio sanguinei - Pogonarthrion squarrosae* (3) (Figure 4). The diagnostic species

(Table 1, species group N) are the perennial grass *Cymbopogon plurinodis* and the perennial forbs *Helichrysum rugulosum*, *Scabiosa columbaria*, *Barleria macrostegia* and *Turbina oblongata* and the annual/perennial forb (Van Wyk & Malan 1988) *Polygala hottentotta*. Two subassociations and one community without syntaxonomic rank are distinguished and the association is represented by 40 relevés.

4.1 *Elionurio mutici - Cymbopogonetum plurinodis eragrostidetosum racemosae* subass. nov.

Nomenclatorial Type: relevé 297

The *Elionurio mutici - Cymbopogonetum plurinodis eragrostidetosum racemosae* grassland is the typical subassociation of the association and is associated with the midslopes (3) of the Ba land type (Figure 2). The dominant soil forms present in this subassociation are Hutton (Hu - 47 % of the terrain type), Mispah (Ms - 11 % of the terrain type) and Avalon (Av - 10 % of the terrain type) (Land Type Survey Staff 1984). Less than 10 % stones or rocks cover the soil surface. The soil depth varies from 900 - 1 100 mm.

No character species could be identified for this subassociation but the species of species group O and P may be considered as differential. The presence of species groups N (diagnostic for the association) and Q (Table 1) and the absence of species groups G (diagnostic for *Aristido stipitatae - Pogonarthrietum squarrosae* (3.2)), H (diagnostic for *Schizachyrio sanguinei - Pogonarthrion squarrosae* (3)) and I (diagnostic for *Loudetio simplicis - Schizachyrietalia sanguinei* (B)) characterize this subassociation (Table 1). The common species from species group U (Table 1) are also present. An average of 34 species per sample plot was noted.

No trees and shrubs were noted in this grassland subassociation. The herbaceous layer is well developed and is 0.7 m tall with a canopy cover of 61.6 %. The following perennial grass species are prominent in this subassociation: *Cymbopogon plurinodis*, *Elionurus muticus*, *Themeda triandra* and *Eragrostis curvula*. Although forbs are present, none are prominent.

4.2 *Elionurio mutici - Cymbopogonetum plurinodis aristidetosum canescentis* subass. nov.

Nomenclatorial Type: relevé 277

This grassland subassociation also occurs on the midslopes (3 in Figure 2) but is lower in altitude than *Elionurio mutici - Cymbopogonetum plurinodis eragrostidetosum racemosae* (4.1). It has also the same dominant soil forms present and the soil is deep (900 - 1 100 m) (Figure 4). The habitat difference between *Elionurio mutici - Cymbopogonetum plurinodis eragrostidetosum racemosae* (4.1) and *Elionurio mutici - Cymbopogonetum plurinodis aristidetosum canescentis* (4.2) is that there are no stones or rocks on the soil surface of the latter (4.2) (Figure 4).

The diagnostic species are the perennial grasses *Aristida canescens*, *Eragrostis superba*, *Microchloa caffra* and *Sporobolus discosporus* (Table 1, species group M). With the exception of the grass *Eragrostis superba* which has an average grazing value, the rest of these grasses have a low grazing value (Van Oudtshoorn 1991). Other species from species groups N (diagnostic for association), Q and U (common species) are also present in this subassociation (Table 1). An average of 32 species per sample plot was recorded.

With the tree and shrub strata absent, the herbaceous layer is 0.7 m tall with a canopy cover of 52 %. Other prominent grass species, apart from the diagnostic species, are *Cymbopogon plurinodis*, *Trichoneura grandiglumis* and *Aristida congesta*.

4.3 *Themeda triandra - Cymbopogon plurinodis* Grassland (community without syntaxonomic rank)

This grassland community occurs on the bottomland flats (4 in Figure 2) of the Ba land type (Figure 4). The *Protasparago suaveolentis - Acacietum karroo* (1.1) is also found on the bottomland flats but the habitat differs (Figure 2). The dominant soil forms of the *Themeda triandra - Cymbopogon plurinodis* Grassland are the Valsrivier (Va - 33 % of the terrain type), Westleigh (We - 20 % of the terrain type) and Glencoe (Gc - 10 % of the terrain type). The shallow to moderate deep soil (200 - 550 mm) has a clay content in the B-horizon of 30 - 40 %. This habitat is wetter than the habitats of the other two subassociations of this association. There are also no rocks or stones on the soil surface present (Figure 4).

There are no diagnostic species for this community but the presence of species groups N (diagnostic for the alliance) and Q together with the absence of species groups M, O and P (Table 1) characterize this community. The common species of species group U (Table 1) are also present in this community. An average of 30 species per sample plot was recorded.

No trees and shrubs are present in the *Themeda triandra* - *Cymbopogon plurinodis* community. The herbaceous layer is well developed with a canopy cover of 68 % and is 0.68 m tall. Prominent species are the perennial grasses *Themeda triandra*, *Eragrostis curvula*, *Cynodon dactylon* and *Digitaria eriantha*.

5. *Falckio oblongae - Eragrostidetum planae* ass. nov.

Nomenclatorial Type: relevé 243

The *Falckio oblongae* - *Eragrostidetum planae* is found in the drainage lines (5 in Figure 2) of the Ba land type (Figure 4). The medium deep (600 - 900 mm), poorly drained margalitic soils are characterized by Rensburg (Rg), Willowbrook (Wo) and Arcadia (Ar) (together 90 % of the terrain type) soil forms (Figure 2). The clay content of the B-horizon of the soils varies between 35 - 50 % while the slope varies very little (0 - 1 %) (Figure 4). No rocks or stones occur on the soil surface of this relatively low lying wet grassland association. The diagnostic species are the perennial grass *Eragrostis plana* and the perennial dwarf forb *Falckia oblonga* (Table 1, species group R). Within the association two subassociations could be identified (Figure 4). Due to all the ploughing in the Ba land type, the unploughed habitat of the *Falckio oblongae* - *Eragrostidetum planae* are normally overgrazed, which are indicated and emphasized by some of the diagnostic species present in the subassociations.

5.1 *Falckio oblongae - Eragrostidetum planae verbenetosum bonariensis* subass. nov.

Nomenclatorial Type: relevé 243
This subassociation has the same abiotic factors as were described for *Falckio oblongae - Eragrostidetum planae*. This subassociation's habitat is however much wetter than that of the *Falckio oblongae - Eragrostidetum planae cirsetosum vulgaris* (Figure 4). The diagnostic species which characterize this subassociation are the perennial exotic grass *Paspalum dilatatum* and the weed *Verbena bonariensis* (Table 1, species group S). An average of 24 species per sample plot was noted.

No trees and shrubs are present and the herbaceous layer is well developed, is 1.02 m tall and has a canopy cover of 74 %. The prominent grass species are *Eragrostis plana*, *Themeda triandra*, *E. curvula*, *Digitaria eriantha* and *Setaria sphacelata*. The perennial forbs *Falckia oblonga* and *Berkheya radula* are also prominent in this subassociation.

5.2 *Falckio oblongae - Eragrostidetum planae cirsetosum vulgaris* subass. nov.

Nomenclatorial Type: relevé 661
The *Falckio oblongae - Eragrostidetum planae cirsetosum vulgaris* is associated with the relatively drier habitat of the drainage lines (5 in Figure 2) of the Ba land type (Figure 4). The soil depth, clay-content of the B-horizon and the slope are the same as were described for the alliance (Figure 4). The diagnostic species (Table 1, species group T) are the conspicuous exotic perennial forb *Cirsium vulgare* and the inconspicuous perennial *Oxalis* species. An average of 18 species per sample plot was recorded.

In this subassociation no trees and shrubs are present and the herbaceous layer is well developed. It has a canopy cover of 82 % and is 0.76 m tall. Perennial grasses like *Eragrostis plana*, *Themeda triandra*, *E. curvula*, *Setaria sphacelata* and the tall *Hyparrhenia hirta* are prominent.

Conclusions

As was noted in the past by several authors (Kooij *et al*. 1990, Fuls *et al*. 1993, Eckhardt *et al*. 1993) as well as own studies (Bezuidenhout & Bredenkamp 1991, Bezuidenhout *et al*. 1993) two structural units, namely woodland and grassland could be identified. Apart from the above structural units and some similar species, very little similarities could be recognized between the syntaxa of the adjacent north-western Orange Free State (Kooij *et al*. 1990) and this study. The climate, as well as the habitat differs substantially and are considered to be reason for this dissimilarity.

The vegetation of the Ba land type is in a state of degradation because of relatively low rainfall for the last number of years, as well as the continuous over-utilization of the little remaining natural vegetation. The presence of a large number of species of low successional status are ascribed to the degradation of the grassland and bush encroachment resulting in woodland and shrubland. The grassland is being overgrazed and burnt. The need to get a better understanding of the vegetation in order to manage the resources in a better way is being stressed by the results of this study. This classification of the vegetation and associated habitat of the Ba land type should contribute to form a better ecological basis for the vegetation-related management planning in this region. These descriptions and ecological interpretations of the vegetation of the Ba land type contribute considerably to the understanding and present knowledge of the western Transvaal grassland.

Acknowledgement
Mrs. D. Bezuidenhout is thanked for assistance in the preparation of the manuscript.

References

ACOCKS, J.P.H. 1988. Veld types of South Africa. *Mem. Bot. Surv. S. Afr.* 57: 1 - 146.

ARNOLD, T.H. & DE WET, B.C. 1993. Plants of Southern Africa: Names and distribution. *Mem. bot. Surv. S. Afr.* 62: 1 - 825.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of Phytosociological Nomenclature, 2nd edn. *Vegetatio* 67: 145 - 195.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H. *in prep*. Syntaxonomy and synecology of western Transvaal grasslands, South Africa. Ph.D. dissertation, University of Pretoria, Pretoria.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* 18: 387 - 403.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991. Die plantgemeenskappe van die Ba-landtipe in die Mooirivieropvanggebied, Transvaal. *S.A. Tydsk. vir Nat. en Tegn.* 10: 85 - 92.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991a. The vegetation of the Bc land type in the western Transvaal Grassland, South Africa. *Phytocoenologia* 19: 497 - 518.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydskr. vir Natuurwet. en Tegnol.* 7: 4 - 9.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. 1993. The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa. *S. Afr. J. Bot.* 59: 319 - 331.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. & THERON, G.K. *in press*. Syntaxonomy of the vegetation of the Fb land type in the western Transvaal Grassland, South Africa. (*S. Afr. J. Bot.*)

BEZUIDENHOUT, H. & BREDENKAMP, G.J. & THERON, G.K. *in prep*. The vegetation of the dolomitic and chert in the western Transvaal grassland, South Africa.

BLOEM, K.J., THERON, G.K. & VAN ROOYEN, N. 1993. Grassland communities of the Verlorenvalei Nature Reserve in the North-eastern Sandy Highveld, Transvaal. *S. Afr. J. Bot.* 59: 273 - 280.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. 1990. The vegetation of the Faan Meintjes Nature Reserve, Transvaal. *S. Afr. J. Bot.* 56: 54 - 64.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area. *S. Afr. J. Bot.* 55: 199 - 206.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve. 1. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 - 529.

BREYTENBACH, P.J.J., MYBURGH, W.J., THERON, G.K. & BREDENKAMP, G.J. 1992. The phytosociology of the Villiers - Grootvlei area, South Africa. 1. Physical environment and the plant communities of the Bb Land Type. *S. Afr. J. Bot.* 58: 239 - 249.

COETZEE, B.J. 1983. Phytosociology, vegetation structure and landscapes of the Central District, Kruger National Park. Dissertationes Botanicae 69. Cramer, Vaduz.

DU PREEZ, P.J. & BREDENKAMP G.J. 1991. Vegetation classes of the southern and eastern Orange Free State (Republic of South Africa) and the highlands of Lesotho. *Navors. Nas. Mus., Bloemfontein* 7: 477 - 525.

DEPARTMENT OF AGRICULTURE AND WATER SUPPLY. 1986. Landbou-ontwikkelingsprogram: Hoëveldstreek. Directorate Agricultural Information, Government Printer, Pretoria.

ECKHARDT, H.C., VAN ROOYEN, N., BREDENKAMP, G.J. & THERON G.K. 1993. An overview of the vegetation of the Vrede-Memel-Warden area, north-eastern Orange Free State. *S. Afr. J. Bot.* 59: 391 - 400.

EDWARDS, D. 1983. A broad-scale structural classification of vegetation for practical purposes. *Bothalia* 14: 705 - 812.

FULS, E.R., BREDENKAMP, G.J., VAN ROOYEN, N. & THERON, G.K. 1993. The physical environment and major plant communities of the Heilbron-Lindley-Warden-Villiers area, northern Orange Free State. *S. Afr. J. Bot.* 59: 345 - 359.

GIBBS RUSSELL, G.E., WATSON, L., KOEKEMOER, M., SMOOK, L., BARKER, N.P., ANDERSON, H.M., DALLWITZ, M.J. 1990. Grasses of Southern Africa. *Mem. bot. Surv. S. Afr.* 58: 1 - 437.

HILL, M.O. 1979. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

KOOIJ, M.S., BREDENKAMP, G.J. & THERON, G.K. 1990. Classification of the vegetation of the B land type in the north-western Orange Free State. *S. Afr. J. Bot.* 56: 309 - 318.

LAND TYPES SERIES. 1979. 2626 West-Rand. Prepared by the Soil and Irrigation Research Institute, Pretoria. 1:250 000. Government Printer, Pretoria.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. agric. nat. Resour. S. Afr.* 4: 1 - 441.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. bot. Surv. S. Afr.* 24: 1 - 105.

MACVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H. & HARMSE, H.J. VON M. 1977. Soil classification - A binomial system for South Africa. Department Agricultural Technical Services, Pretoria.

MENTIS, M.T. & HUNTLEY, B.J. 1982. A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog.* 62: 1 - 29.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

MYBURGH, W.J., BREYTENBACH, P.J.J, THERON, G.K. & BREDENKAMP, G.J. 1992. Die fitososiologie van die Bankenveld in die Grootvlei-omgewing, Suid-Transvaal. *Bothalia* 22: 245 - 254.

RUTHERFORD, M.C. & WESTFALL, R.H. 1986. Biomes of Southern Africa - an objective categorization. *Mem. bot. Surv. S. Afr.* 54: 1 - 97.

SCHULZE, R.E. & MCGEE, O.S. 1978. Climate indices and classifications in relation to the biogeography of southern Africa. In *Biogeography and ecology of southern Africa*, Werger, M.J.A. ed. Junk, The Hague.

SMIT, C.M., BREDENKAMP, G.J. & VAN ROOYEN, N. 1993. Plant communities of the Ad land type in the Newcastle - Memel - Chelmsford Dam area. *S. Afr. J. Bot.* 59: 116 - 122.

VAN WYK, A.E., & MALAN, S.J. 1988. Veldgids tot die veldblomme van die Witwatersrand- & Pretoria-gebied. Struik, Cape Town.

VAN OUDTSHOORN, F.P. 1991. Gids tot grasse van Suid-Afrika. Briza, Pretoria.

VAN ROOYEN, N., THERON, G.K. & GROBBELAAR, N. 1981. A floristic description and structural analysis of the plant communities of the Punda Milia-Pafuri-Wambiya area in the Kruger National Park. 1. The hygrophilous communities. *Jl S. Afr. Bot.* 47: 213 - 246.

WEATHER BUREAU. 1988. Climate of South Africa. WB 40: 1 - 475. Government Printer, Pretoria.

4.9 A Braun-Blanquet reclassification of the Bankenveld Grassland in the Lichtenburg area, south-western Transvaal.

* To be *submitted* to: *Bothalia*

A Braun-Blanquet reclassification of the Bankenveld Grassland in the Lichtenburg area, south-western Transvaal.

H. Bezuidenhout*, G.J. Bredenkamp, G.K. Theron & J.W. Morris$

Department of Botany, University of Pretoria, Pretoria 0002, Republic of South Africa

$ Pretoria Software Solutions (Pty) Ltd, P.O.Box 912805, Silverton 0127, Republic of South Africa

* To whom correspondence should be addressed: National Parks Board, Scientific Services, P.O. Box 110040, Hadison Park, Kimberley 8306, Republic of South Africa

Abstract

The Bankenveld Grassland in the Lichtenburg area was reclassified using TWINSPAN classification and subsequently Braun-Blanquet procedures to refine these results. In two phytosociological tables, two Major Communities, six Communities and eight Variants were identified and described. This new classification can now be included in the comprehensive phytosociological and syntaxonomical synthesis of the western Transvaal Grassland.

Uittreksel

Die Bankenveldgrasveld in die Lichtenburg omgewing is deur middel van TWINSPAN geherklassifiseer en daarna deur Braun-Blanquet prosedures verfyn. In die twee fitososiologiese tabelle word twee hoof plantgemeenskappe, ses plantgemeenskappe en agt variasies geïdentifiseer en beskryf. Die nuwe klassifikasie kan nou by die omvattende fitososiologiese en sintaksonomiese sintese van die Wes-Transvaalse grasveld ingesluit word.

Keywords: Association analysis, Braun-Blanquet procedures, Bankenveld, classification, Western Grassland Biome.

Introduction

During the mid-sixties an ecological survey of the natural and semi-natural vegetation of the Highveld Agricultural Region of South Africa was undertaken by the Botanical Research Institute (Scheepers 1975, Morris 1973). As part of this survey, a quantitative, semi-detailed plant ecological study of the highveld grassland of the Lichtenburg area was done by Morris (1973). At that time the only objective method used for classifying vegetation in South Africa, was the hierarchical Association Analysis technique of the Southampton-Canberra school (Williams & Lambert 1959, 1961; Lambert & Williams 1962). Association analysis is based on the successive subdivision of vegetation samples into two groups according to the presence or absence of a single species. This monothetic-divisive technique is repeated a number of times in order to yield a hierarchy. The dividing species are those that have the maximum ability to separate one group of species from another, implying the maximum sum of chi-squared values with all other species (Kooij *et al.* 1991). Morris (1973) used this technique to classify 220 relevés from the Lichtenburg area to distinguish the main vegetation types. He then carried out a second analysis on 110 relevés to obtain more information on the Bankenveld, due to the importance of its natural vegetation. This enabled him to distinguish and describe ten groups (reduced to seven) in the Bankenveld Grassland (Morris 1973).

These groups are:

Group 1 - *Diheteropogon-Stipagrostis* Primary Bankenveld
Group 2 - *Diheteropogon-Schizachyrium* Bankenveld
Group 3 - *Chascanum-Eragrostis racemosa* Sandy Bankenveld
Group 4 - *Chascanum-Anthephora pubescens* Sandy Bankenveld
Group 5 - *Corchorus-Ursinia* Bankenveld of Disturbed Sites
Group 6 - *Fingerhuthia-Oropetium* Bankenveld of Dolomite Sheets
Group 7 - No name.

Group 2 was subdivided into four groups thus, in total ten groups were identified.

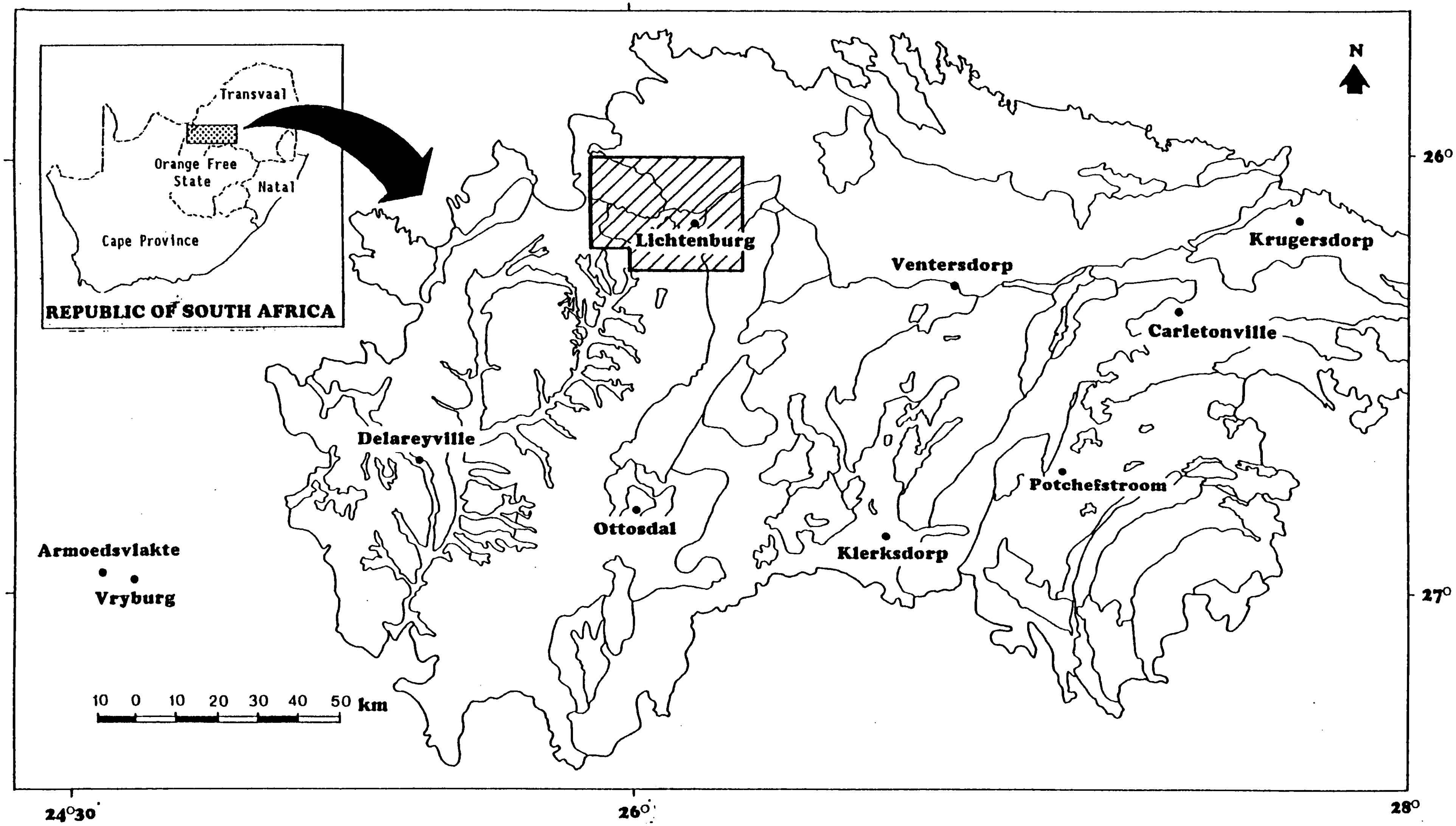


Figure 1: The location of the Morris study area (Morris 1973) in the western Transvaal Grassland (Bezuidenhout in prep.(a)), South Africa.

Although these groups were ecologically interpretable, results of this classification are difficult to reconcile with the results of the Braun-Blanquet classifications presently used for the synthesis of the Grassland Biome. Furthermore Coetzee & Werger (1975) reported that the polythetic Braun-Blanquet analysis of floristic data results in more reliable vegetation classes than the results of the monothetic divisive association analysis (Kooij *et al*. 1991, 1992). The original data set of Morris (1973) consisted of total floristic composition with Braun-Blanquet cover-abundance values for all identified species. Thus, in order to include Morris' Bankenveld data in the synthesis of the western Transvaal grassland (Bezuidenhout *et al. in prep*.(a)), the data were reclassified by means of Braun-Blanquet procedures (Westhoff & Van der Maarel 1978). Kooij *et al*. (1991 & 1992) used this procedure successfully to contribute towards a synthesis of the vegetation from the north-western Orange Free State and Du Preez & Scheepers (1993) also applied it successfully in the Bethlehem area. In this report the Braun-Blanquet classification of the Bankenveld Grassland in the Lichtenburg area is presented.

Study area

The study area of Morris (1973) is bounded by latitudes 26° 00' and 26° 20' south and longitudes 25° 54' and 26° 22' east. This study area is situated in the north-northwestern part of the area where Bezuidenhout (*in prep*.(a)) is currently preparing a comprehensive synthesis of the vegetation of the western Transvaal (Figure 1). The study area comprises approximately 177 000 ha. A detailed description of the physical environment was given by Morris (1973 & 1976), and is not presented here. The Bankenveld within this area is generally situated on the dolomite and chert of the Chuniespoort Group (Transvaal Sequence). The rocks in the western part of the area are covered with a thin layer of aeolian sand. The area is generally known as Klipveld (Louw 1951).

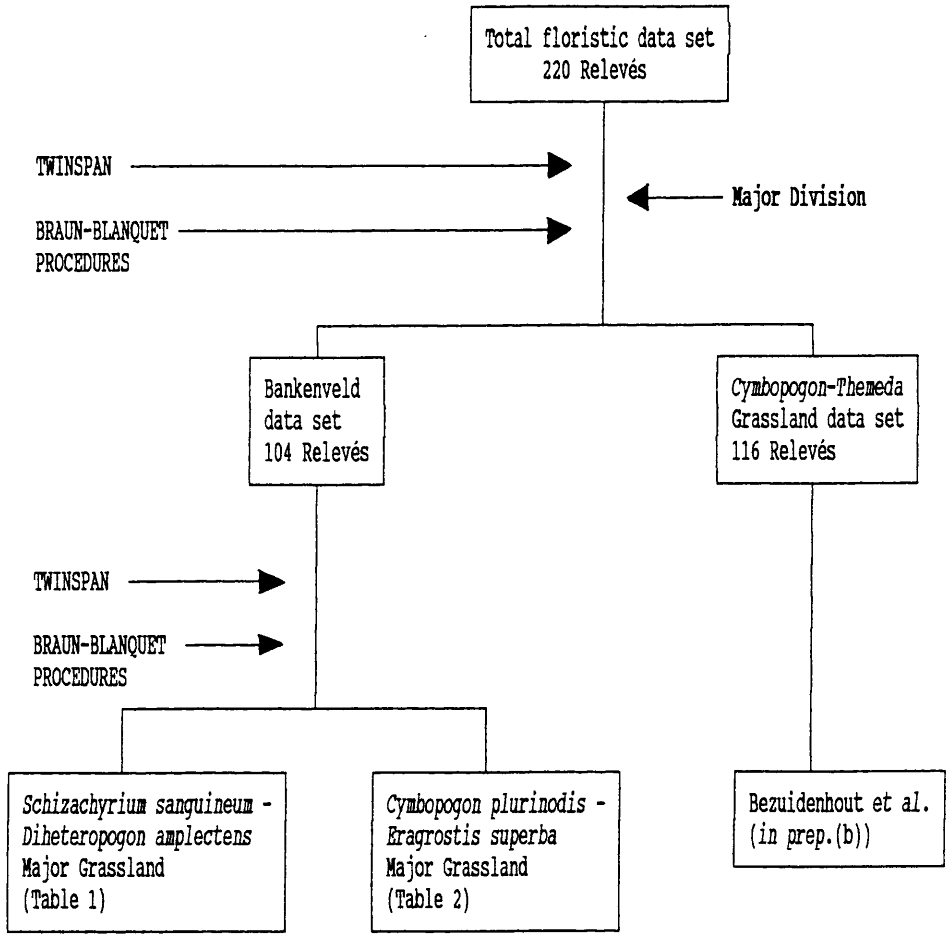
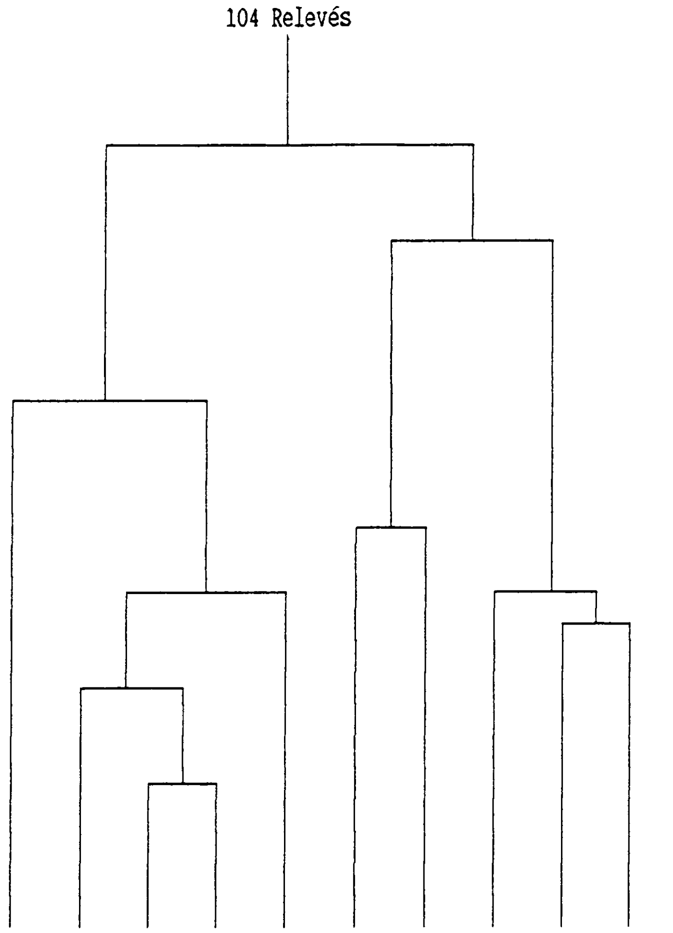


Figure 2: A dendrogram to illustrate the major division of the total floristic data set (Morris 1973) as well as the division of the Bankenveld data set into two Major Grasslands.



Association analysis groups

1	2a	2b	2c	2d	3	4	5	6	7
1	71	44	38	10	30	13	8	14	3
5	96	45	46	24	32	15	17	16	4
6	98	47	51	58	41	25	19	66	9
7		48	55	61	43	26	28	84	11
18		49	64	73	52	27	40	85	12
20		50	68	76	78	29	42	87	23
21		53		82	79	34	69	89	33
22		56		88	80	36	83	91	35
31		57		93	81	37	95	101	90
54		59		110	97	39			103
65		60			99	63			105
70		62				72			106
		67				74			107
		86				77			109
						92			
						94			

Relevés

Figure 3: A dendrogram of Association Analysis of the Bankenveld vegetation (Morris 1973).(Six relevés excluded and added to *Cymbopogon-Themeda* Grassland data set (Bezuidenhout *et al. in prep.*(b)).

Methods

The stratification of the study area by Morris (1973, 1976) was based on the Bankenveld and *Cymbopogon-Themeda* Grassland Land Systems (Mabbutt 1968) excluding all lands under cultivation, or showing signs of past cultivation, as well as the town of Lichtenburg and the bed of the Harts River. Relevés were compiled in 220 stratified random sample plots. The cover-abundance for each species present in the sample plots was allocated according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974) and limited habitat information was noted in each sample plot of 16 m^2. More details are given by Morris (1973, 1976).

In the present study the classification algorithm TWINSPAN (Hill 1979) was used for analysing the total floristic data set (220 relevés), and subsequently Braun-Blanquet procedures were used to refine these results (Figure 2). The final phytosociological Tables, and plant community classification and descriptions are in Braun-Blanquet format (Tables 1 & 2). Amongst others these procedures were successfully used by Bezuidenhout (1988), Bezuidenhout *et al.* (1988), Behr & Bredenkamp (1988) and Bredenkamp *et al.* (1989).

Taxa names used in the plant community descriptions conform to those of Arnold and De Wet (1993).

Topographical positions, adapted from Land Type Survey Staff (1984), used in the descriptions are crest, upper midslope and lower midslope.

A tabular comparison was made of the Bankenveld association analysis classification (Morris 1973) and the Bankenveld Braun-Blanquet classification (Table 3).

Results

The major division obtained by this procedure separates the total floristic data set (220 relevés) into the Bankenveld data set, consisting of 104 relevés, and *Cymbopogon-Themeda* Grassland data set, consisting of 116 relevés (Bezuidenhout *et al. in prep.*(b)) (Figure 2). Six relevés, which were originally classified as part

Table 1: A phytosociological table of the *Schizachyrium sanguineum* - *Diheteropogon amplectens* Major Grassland from the Lichtenburg area.

Sample plots	00000	00000000	00000000000	00000000000000	00000	0000000	000000	00100
	44445	46655568	97589656657	00099082845198	26322	2772531	343337	54133
	54896	67275946	71888830113	61539704172062	05185	2946408	432578	01086
Communities (in text)	1							
	1.1			1.2				1.3
	1.1.1	1.1.2	1.1.3	1.2.1	1.2.2	1.2.3	1.2.4	
Species group A								
Eragrostis racemosa	++++1	++++++++	++ +++++ ++	++ ++ +++++1 +	+ +	++ +++	+++ +	+1++
Schizachyrium sanguineum	22212	2+1+1+11	+1+11+1++11	+++++1 ++++++	+++ +	++	+ + +1	2+ +
Diheteropogon amplectens	12121	+++211+2	2+11+21+++	+11+ + 1 ++1++	+11	1 + 1	+	1 1+
Trachypogon spicatus	++121	211 1 2+	1+ + +1 ++	+ ++++ 2 +++	1 +	+	++++ +	+111+
Kyphocarpa angustifolia	++ +	+++++	++ +++ +	+ + + ++++	++++	+ ++	+ ++	+ +
Oxygonum dregeanum	++	++++ ++	+++++++ ++	++ + + ++++	+	+ + +	++++ +	++++
Ophrestia oblongifolia	++ +	++++++	++ ++++++ +	++ + + +++++	++ +	+ +	+++++	+ ++
Dicoma anomala	+++++	++++++++	+++++++++++	+++ ++++++ ++	+++	+ ++++	++ +++	+++++
Species group B								
Loudetia simplex	+2++	2+3+++++	+ ++1+1++1+	+				
Bewsia biflora	+++++	++ ++++	+ +++ + +	+ +	+			
Urelytrum agropyroides	++	+ ++	+ +	+ +				
Species group C								
Rhynchosia nervosa	+	++++++++	+	+				
Silene undulata	+	++ + +	+	+				
Dianthus mooiensis		+ + +	+ +	+				
Cyperus sphaerospermus	++	++	+	+				+
Tribulus terrestris	++	++ +		+				
Species group D								
Anthephora pubescens		+	2 2	++ +++ 1++1	1+ 1	+ + 23+	++ +	
Indigofera daleoides	+			+ + +++++ +	+	+++ +++	+ +	+
Stipagrostis uniplumis				++1 +	113 2	++ 2121	2 +1	
Hermannia tomentosa				+++++ +	+ ++	+ ++++	+ +	
Setaria sphacelata			++	+ + +1+ ++	+ ++	++ ++++	3	
Eragrostis trichophora	+	+		++ + 1	+ 2+	2 +	+12211	+ +2
Cyperus marginatus	+		+ +	+ + +	+++	+++	+++ +	
Species group E								
Cyperus capensis			+	+ + ++++ +		+		
Tephrosia lupinifolia	+		+	+++ +				
Antizoma angustifolia	1			++ +	+			
Species group F								
Oropetium capense					++++	+		
Turbina oblongifolia				+ +	+++	+ +		

Species group G								
Fimbristylis hispidula							+ ++	
Eragrostis gummiflua				+	+	+	++ +	
Scilla nervosa						+	++ +	+
Walafrida saxitalis							++	
Digitaria argyrograpta		+		+ +	+	+	++	+
Species group H								
Eustachys paspaloides			+	+ + +	+ + 1	++1	+++ +	+
Cymbopogon plurinodis					+1+	+ + +	+ +	+
Eragrostis superba					+ +1	+ +	+++ +	
Cynodon dactylon			+		+	2	++++	
Eragrostis lehmanniana			+	+	+	1	+++1+	+
Species group I								
Andropogon appendiculatus							+ + +	1 ++
Sporobolus fimbriatus			+				+ 1+	+ +
Selago welwitschii				+ + +	+	+	+ +	+ ++
Species group J								
Talinum caffrum		+	+ +	++ + + +	+ +			
Polygala rehmannii	+		++ +	++ ++ +	+ +			+
Species group K								
Ipomoea obscura		++++	+++++ + +	+++ + ++ ++	++++			
Chaetacanthus costatus	+	++ ++ ++	+++++ ++++	++ + + ++	+++ +	+	+	
Species group L								
Sporobolus pectinatus	+1++1	++++++++	++ +++++ +	+++ ++ ++ +	+		+	+ +
Andropogon schirensis	11 2	1 111	+11 + 1 1+	+1 ++ 1	+		1	
Tephrosia longipes	++++	++ ++	+ + +++	+ +++ + +	+			+
Species group M								
Senecio coronatus	+++	++++++	++++ ++++	+ ++ + + +	+ +			
Senecio venosus	+++ +	+++++++	+++++ ++	+++ ++++++++	+++ +	++ +		+
Thesium magalismontanum	+++++	+ ++++++	++++ ++	+++ + +	+++ +	+		+
Species group N								
Solanum supinum			+ ++ + +	++ + + +	+ +	+ +	+	
Corchorus asplenifolius			++ +	++ + + + +++	++++	++ + ++	+ ++1	++
Kohautia amatymbica	+	+	+ ++ +	++ + + ++ ++	+++++	+++++++	+++ +	+
Species group O								
Eragrostis stapfii	+	+ +	++ + +	+ +	++ +	+ +++ +	+ +	+
Ursinia nana		+ +	++ + +	+ ++++ ++	++++	+ ++ +	+ +++	++
Triraphis andropogonoides	+	1 ++	12++1 ++	+ 11+++++ 1+++	12+++	2++++++	++2++1	++

Species group P

Aristida congesta	1 +++	+++ ++	++++ 1+++++	+1 ++ ++++++++	+ ++1	+3+1+1+	+++1++	+++++
Themeda triandra	++1	+ +++ 1	1 ++ +	1+++1+12+1++ +	1 ++2	121+++2	+2+++1	+++ +
Anthospermum rigidum	+ +++	+ +++	+ ++++++	+++++++++++ +	+++++	+++++++	++++++	+++++
Elionurus muticus	++++	++++++++	++++ 2++ +	+++12+1+22++1+	11 +	12 ++ +	++++++	12++1
Brachiaria serrata	+++++	++ +++++	++++ +++++	+++++++++1++++	++1++	+++++++	++ + 1	+++++
Justicia anagalloides	+++++	+++++++	+++++++++++	++++++++++++++	+++++	++++ ++	+ +++1	+++++
Crabbea angustifolia	++ ++	+++++ +	+++++++++	++++++++++ +++	+++++	+ +++++	+++ +	+ ++
Commelina africana	+++	++++++++	+ ++++++++	++++++ +++ ++	++	+ ++	++++++	++++
Helichrysum caespititium	+++++	++++++++	+++++++++++	++ ++++++++++	++ ++	++ +++	+ ++++	+++++
Diplachne fusca	+ +++	++++++++	+ ++ ++++++	++++ ++ +++++	+++	++ + 1+	++++++	++ ++
Pogonarthria squarrosa	++ +	+++ +++	1+ + +	+ + + +++	+++ +	1++++++	++ +++	+1
Chamaesyce inaequilatera	++	+ + +	+	+++++++++ ++	+++ +	+ +++++	+++ ++	+ +
Heteropogon contortus	+++++	1++ + 1	+1++ +++2 +	+ +++++1+ + 1	+ + +	++++1+1	++1+	+ +
Aristida diffusa	+++++	+ ++ 1	1121 +1+++1	+1+++++1+++ ++	1++	+++ +	+ ++	+++
Blepharis integrifolia	+ +	++ + + +	++ ++ + +	++++ ++++++++	++	+ ++ +	++++++	+ ++
Eragrostis curvula	++ +	+ ++1	++112+11+++	2+ 1 + 2+11	+++	+ ++ +	+ +	
Plexipus hederaceus	+++++	+++++	+++++++ + +	++++++++++++++	++ +	1+++++	+++ ++	++ ++
Bulbostylis burchellii	+++++	1+++++++	+++++++ ++	+++++++ +++++	++	+ +	+ ++	+++++
Barleria macrostegia	+ +	+ + +	+++++ + +	+++ ++ + ++	++	++ +++	+++	+
Nolletia ciliaris	+++++	+++ +++	+++++ + ++	++++ + ++++	++	+ +++++		++
Chamaecrista biensis	++ +	+ ++	+ + +++ ++	++ ++ +++ +	+++ +	+ + ++	+++ +	+ +
Cymbopogon excavatus	1+ 1	+++2 +	+ +1+ + 1	++++ 1 1	+1 1	+ ++	1+ +1	1111
Gazania krebsiana	+++	+++ +	+ +	++++++ ++	+ +	+++ + +	++ +	+ ++
Elephantorrhiza elephantina	+ ++	++ ++	+++ + ++	+ +	+	+	+ ++	+++
Raphionacme hirsuta	+	+ ++ +	+ +	++ + ++		+ +	+	+
Zornia milneana	+ +		+	++ ++++ +	+	++	+ ++	+
Lightfootia denticulata	+	++ ++	++ ++++	+ ++ +	+ +		++	++
Clematis brachiata	+	+	+ + + +	++ +	+	+ +		++
Geigeria burkei		+ +		+ +	+	++	+ +	+ +
Nidorella hottentotica		+ ++	+ +++	+			+	
Gnidia capitata	+	++ +	+++	+ + +++	+	+ + +		+
Melinis repens	++ +	+	+ ++	+ ++ + +	+ ++	+ +	+++++	+
Dicoma macrocephala	+ +		+	++++++++ +	+ ++	+ + ++		
Plexipus pinnatifidus				+ + +	+ ++	+ + +		
Lippia scaberrima		+		+ + ++	+ +	+	+ ++	+
Sida chrysantha			+ +	+ + + +			++ ++	+

of the Bankenveld Grassland (Morris 1973, 1976) are now classified in the *Cymbopogon-Themeda* Grassland. The Bankenveld is clearly represented by two Major Grassland communities which are presented in two separate phytosociological tables in this report (Tables 1 & 2).

(i) Braun-Blanquet classification

The vegetation of the Bankenveld Grassland in the Lichtenburg area can be described as an *Elionurus muticus - Brachiaria serrata* Grassland. The most conspicuous feature of the vegetation of the Bankenveld Grassland on dolomite and chert is the complete absence of dominants (Louw 1951). A large number of species is represented but none succeeds in obtaining dominance. The relatively low cover of *Themeda triandra* is also not attributed to the grazing factor as is the case in the *Cymbopogon-Themeda* Grassland. This heterogeneous character of the vegetation is mainly determined by the physical nature of the soil (Louw 1951).

The Braun-Blanquet hierarchical classification of these plant communities is as follows:

1 *Schizachyrium sanguineum - Diheteropogon amplectens* Major Grassland (Table 1)

1.1 *Loudetia simplex - Schizachyrium sanguineum* Grassland

1.1.1 *Andropogon schirensis - Loudetia simplex* Variant
1.1.2 *Rhynchosia nervosa - Loudetia simplex* Variant
1.1.3 *Triraphis andropogonoides - Loudetia simplex* Variant

1.2 *Anthephora pubescens - Schizachyrium sanguineum* Grassland

1.2.1 *Elionurus muticus - Anthephora pubescens* Variant
1.2.2 *Oropetium capense - Anthephora pubescens* Variant
1.2.3 *Stipagrostis uniplumis - Anthephora pubescens* Variant
1.2.4 *Eragrostis trichophora - Anthephora pubescens* Variant

1.3 *Andropogon appendiculatus - Cymbopogon excavatus* Grassland

2 *Cymbopogon plurinodis - Eragrostis superba* Major Grassland (Table 2)

2.1 *Fingerhuthia africana - Aristida diffusa* Grassland
2.2 *Digitaria argyrograpta - Eragrostis lehmanniana* Grassland
2.3 *Aristida congesta - Crassula transvaalensis* Grassland
2.3.1 Variant

Description of the plant communities

1 *Schizachyrium sanguineum - Diheteropogon amplectens* Major Grassland

This Major Grassland is typically found on the relatively high lying chert crests and upper midslopes in the Bankenveld Land System of the Lichtenburg area. It relates to Morris' groups 1, 2 and 3 (Table 3). The soil is heterogeneous and varies in depth (0.1 - 0.8 m), but is mostly considered as rocky and shallow. The diagnostic species are the perennial grasses *Eragrostis racemosa*, *Schizachyrium sanguineum*, *Diheteropogon amplectens* and *Trachypogon spicatus* as well as the forbs *Oxygonum dregeanum*, *Kyphocarpa angustifolia*, *Ophrestia oblongifolia* and *Dicoma anomala* (species group A; Table 1). Typical of Bankenveld dolomite and chert, no species attains dominance, but the diagnostic grass species *Schizachyrium sanguineum*, *Diheteropogon amplectens* and *Trachypogon spicatus*, all indicators of shallow rocky soils, have relatively high cover-abundance values.

This major high lying Grassland is divided into three communities.

1.1 *Loudetia simplex - Schizachyrium sanguineum* Grassland

This community relates to group 2 of the Bankenveld Association analysis (Morris 1973)(Table 3). With the exception of relevé 97 (group 3) all relevés are grouped in group 2 (Table 3). Morris (1973) gives a broad description of the habitat features of group

2 but not of the individual groups 2a, 2b, 2c and 2d.

The *Loudetia simplex - Schizachyrium sanguineum* Grassland is strongly associated with the chert crests and south and north facing upper slopes of the rises. The stony, very shallow (0,1 - 0,2 m) soil is normally littered with chert gravel on the soil surface. Outcrops of chert are present in this community.

The diagnostic species for the *Loudetia simplex - Schizachyrium sanguineum* Grassland are the perennial grasses *Loudetia simplex*, *Bewsia biflora* and *Urelytrum agropyroides* (species group B; Table 1). These species are typically restricted to very rocky and very shallow soils, while the diagnostic species of the *Schizachyrium sanguineum - Diheteropogon amplectens* Grassland, namely *Schizachyrium sanguineum*, *Diheteropogon amplectens* and *Trachypogon spicatus* are prominent due to high cover-abundance values.

Three Variants of this community are identified in Table 1.

1.1.1 *Andropogon schirensis - Loudetia simplex* Variant

This Variant relates to group 2b (Morris 1973)(Table 3) and is concentrated in the eastern and central parts of the study area (Figure 1). It is associated with the microhabitat created by loose surface rocks, where the crests form plateaux. There are no diagnostic species for this Variant but the species from species groups A (diagnostic for *Schizachyrium sanguineum - Diheteropogon amplectens* Major Grassland), B (diagnostic for *Loudetia simplex - Schizachyrium sanguineum* Grassland), L, M and P (common species) are present in this Variant (Table 1), while species group C and K are characteristically absent.

1.1.2 *Rhynchosia nervosa - Loudetia simplex* Variant

The *Rhynchosia nervosa - Loudetia simplex* Variant relates to groups 2b and 2c (Morris 1973)(Table 3). This Variant is found in shallow depressions on waning slopes. The diagnostic species from species group C (Table 1) are the forbs *Rhynchosia nervosa*, *Silene undulata*, *Dianthus mooiensis*, *Cyperus sphaerospermus* and *Tribulus terrestris*. Other species which are also present in this

Variant are shown in Table 1.

1.1.3 *Triraphis andropogonoides* - *Loudetia simplex* Variant

The relevés of this Variant are scattered among groups 2a, 2b, 2c, 2d and 3 (Morris 1973)(Table 3). It occurs on the gentle waxing north and south facing slopes of the rises. No diagnostic species are present, but the Variant differs from the *Andropogon schirensis* - *Loudetia simplex* Variant in that species from species groups J, K, N and O (Table 1) are present.

1.2 *Anthephora pubescens* - *Schizachyrium sanguineum* Grassland

The *Anthephora pubescens* - *Schizachyrium sanguineum* Grassland is mostly found on the upper midslopes of the Bankenveld of the Lichtenburg area. Chert fragments and loose dolomite rocks are often found on the soil surface (Morris 1973). Although Morris (1973) mentioned a variety in soil depth, the soil of this Grassland is generally less rocky, deeper and more sandy than that of the *Loudetia simplex* - *Schizachyrium sanguineum* Grassland.

The diagnostic species for this community are the perennial grasses *Anthephora pubescens*, *Stipagrostis uniplumis*, *Setaria sphacelata* and *Eragrostis trichophora* while the perennial forbs *Indigofera daleoides*, *Hermannia tomentosa* and *Cyperus marginatus* are also diagnostic (species group D; Table 1). Most of these diagnostic species are associated with relatively deep sandy soils (Bezuidenhout *et al.* 1993 and Bezuidenhout *in prep.*(a)). The wiry sour grasses *Loudetia simplex* and *Uryletrum agropyroides*, diagnostic for the *Loudetia simplex* - *Schizachyrium sanguineum* Grassland are absent, and *Schizachyrium sanguineum*, *Diheteropogon amplectens* and *Trachypogon spicatus* are less prominent. On the contrary the more palatable grasses *Anthephora pubescens*, *Eustachys paspaloides*, *Themeda triandra* and *Elionurus muticus* are often conspicuously present, indicating a higher grazing potential of the vegetation on the deeper soils. Evidence of patch selection by livestock, and resulting overgrazing and degradation of the vegetation is shown by the presence of pioneer species such as *Cynodon dactylon* and *Eragrostis lehmanniana*.

With the exception of the *Elionurus muticus* - *Anthephora pubescens* Variant (1.2.1) the rest of this community corresponds well with group 1 (Morris 1973)(Table 3).

Four Variants are identified in Table 1.

1.2.1 ***Elionurus muticus* - *Anthephora pubescens*** Variant

The relevés of this Variant are mainly scattered among groups 1, 2d and 3 (Morris 1973)(Table 3). Diagnostic species include *Antizoma angustifolia*, *Cyperus capensis* and *Tephrosia lupinifolia* (species group E; Table 1). The presence of species from species groups K, L and M (Table 1) indicate that this Variant has affinity to the more rocky *Loudetia simplex* - *Schizachyrium sanguineum* Grassland.

1.2.2 ***Oropetium capense* - *Anthephora pubescens*** Variant

This Variant is quite similar to group 1 (Morris 1973)(Table 3). Diagnostic species are *Oropetium capense* and *Turbina oblongifolia* (species group F; Table 1).

1.2.3 ***Stipagrostis uniplumis* - *Anthephora pubescens*** Variant

The relevés of this Variant are scattered among groups 1, 3 and 4 (Morris 1973)(Table 3). No diagnostic species were identified, but this Variant can easily be recognized by the absence of groups E, F, G and I (Table 1).

1.2.4 ***Eragrostis trichophora* - *Anthephora pubescens*** Variant

This Variant relates to groups 3 and 4 and to a lesser extent group 7 (Morris 1973)(Table 3). The Variant is characterized by species group G (Table 1) with the diagnostic species *Fimbristylis hispidula*, *Eragrostis gummiflua*, *Walafrida saxatilis*, *Scilla nervosa* and *Digitaria argyrograpta*.

Species group H indicates a close floristic relationship between communities 1.2.2, 1.2.3 and 1.2.4, and these communities are also typical representatives of the *Anthephora pubescens* - *Schizachyrium sanguineum* Grassland.

Table 2: A phytosociological table of the *Cymbopogon plurinodis* - *Eragrostis superba* Major Grassland from the Lichtenburg area.

	2.1	2.2	2.3	2.3.1
Sample plots	1 1 1	1 1	1	
	880718218099078	4 1 03704	1111922666023	997 1
	496265143510977	0419319632	5397573693793	42082
		2		
Communities (in text)	2.1	2.2	2.3	2.3.1
Species group A				
Cymbopogon plurinodis	+ +1+1++ + +	++1+1 +	+++ +++++1+2	+ +1
Eragrostis superba	1 ++1+1++1+	+ +++1+ ++	1 + 12++ ++	+ +
Sporobolus africanus	+ + + +++	+ 1+ +	+1 ++	++ +
Species group B				
Oropetium capense	++ 1+++++ + +	+ +	+ +	
Fingerhuthia africana	11 + +++ 1	+		
Tragus berteronianus	+ + ++ + +		+	
Cyperus margaritaceus	+ ++++++ ++	+	+	
Commelina benghalensis	++ + ++	+	+	
Lippia scaberrima	+ + + + +			+
Sida chrysantha	+ + + + +	+	+	+
Limeum viscosum	+ + ++	+	++	
Salvia radula	++ 1 +			
Raphionacme velutina	+ + + +			
Maytenus heterophylla	+ + + +			
Species group C				
Digitaria argyrograpta	+	++21+++		+
Cynodon dactylon	+ +	++ 113		
Species group D				
Plexipus hederaceus	+ +	+	++ ++ + +	+++
Crassula transvaalensis	+ +	+	++ + + + +	++
Blepharis angusta	+		++ + +	+
Guilleminea densa			+ +	++
Species group E				
Aristida diffusa	+11+ ++++22+++	+ ++	+ + +++	+
Diplachne fusca	+ ++ ++ + ++	+++++	+ +++++ ++++	
Eragrostis lehmanniana	++1 + +++ ++	+ + 21+11	++ +	
Setaria sphacelata	+++ + ++	++ +	++ +++1+ 2	
Turbina oblongata	++ +++++++++ +	+ +++ ++	++ ++++ +++	+
Eragrostis trichophora	++ 1 +	++ + 1	1 + ++ +	
Bulbostylis burchellii	+++ + +	+ + ++	++++ + ++	
Cymbopogon excavatus	++ + + ++	1 1	+ + + +	

Species group F

Aristida congesta	+++1+111+1++1++	+++++11+	++21++2++1212	1+1++
Stipagrostis uniplumis	112 +1+++212 ++	+ 1+ ++	1++++222311+	+ 111
Themeda triandra	+1+11+++1+11+	21++++21++	1+1 11121132	+1 1+
Triraphis andropogonoides	++ ++ +++++ ++	+++++	+1+ ++++++	++ +
Anthephora pubescens	1 ++11+21 ++22+	21+ +++	+11+1+ 2+1+1	121+1
Elionurus muticus	++ 1++++11+	++ ++++	++ +++11 +	++
Pogonarthria squarrosa	+1+ +++ +++ +	1++ +	+++12++ ++++	++ ++
Eragrostis curvula	11 1 1++1+ 1	+ 1 +	+ ++ +	111+
Anthospermum rigidum	++ ++ ++++++	++ + +++++	++++++ +++	+++ +
Plexipus pinntifidus	++++++ ++ + +	++ +	++ +++++++ ++	+++
Brachiaria serrata	+ ++ ++ +++2	++1 + +	++ +1 + +++	++++
Barleria macrostegia	++ ++ ++++	+++++ +	+++ + +++++++	+++++
Blepharis integrifolia	++ +++++ ++	+ ++	+++ + +	+++++
Corchorus asplenifolius	++ ++ +++++	+ + +	++++++ ++ +	+++++
Crabbea angustifolia	++ ++++ +++	+ + + +	+ + +++++++	+ +++
Commelina africana	+++++ +++++ +	+++ ++ ++	+ +++++++	++++
Eragrostis stapfii	++ +++ +++	+1++++++	+++ ++ ++++	+ ++
Chamaesyce inaequilatera	+++++ ++++++ ++	+ + +++	+ +++++++	++++
Eustachys paspaloides	+ 1+++ + +++	+ +	++1 + ++ +1	+1+1
Hermannia tomentosa	++ ++++++++	+ ++ ++	++++++ + +	+++++
Heteropogon contortus	+ ++ + + ++	+ ++	++ +++ ++++	1 +
Chamaecrista biensis	+ ++++++ + +	+ + +	+ + ++	++ +
Indigofera daleoides	++ +++ ++ ++++	+++++ 1+	+++++ ++++++	+++++
Dicoma macrocephala	+ ++ ++ + +	+ +	++ ++++++	++++
Chaetacanthus costatus	+ +++ +	+ +	+ + ++ +	++
Helichrysum caespititium	+ + ++	+++ ++ +	++ + +++ +	++
Ipomoea obscura	+ + + + ++ +	+	+ +	+++ +
Justicia anagalloides	+ + + + +	+++ + ++	+++ + +++	+++++
Kohautia amatymbica	+ + + + +	+ + ++ +	+++++++ ++++	+++++
Solanum supinum	+ ++ ++ +	+ +	+++ ++ +	++
Ursinia nana	+ + +	+ ++ +	+2++ ++ +	+++
Vernonia oligocephala	++ ++ + +++ +	+ +	+ + + ++	+ ++
Nolletia ciliaris	++ + + ++	+ ++	+ +	+ ++
Elephantorrhiza elephantina	+ +	++	+ + +	
Raphionacme hirsuta	+ + +	+ +	+ + + +	+

1.3 *Andropogon appendiculatus - Cymbopogon excavatus* Grassland

This community relates to no particular Association analysis group and one relevé is classified in each of groups 2b, 2c, 2d, 3 and 4, indicating that this community was not recognized by Morris (1973, 1976)(Table 3). This vegetation is transitional to the *Cymbopogon plurinodis - Eragrostis superba* Major Grassland community (Community 2, Table 2). The vegetation is characterized by low species diversity, with only species groups A (diagnostic for *Schizachyrium sanguineum - Diheteropogon amplectens* Major Grassland), I and the widespread and general species of species group P (Table 1) present.

2 *Cymbopogon plurinodis - Eragrostis superba* Major Grassland

This Major Grassland community relates to groups 4, 5, 6 and 7 (Morris 1973)(Table 3). The *Cymbopogon plurinodis - Eragrostis superba* Major Grassland is situated on the lower midslopes of the Bankenveld Grassland in the Lichtenburg area. Due to the dolomite sheet outcrops which occur scattered throughout the area, the soil depth varies between very shallow (0.1 - 0.2 m) to moderately deep (0.5 - 0.8 m).

The diagnostic species for this community are the perennial grasses *Cymbopogon plurinodis*, *Eragrostis superba* and *Sporobolus africanus* (species group A; Table 2). Species typically found on the moderately deep sandy soils are *Stipagrostis uniplumis*, *Anthephora pubescens*, *Aristida diffusa* and *Eragrostis lehmanniana*, while *Themeda triandra*, *Brachiaria serrata* and *Eragrostis curvula* are prominently present. The relatively high cover-abundance of these species results in the relatively high grazing potential of this community.

2.1 *Fingerhuthia africana - Aristida diffusa* Grassland

The relevés of the *Fingerhuthia africana - Aristida diffusa* Grassland are scattered among groups 1, 4, 5, 7 but the community relates best to group 6 (Morris 1973)(Table 3).

This Grassland community is found on extensive plains with stony, shallow (0.1 - 0.2 m) soils where dolomite sheets and outcrops cover the surface. This community is characterized by the diagnostic shrub *Maytenus heterophylla*, diagnostic perennial grasses *Fingerhuthia africana*, *Oropetium capense* and *Tragus berteronianus* and the diagnostic forbs *Limeum viscosum*, *Salvia radula*, *Sida chrysantha*, *Raphionacme velutina*, *Senecio coronatus*, *Cyperus margaritaceus*, *Commelina benghalensis* and *Lippia scaberrima* (species group B; Table 2).

2.2 *Digitaria argyrograpta - Eragrostis lehmanniana* Grassland

This community is akin to, particularly, group 7 but some relevés were classified in groups 2d, 4, 5 and 6 (Morris 1973)(Table 3).

This community is situated on bare patches on the lower midslopes and sometimes outcrops of dolomite may occur. Two diagnostic species characterized this community, namely the perennial grasses *Digitaria argyrograpta* and *Cynodon dactylon* (species group C; Table 2).

2.3 *Aristida congesta - Crassula transvaalensis* Grassland

This Grassland community relates with group 4 but relevés also occur in groups 1, 5 and 7 (Morris 1973)(Table 3).

The *Aristida congesta - Crassula transvaalensis* Grassland is strongly associated with disturbed habitats, for example old diamond diggings, abandoned fields or heavily trampled or overgrazed areas. The habitat consists of some near diamond diggings, others on abandoned lands and the rest on heavily trampled and overgrazed vegetation. The soil is normally relatively deep (> 0.5 m).

The vegetation is characterized by species group D (Table 2) which includes the diagnostic inconspicuous forbs *Crassula transvaalensis*, *Plexipus hederaceus*, *Blepharis angusta* and *Guilleminea densa*.

Occasionally, where large sheets of rock are exposed, the soil is very shallow (0.1 - 0.2 m). Here a Variant (2.3.1) of the community is recognised. This Variant is recognised by the absence of species group E. Species groups A, D and F are present

Table 3: A comparison between the Bankenveld Association analysis and Braun-Blanquet Bankenveld classification.

Association analysis

Braun-Blanquet classification		1	2a	2b	2c	2d	3	4	5	6	7	Total
	1.1.1			5								5
	1.1.2			5	3							8
	1.1.3		2	2	2	4	1					11
	1.2.1	4	1	1		4	4					14
	1.2.2	3						1	1			5
	1.2.3	3					2	2				7
	1.2.4						3	2			1	6
	1.3			1	1	1	1	1				5
	2.1	1						2	1	7	4	15
	2.2					1		1	2	1	5	10
	2.3	1						7	5	1	4	18
	Total	12	3	14	6	10	11	16	9	9	14	104

in this Variant (Table 2), indicating a relatively low species diversity.

(ii) Comparison of Association analysis and Braun-Blanquet classifications

The dendrogram produced by the Association analysis of the vegetation (Morris 1973) is given in Figure 3. The allocation of relevés from the Association analysis classification of the plant communities to the Braun-Blanquet analysis is given in Table 3. The general structure of this table broadly confirms the subdivision of the Bankenveld vegetation into two Major Grassland communities. Association analysis groups 1 - 3 mainly represent the *Schizachyrium sanguineum* - *Diheteropogon amplectens* Major Grassland (Community 1, Table 1), while groups 4 - 7 mainly represent the *Cymbopogon plurinodis* - *Eragrostis superba* Major Grassland (Community 2, Table 2). The comparison between the Association analysis and the Braun-Blanquet classification of the Bankenveld shows that 47 of the 104 relevés (45.19 %) were classified in accordance with the Bankenveld Braun-Blanquet classification. This is due to the differences between the monothetic and polythetic divisions of the two approaches.

The results indicate that Association analysis group 2b represents two easily recognisable and ecologically interpretable communities (1.1.1 and 1.1.2), while group 2d vaguely represents community 1.1.3. Groups 2a and 2c cannot be reconciled with any of the communities identified by the Braun-Blanquet procedures. On the other hand, group 1 is represented in three communities (1.2.1, 1.2.2 and 1.2.3), but community 1.2.1 is not recognised by the Association analysis, as the relevés representing this community are scattered amongst five Association analysis groups. Community 1.2.4 is mostly represented by relevés classified in group 3, but this group also contains relevés classified into other communities. Community 1.3 is not represented by any Association analysis group. Communities 2.1 and 2.2 are mainly represented by groups 6 and 7 respectively, but community 2.3 mostly contains relevés from groups 4 and 5.

Conclusion

The data of Morris (1973, 1976) were successfully reclassified by Braun-Blanquet procedures. The plant communities identified and described coincide only partially with the previously described communities derived from the Association Analysis. This new classification can now be reconciled and compared with the other vegetation classifications of the Grassland Biome and can be included in the comprehensive phytosociological and syntaxonomical synthesis of the western Transvaal grassland.

It is interesting to note that these far western Bankenveld communities show very little floristical relationships with the vegetation of the Fa land type on dolomite and chert to the east (Bezuidenhout *et al. submitted*). This is ascribed to the presence of the aeolian sand layer covering the soil in the north-western part of the western Transvaal grasslands.

Acknowledgement

Thea Bezuidenhout is thanked for assistance in the preparation of the figures and tables.

References

ARNOLD, T.H. & DE WET, B.C. 1993. Plants of southern Africa: names and distribution. *Mem. bot. Surv. S. Afr.* 62: 1 - 825.

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanical Garden. *S. Afr. J. Bot.* 54: 525 - 533.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H. *in prep.*(a). Syntaxonomy and synecology of western Transvaal grasslands, South Africa. Ph.D. dissertation, University of Pretoria, Pretoria.

BEZUIDENHOUT, H. *in prep.*(b). The vegetation of the Vaalbos National Park, north-eastern Cape.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 7: 4 - 9.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. 1993. The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa. *S. Afr. J. Bot.* 59: 319 - 331.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted*. The vegetation of the western Transvaal dolomitic and chert grassland, South Africa. (*S. Afr. J. Bot.*)

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *in prep.*(a). Phytosociological Classes of the western Transvaal grassland, South Africa.

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep.*(b) A Braun-Blanquet reclassification of the *Cymbopogon-Themeda* Grassland in the Lichtenburg area, south-western Transvaal.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom - Fochville - Parys area. *S. Afr. J. Bot.* 55: 199 - 206.

COETZEE, B.J. & WERGER, M.J.A. 1975. An association-analysis and the classification of plant communities. *Vegetatio* 30: 201 - 206.

DU PREEZ, P.J. & SCHEEPERS, J.C. 1993. 'n Herklassifisering van die grasveld in die Bethlehem-omgewing. *Bull. Grassland Soc. Sth. Afr.* 4: 37.

HILL, M.O. 1979. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

KOOIJ, M.S., SCHEEPERS, J.C., BREDENKAMP, G.J. & THERON, G.K. 1991. The vegetation of the Kroonstad area, Orange Free State I: vlei and bottomland communities. *S. Afr. J. Bot.* 57: 213 - 219.

KOOIJ, M.S., SCHEEPERS, J.C., BREDENKAMP, G.J. & THERON, G.K. 1992. The vegetation of the Kroonstad area: A description of the grassland communities. *S. Afr. J. Bot.* 58: 155 - 164.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2627 Kroonstad. *Mem. agric. nat. Resour. S. Afr.* 4: 1 - 441.

LAMBERT, J.M. & WILLIAMS, W.T. 1962. Multivariate methods in plant ecology. IV. Nodal analysis. *J. Ecol.* 50: 775 - 802.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. bot. Surv. S. Afr.* 24: 1 - 106.

MABBUTT, J.A. 1968. Review of concepts of land classification. *In* G.A. Stewart (ed.), Land evaluation. Macmillan, Melbourne. pp. 11 - 28.

MORRIS, J.W. 1973. Automatic classification and ecological profiles of South-western Transvaal Highveld Grassland. D.Sc. dissertation, University of Natal, Durban.

MORRIS, J.W. 1976. Automatic classification of the highveld grassland of Lichtenburg, south-western Transvaal. *Bothalia* 12: 267 - 292.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

SCHEEPERS, J.C. 1975. The plant ecology of the Kroonstad and Bethlehem areas of the Highveld agricultural region. D.Sc. dissertation, University of Pretoria, Pretoria.

WESTHOFF, V. & VAN DER MAAREL, E. 1978. The Braun-Blanquet approach. *In* R.H. Whittaker (ed.), Classification of Plant Communities. W. Junk, London. pp. 287 - 399.

WILLIAMS, W.T. & LAMBERT, J.M. 1959. Multivariate methods in plant ecology. I Association-analysis in plant communities. *J. Ecol.* 47: 83 - 101.

WILLIAMS, W.T. & LAMBERT, J.M. 1961. Multivariate methods in plant ecology. III. Inverse association-analysis. *J. Ecol.* 49: 717 - 729.

4.10 **A Braun-Blanquet reclassification of the *Cymbopogon-Themeda* Grassland in the Lichtenburg area, south-western Transvaal.**

* To be *submitted* to: *Bothalia*

A Braun-Blanquet reclassification of the *Cymbopogon-Themeda* Grassland in the Lichtenburg area, south-western Transvaal.

H. Bezuidenhout*, G.J. Bredenkamp, G.K. Theron & J.W. Morris$

Department of Botany, University of Pretoria, Pretoria 0002, Republic of South Africa

$ Pretoria Software Solutions (Pty) Ltd, P.O.Box 912805, Silverton 0127, Republic of South Africa

* To whom correspondence should be addressed: National Parks Board, Scientific Services, P.O. Box 110040, Hadison Park, Kimberley 8306, Republic of South Africa

Abstract

The vegetation data of the *Cymbopogon-Themeda* Grassland in the Lictenburg area was reclassified by a numerical classification technique (TWINSPAN) and refined by applying Braun-Blanquet procedures. The result, which can be integrated with existing phytosociological classifications of the western Transvaal grassland, is two phytosociological tables where 12 communities or variants, variously grouped into larger more comprehensive vegetation units were identified. These plant communities are ecologically interpreted and described.

Uittreksel

Die plantegroeidata van die *Cymbopogon-Themeda*-grasveld in die Lichtenburg omgewing is deur 'n numeriese klassifikasietegniek (TWINSPAN), wat verder deur die Braun-Blanquet prosedure verfyn is, geklassifiseer. In die resultaat, wat met bestaande fitososiologiese klassifikasies van die Wes-Transvaalse grasveld geïntegreer kan word, is twee tabelle waarin 12 plantgemeenskappe of variante geïdentifiseer, wat in 'n verskeidenheid groter meer omvattende plantegroei-eenhede gegroepeer kan word. Die plantgemeenskappe is ekologies geïnterpreteer en beskryf.

Keywords: Association Analysis, Braun-Blanquet procedures, classification, *Cymbopogon-Themeda* Grassland, Western Grassland Biome.

Introduction

Morris (1973, 1976) classified the vegetation of the Lichtenburg area by Association Analysis, a monothetic-divisive classification technique (Lambert & Williams 1962, Williams & Lambert 1959). From the results he recognized 18 final groups, 13 of which contained relevés from the *Cymbopogon-Themeda* Grassland system and six (Association analysis groups 1 - 4a) of which contained relevés from the Bankenveld Grassland system (Figure 2). The reclassification of the Bankenveld Grassland is reported elsewhere (Bezuidenhout *et al. in prep.*(b)). However, due to heterogeneity in certain groups, he discussed only the following nine groups:

4b - Short *Stipagrostis uniplumis* Calcareous Grassland.
5b - *Elionurus muticus* Secondary Grassland
6a - Tall *Stipagrostis uniplumis* Calcareous Grassland
7a - *Cymbopogon plurinodis* Grassland
7b/c - No name
8 - *Elionurus muticus* Primary Grassland
9a - *Acacia karroo* Savanna and Secondary *Cymbopogon plurinodis* Grassland
9b - *Acacia karroo* Open Woodland
9c - Drainage Basin *Acacia karroo* Open Woodland

Although most of these groups were ecologically interpretable some are quite heterogeneous in floristic composition and habitat characteristics and do not represent ecologically interpretable vegetation units.

Vegetation units derived from Association Analysis are often not reconcilable with classes obtained from polythetic or Braun-Blanquet techniques. The inclusion of these units in comprehensive phytosociological studies is therefore difficult or impossible (Kooij *et al.* 1992). Coetzee and Werger (1975) showed that

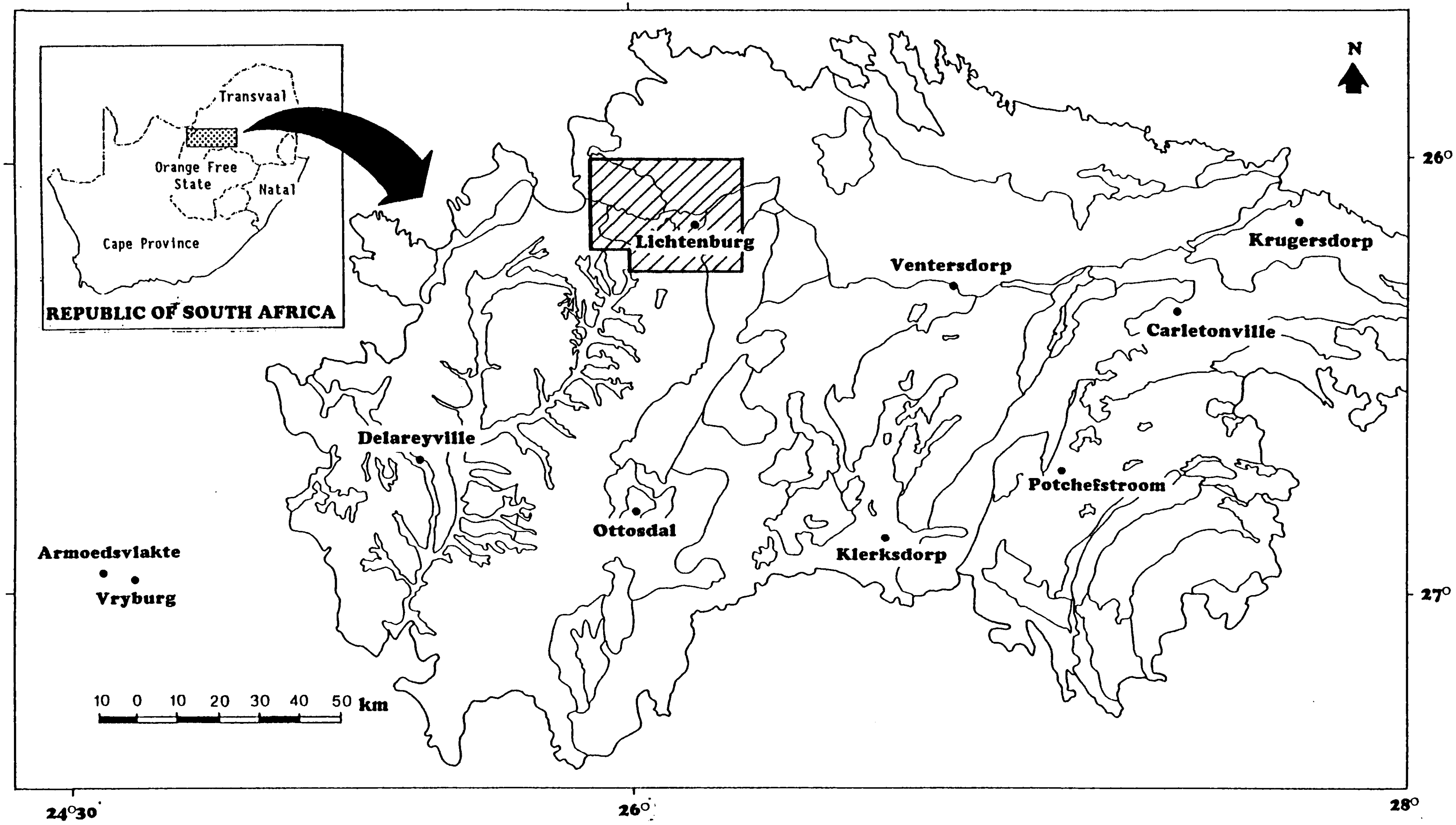


Figure 1: The location of the Morris study area (Morris 1973) in the western Transvaal Grassland (Bezuidenhout in prep.(a)), South Africa.

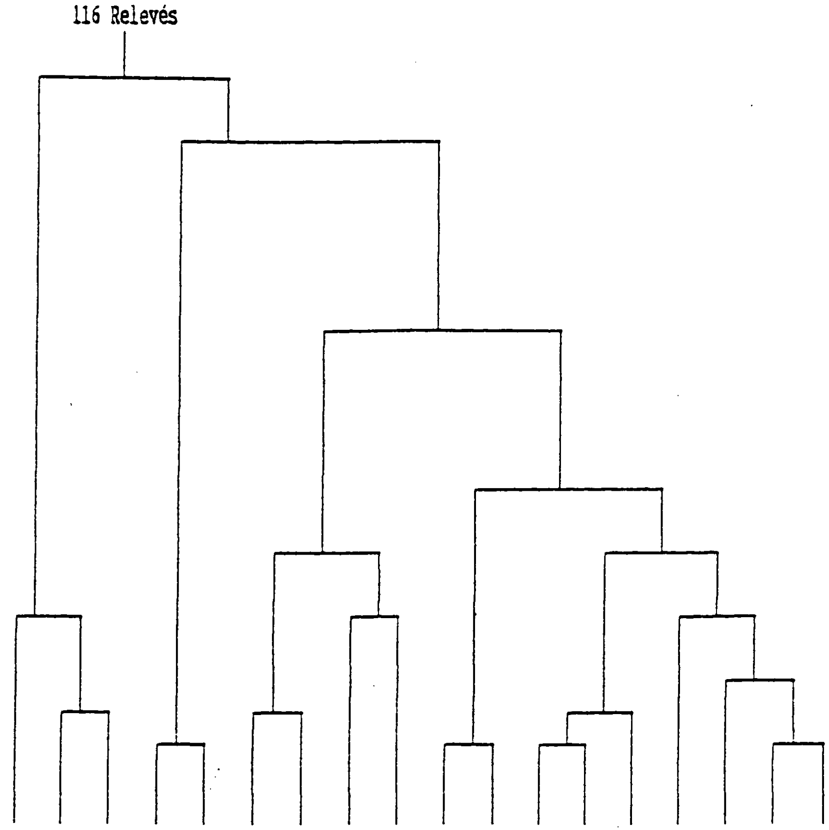
polythetic Braun-Blanquet analyses of floristic data result in ecologically more reliable vegetation classes than those derived from monothetic techniques. Although Morris (1973, 1976) derived ecologically interpretable vegetation types from the results of the Association Analysis, reconciliation of this classification, with the comprehensive phytosociological classification of the western Transvaal (Bezuidenhout *in prep.*(a)) is difficult, due to major differences in the procedures applied. The original data set of Morris (1973) comprised of total floristic composition, with Braun-Blanquet cover-abundance values for all identifiable species in the sample plots.

Thus, in order to include Morris' *Cymbopogon-Themeda* Grassland data in the synthesis of the western Transvaal grassland, the data were reclassified by means of Braun-Blanquet procedures (Westhoff & Van der Maarel 1978). Kooij *et al.* (1991 & 1992) used this procedure successfully to contribute towards a synthesis of the vegetation from the north-western Orange Free State and Bezuidenhout *et al.* (*in prep.*(b)), also applied it successfully to reclassify the Bankenveld vegetation in the Lichtenburg area. In this report the Braun-Blanquet classification of the *Cymbopogon-Themeda* Grassland in the Lichtenburg area is presented.

Study area

The study area of Morris (1973) is bounded by latitudes 26° 00′ and 26° 20′ south and longitudes 25° 54′ and 26° 22′ east. This study area is situated in the north-northwestern part of the area where Bezuidenhout (*in prep.*(a)) is currently preparing a comprehensive synthesis of the vegetation of the western Transvaal (Figure 1). The study area comprises approximately 177 000 ha. A detailed description of the physical environment was given by Morris (1973 & 1976), and is not presented here.

The *Cymbopogon-Themeda* Grassland is generally situated on the flat plains associated with volcanic lava and quartzite of the Ventersdorp Supergroup and Dwyka tillite of the Karoo Sequence to the east of Lichtenburg, with recent surface limestone and aeolian



Association Analysis groups

1	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	7c	8	9a	9b	9c
-	-	-	-	-	2	111	167	112	118	102	120	115	75	100	126	182	172
						114		132	119	104	141	219	108	146	150	185	177
						116		153	124	113	142	220	117	164	156	187	178
						121		155	130		144		129	165	157	188	179
						122		162	210		145		191	169	163	195	180
						123		166			147		202	170	173	197	181
						125		168			148		212	199	174	198	183
						127		171			149			209	175	200	
						128		189			151			213	176	205	
						131		192			152			214	184	206	
						133		193			154				186		
						134		196			158				190		
						135		201			159						
						136		203			160						
						137		204			143						
						138		207									
						139		208									
						140		215									
						161		216									
						194		217									
						211		218									

Bankenveld Grassland (Bezuidenhout *et al.* *in prep.*(b))

Relevés

Figure 2: A dendrogram of the Association analysis of the *Cymbopogon-Themeda* Grassland (Adapted from Morris 1973).

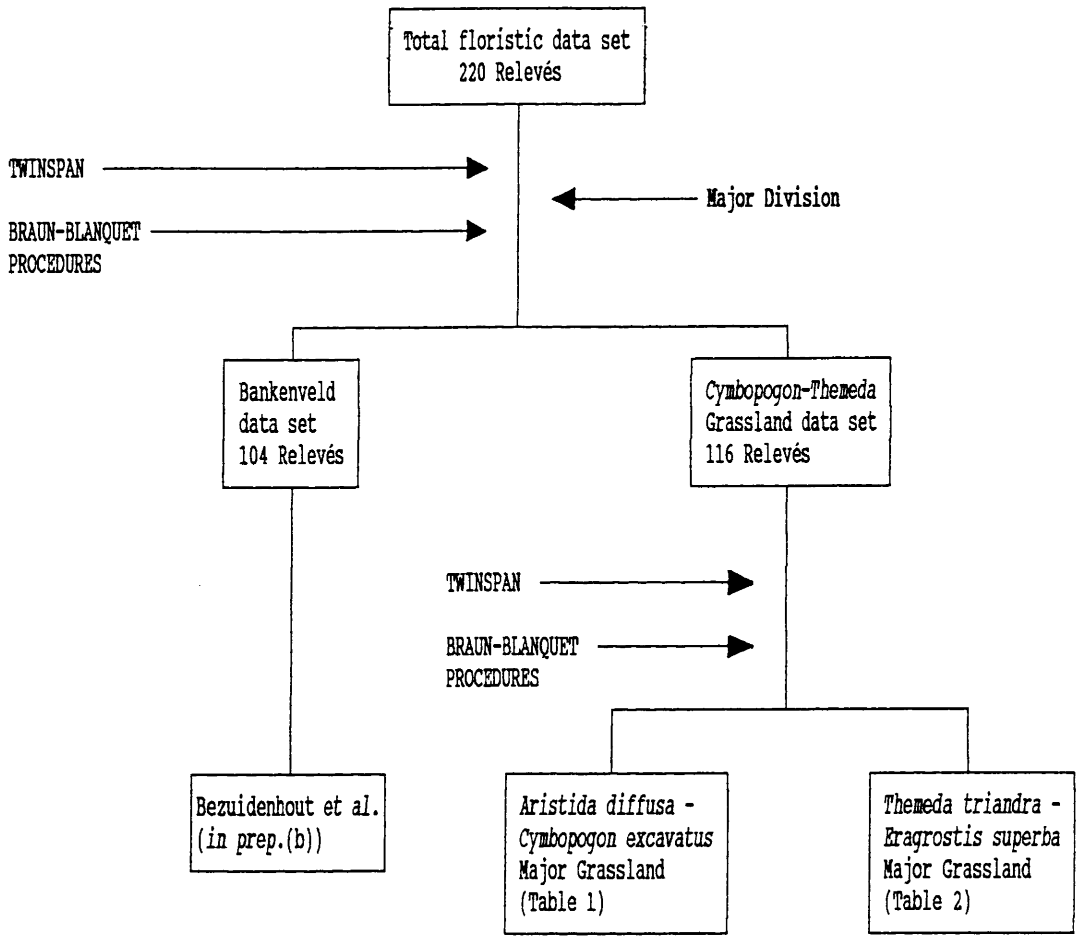


Figure 3: A dendrogram to illustrate the major division of the total floristic data set (Morris 1973) as well as the division of the *Cymbopogon-Themeda* Grassland data set into two Major Grasslands.

sands to the west (Von Backström *et al.* 1953, Morris 1976).

Methods

The stratification of the study area by Morris (1973, 1976) was based on the Bankenveld and *Cymbopogon-Themeda* Grassland Land Systems (Mabbutt 1968) excluding all lands under cultivation, as well as the town of Lichtenburg and the bed of the Harts River. Relevés were compiled in 220 stratified random sample plots. The cover-abundance for each species present in the sample plots according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974) and limited habitat information were noted in each sample plot of 16 m^2. More details are given by Morris (1973, 1976).

In the present study the classification algorithm TWINSPAN (Hill 1979) was used for analysing the total floristic data set (220 relevés), and subsequently Braun-Blanquet procedures were used to refine these results. Amongst others, these procedures were successfully used by Bezuidenhout (1988), Bezuidenhout *et al.* (1988), Behr & Bredenkamp (1988) and Bredenkamp *et al.* (1989).

Taxa names used in the plant community descriptions conform to those of Arnold and De Wet (1993). The description of the soils is according to Macvicar *et al.* (1977).

A tabular comparison was made of the total association analysis classification and the Braun-Blanquet classification (Table 3).

Results

The major division obtained by this procedure separates *Cymbopogon-Themeda* Grassland, consisting of 116 relevés, and Bankenveld, consisting of 104 relevés (Bezuidenhout *et al. in prep.*(b)). The *Cymbopogon-Themeda* Grassland, discussed in this paper, is clearly represented by two Major Grassland communities which are presented in two separate phytosociological tables (Tables 1 & 2) (Figure 3).

Table 1: A phytosociological table of the *Aristida diffusa* - *Cymbopogon excavatus* Major Grassland from the *Cymbopogon-Themeda* Grassland, Lichtenburg area.

Sample plots	138	130	127	111	131	216	161	134	135	137	139	140	167	121	122	123	133	125	118	116	124	114	136	119	128	196	112	189	218	176	100	129	204	132	212	117	203	211	217	208	215	165	168	162	209	210	220	213	169	170	214	2	163	183	219	164	166	171
Communities (in text)	1																																																									
	1.1																									1.2																																
	1.1.1							1.1.2						1.1.3												1.2.1											1.2.2										1.2.3											
Species group A																																																										
Aristida diffusa	2	+				1	+	2	+	1	1	1	1	1		1	+	+		1	+	1	+	+	+	+	+	+	+			+		+		+	+	+	+	+	1	+	+	1					+	+			+				+	+
Cymbopogon excavatus	+			+		+		+		+	+	+											+		+		+	1	+				+	+				1	1		+		+		+	1	1	2	+		2							+
Species group B																																																										
Stipagrostis uniplumis	+	2	+	+	2	+	2	+	1	+	1	2		1	1	2	+	2	+	1	+	+	+	3	1						+				+			+								+						1						
Fingerhuthia africana	+	+	+	+	+		1	+	+	+	+	+		1			1	+	+	+	+			+	+																																	
Convolvulus ocellatus	+	+		+	+			+	+	+	+	+		+			+	+		+			+	+	+									+																								
Corchorus asplenifolius	+	+	+		+		+	+	+	+	+	+		+	+	+	+	+					+	+	+			+							+										+	+												+
Helichrysum cerastioides	+	+					+			+	+	+	+	+					+	+																					+										+							
Species group C																																																										
Diheteropogon amplectens						+	+	+	+	+	+	+	+										+				+										1		+																			
Trachypogon spicatus								+		+		+	+									+						+										+					+															+
Species group D																																																										
Salvia radula					+									+	+		+	+	+	1	+		+								+					+																						
Eragrostis lehmanniana	+		+												+		+	+	+	+		+		+						+						+																	+	2				
Sutera atropurpurea				+				+						+		+	+	+	+																																							
Mariscus capensis															+	+		+			+	+		+										+																								
Berkheya onopordifolia														+		+				+		+		+										+		+							+															
Species group E																																																										
Wahlenbergia undulata		+							+		+	+	+	+		+				+		+														+																			+			
Geigeria burkei								+			+	+		+	+	+	+			+		+	+		+									+					+								+	+			+				+			
Oropetium capense										+		+		+	+		+														+																											
Selago welwitschii	+									+	+			+	+	+	+	+	+	+		+		+						+						+																						
Nidorella hottentotica							+	+				+		+			+		+	+		+			+				+												+										+							
Commelina africana		+						+			+	+		+		+		+			+											+																				+						
Scabiosa columbaria						+	+			+							+					+	+		+		+	+		+																												
Species group F																																																										
Diplachne fusca	+			+		+							+									+							+	+			+	+	+			+				+	+		+	+	+	+		+	+	+			+			
Aristida canescens			+													+					1				+	1	1	+						1	+			1			+				+	+												
Raphionacme hirsuta		+	+							+	+	+									+						+		+			+		+	+			+			+				+		+	+			+							
Helichrysum nudifolium						+														+							+			+											+		+	+					+	+					+			
Cyperus marginatus														+											+						+				+			+			+				+			+					+					
Helichrysum zeyheri													+													+		+					+											+			+		+	+	+				+			
Cynodon dactylon			+		+							+							2				+	+							+		+		+	+		+					+		+		+	+			2				1			
Gnidia capitata								+					+													+		+					+	+			+	+	+	+	+	+	+						+	+	+	+					+	+

Species group G						
Cymbopogon plurinodis	+2 +	+	+ +	11 ++11+++	1 +	1 + +
Plexipus hederaceus	+		+	+++ + +	++	
Chamaecrista biensis				+ + +		+
Thesium transvaalensis	+		+	+ + +		
Species group H						
Eragrostis racemosa		+		+	++++++++	+ +
Senecio venosus	+	+ +		+ +	+++++ ++	+ + +
Ophrestia oblongata		+		+	++ +++ +	+ +
Species group I						
Anthephora pubescens				+	+	+++
Species group J						
Eragrostis superba			+ + +	++ 11+++		+
Felicia muricata		+	1+ + + +	1 + +		
Species group K						
Chamaesyce inaequilatera	+++++ +	+ +	+++++ + ++++	+ + + +	++	+
Thesium magalismontanum	++ +	++ +++	+ + +	+ + + + +		+
Species group L						
Hermannia geniculata	++		+ + ++	+	+ + ++	++++ + +
Nolletia ciliaris	+		+ + + +	+ + +	+++	++ + +++
Solanum supinum	+		+ + + ++++	+ +	+ + +	+++
Digitaria argyrograpta		+	+ +	+ ++	+ +++	+++ ++ +++
Sporobolus africanus	+	+	+ +	+ 1 1+	+	+ +1
Species group M						
Eragrostis gummiflua		+ 1	+ + ++ +	+ 2++ + +	111	+1 1 11+
Aristida congesta	1	+ ++	++ ++ ++ +	+1+2+++++	+++ 1+++++	+++++++ ++++
Pogonarthria squarrosa		+ +	+ + ++	+ ++1	+++ ++ +++	+++1++ +++
Eustachys paspaloides	+ +	++++	+++ ++	1 +1 ++++	+ + +	1 ++1+++++
Species group N						
Elionurus muticus	11+1+1+	+11++1	+ 2+1 +++++1	++11 211 1	1+13122++	22 + 123
Themeda triandra	1+121++	+++++	+++2+1+++2 2	+++1+++++21	++++1+++12	+++ +++ + ++
Barleria macrostegia	+++ +++	++ +++	++ + ++++	++ + + +	++++ +++ +	+++ ++ +++
Heteropogon contortus	+1+ ++	1 + +	+ + + + +	++++ +2+1+	+1+++++1+	11+++1 2+++
Eragrostis curvula	++ + +	+ + +	+ + +	+ + 1 +1++	+ ++++++	+1++1+ + ++
Triraphis andropogonoides	+++++	++ 1	+++++ 1++++	1++ ++1 +++	+ ++ ++++	11 ++ ++++
Vernonia oligocephala	+++ ++	+ ++	+ ++ ++ ++	+++ ++++++	++ +++ ++	++ + + +
Helichrysum caespititium	++++	++++++	+ ++ ++ ++++	++++ + ++ +	+++ ++++++	++++ +++++
Crabbea angustifolia	+ ++++	++++ +	+ +++ + ++++	++ + +++++	+++++ +	+ + +
Anthospermum rigidum	+ +++++	+ +	+++++++	++++++ ++++	+++++	+++++ + ++++
Justicia anagalloides	++	+ ++	+ ++	+ +++ ++++	+++ ++++++	+++++ ++++
Brachiaria serrata	+ ++++1	++++++	+++++ + ++ +	++1+ ++	++++++++	+ ++

Species group N (continued)

Dicoma anomala	++ + ++	++++++	+++++++ ++++	++++	++++++++	+
Setaria sphacelata	+ + +1+	+	+	+ ++++ + +	1+1+1+1+++	11++ ++ 1++
Gazania krebsiana	+ + +	+ + +	+	+ + + +	+ +++	++ ++
Barleria pretoriensis	+ +	++++	+ +	+ +++	+ ++	
Hermannia depressa	+ +		+ + +	+++ ++	+ +	++ + + + +
Hibiscus micranthus	+ +	+ ++	+	++ ++ +	+ +	++ + +++
Blepharis integrifolia	++		+	+ ++	++	++ ++
Dicoma macrocephala	+ +	+	+	+ + +	+	+ + + +
Elephantorrhiza elephantina	+	+ +	+	+	+ ++	++ ++
Senecio coronatus	+	+ +	+	+ + +	+ +	+
Turbina oblongata	+ +	+++	+ +	+ +++	+++	++ ++
Ziziphus zeyheriana	+ +	++	++		+	+
Hermannia tomentosa	+	+	+ + +	+ +		+ +

(i) Braun-Blanquet classification

The vegetation of the *Cymbopogon-Themeda* Grassland on the flat plains in the Lichtenburg area can be described as a *Themeda triandra* - *Eragrostis curvula* Grassland. A feature of the vegetation of the *Cymbopogon-Themeda* Grassland is the actual or potential dominance of *Themeda triandra* (Louw 1951). Low cover of *Themeda triandra* and the associated increase in *Elionurus muticus*, *Cymbopogon plurinodis* and *Aristida congesta* is attributed to the grazing factor (Louw 1951).

The Braun-Blanquet hierarchical classification of these plant communities is:

1 *Aristida diffusa* - *Cymbopogon excavatus* Major Grassland (Table 1)

1.1 *Stipagrostis uniplumis* - *Fingerhuthia africana* Grassland

1.1.1 *Themeda triandra* - *Stipagrostis uniplumis* Variant
1.1.2 *Diheteropogon amplectens* - *Stipagrostis uniplumis* Variant
1.1.3 *Salvia radula* - *Stipagrostis uniplumis* Variant

1.2 *Diplachne fusca* - *Cymbopogon excavatus* Grassland

1.2.1 *Cymbopogon plurinodis* - *Diplachne fusca* Variant

1.2.2 *Eragrostis racemosa* - *Diplachne fusca* Variant

1.2.3 *Anthephora pubescens* - *Diplachne fusca* Variant

2 *Themeda triandra* - *Eragrostis superba* Major Grassland (Table 2)

2.1 *Elionurus muticus* - *Heteropogon contortus* Grassland

2.1.1 *Aristida canescens* - *Elionurus muticus* Grassland

2.1.1.1 *Eragrostis stapfii* - *Aristida canescens* Variant

2.1.1.2 *Cymbopogon plurinodis* - *Aristida canescens* Variant

2.1.2 *Brachiaria serrata* - *Diplachne fusca* Grassland

2.1.2.1 *Anthephora pubescens* - *Diplachne fusca* Variant

2.1.2.2 *Heteropogon contortus* - *Diplachne fusca* Variant

2.2 *Panicum coloratum* - *Sporobolus africanus* Grassland and Woodland

2.2.1 *Sporobolus africanus* - *Cymbopogon plurinodis* Grassland
2.2.2 *Cynodon dactylon* - *Acacia karroo* Woodland

Description of the plant communities

1 *Aristida diffusa* - *Cymbopogon excavatus* Major Grassland (Table 1)

This community relates to groups 4b, 5b and 8 (Morris 1973)(Table 3).

This Major Grassland community mostly occurs on the flat plains, on surface limestone or on lava conglomerate, and quartzite of the Ventersdorp Supergroup.

The diagnostic species are *Aristida diffusa* and *Cymbopogon excavatus* (species group A, Table 1), which are mostly absent in the *Themeda triandra* - *Eragrostis superba* Major Grassland (Community 2, Table 2).

Various communities were identified in this Grassland. Constantly present, prominent species in all these communities are the grasses *Elionurus muticus*, *Themeda triandra*, *Heteropogon contortus*, *Eragrostis curvula*, *Setaria sphacelata*, *Brachiaria serrata* and *Triraphis andropogonoides*. The most abundantly present or conspicuous Grassland associated forbs include *Barleria macrostegia*, *Vernonia oligocephala*, *Dicoma anomala*, *Helichrysum caespititium*, *Crabbea angustifolia*, *Anthospermum rigidum* and *Justicia anagalloides*.

1.1 *Stipagrostis uniplumis* - *Fingerhuthia africana* Grassland

This community relates to group 4b (Morris 1973)(Table 3).

The *Stipagrostis uniplumis* - *Fingerhuthia africana* Grassland occurs on flat plains with shallow (0.025 - > 0.3 m) aeolian sands overlying surface limestone. The calcareous soils are often slightly alkaline with a pH of 7.5.

This community is characterized by species group B (Table 1) and the diagnostic species include the grasses *Stipagrostis uniplumis* and *Fingerhuthia africana* and forbs *Convolvulus ocellatus* var. *ornatus*, *Helichrysum cerastioides* and *Corchorus asplenifolius*.

In all three recognized Variants the most prominent grass species are *Themeda triandra*, *Elionurus muticus* and *Stipagrostis uniplumis* (Table 1).

1.1.1 *Themeda triandra* - *Stipagrostis uniplumis* Variant

Most relevés of this Variant are from group 4b (Morris 1973)(Table 3).

Within the plains of the *Stipagrostis uniplumis* - *Fingerhuthia africana* Grassland, this Variant is restricted to localities with deeper than 0.3 m sandy soils.

No diagnostic species could be identified but the Variant is characterized by the absence of species groups C and D, and the absence of species groups E and M is also a conspicuous feature of this Variant (Table 1).

1.1.2 *Diheteropogon amplectens - Stipagrostis uniplumis* Variant

Most relevés of this Variant are from group 4b (Morris 1973)(Table 3).

This Variant occurs on very shallow (0.025 - 0.1 m) rocky soils with *Diheteropogon amplectens* and *Trachypogon spicatus* (species group C, Table 1) as diagnostic species.

1.1.3 *Salvia radula - Stipagrostis uniplumis* Variant

This Variant relates to groups 4b and 6a (Morris 1973)(Table 3).

This Variant occurs on deeper (0.3 - 0.5 m) and slightly more clayey soils in local depressions in the extensive flat Grassland plains.

The vegetation is characterized by species group D (Table 1) which includes the grass *Eragrostis lehmanniana* and the forbs *Salvia radula*, *Sutera atropurpurea*, *Mariscus capensis* and *Berkheya onopordifolia*. These diagnostic forb species are associated with the periodically flooded bottomland areas (Bredenkamp & Bezuidenhout 1990).

1.2 *Diplachne fusca - Cymbopogon excavatus* Grassland

This Grassland community relates to groups 5b and 8 (Morris 1973)(Table 3).

The *Diplachne fusca - Cymbopogon excavatus* Grassland occurs on the extensive plains or gentle waxing slopes on conglomerate, lava or quartzites of the Ventersdorp Supergroup. The acid (pH = 6.5) soil is deep (> 0.6 - 1.0 m), not calcareous and represents the Avalon form (Soetmelkvlei series).

The community is characterized by species group F (Table 1) and the diagnostic species are the grasses *Diplachne fusca*, *Aristida canescens* and *Cynodon dactylon* and the forbs *Raphionacme hirsuta*, *Helichrysum nudifolium*, *Helichrysum zeyheri*, *Gnidia capitata* and the sedge *Cyperus marginatus*.

The most prominent species are *Elionurus muticus* and *Heteropogon contortus*, with *Cymbopogon excavatus* and *Setaria sphacelata* locally prominent (Table 1).

1.2.1 *Cymbopogon plurinodis* - *Diplachne fusca* Variant

Most relevés of this Variant are from group 5b and to a lesser extent also in group 7c (Morris 1973)(Table 3).

The habitat is mostly the flat plains with acid soils, not calcareous, of the Avalon form (Soetmelksvlei series).

The Variant is characterized by species group G (Table 1), which includes the grass *Cymbopogon plurinodis* and the forbs *Plexipus hederaceus*, *Thesium transvaalensis* and *Chamaecrista biensis* as diagnostic species.

The most prominent grass species are *Elionurus muticus*, *Cymbopogon plurinodis*, *Heteropogon contortus*, *Eustachys paspaloides* and *Themeda triandra*. Pioneer species such as *Cynodon dactylon*, *Aristida congesta* and *Felicia muricata* are conspicuous on locally overgrazed sites.

1.2.2 *Eragrostis racemosa* - *Diplachne fusca* Variant

This Variant mainly relates to group 8 and to a lesser degree also to group 5b (Morris 1973)(Table 3).

Table 2: A phytosociological table of the *Themeda triandra* - *Eragrostis superba* Major Grassland from the *Cymbopogon-Themeda* Grassland, Lichtenburg area.

Sample plots	11111111111111111	11111	111111	1222101	1122111111121	1111111111
	54455544544455461	57451	999800	9000277	9700859077209	8899888778
	17880552946342905	35173	134428	2721053	7456860478609	1258567920
Communities (in text)	2					
	2.1				2.2	
	2.1.1		2.1.2		2.2.1	2.2.2
	.1	.2	.1	.2		
Species group A						
Blepharis integrifolia	+++++++++++ ++	++++	+++++	+ +++	++ ++ ++ ++	++++++ +
Eragrostis superba	+++ + +++1+++ +	++ 1	+++	+ ++ +	++1+ ++ ++	+++1+ +
Lippia scaberrima	+ + + +	+	+ + +	+++ +	+ +++ ++ ++	+++ +++
Species group B						
Heteropogon contortus	++ + 2+++ + +	+	1	++++	+	
Vernonia oligocephala	+ ++ + ++ +	++	++	++++	+	+
Hibiscus micranthus	++ +++	++	++	++	+	
Gnidia capitata	++ + +	+		++ +	+	
Helichrysum caespititium	++ ++ +++ ++ ++ +	+ + +	+ ++ +	+ + + +	+	+
Crabbea angustifolia	++++ +++++++ +++	+ +	+ ++ +	++ ++		
Justicia anagalloides	+ + ++ +++	++	++++ +	++++ +	+ +	+
Gazania krebsiana	+++ +++ + ++ +	+ +	++++++	+++++	++	
Species group C						
Aristida canescens	++1+ +1 1++1+ ++	++++		+	1	
Turbina oblongata	++ + ++ +++	+ + +	++		+ +	
Nidorella hottentotica	+ + ++	+ + +				
Commelina africana	++ + + +	++ +	+	+	+ +	
Corchorus asplenifolius	+ ++ ++ ++	+ ++	+	+		
Crabbea hirsuta	++++++ + ++ ++	+ +		+	+	+
Species group D						
Euphorbia pseudotuberosa	+++ +++ ++ +++		+		+	
Eragrostis stapfii	+ ++ ++ + +		+ +	+	+	
Chamaesyce inaequilatera	++ ++ + + +++	+	++ +	+	+ + +	
Berkheya onopordifolia	+++ + + ++ +	+				
Rhynchosia totta	++ ++ + + +					
Raphionacme hirsuta	++ ++ ++ +	+	++	+		
Blepharis squarrosa	+ + + +			++	+	
Scabiosa columbaria	+ + ++			+		
Cynoglossum hispidum	++ +			+		
Sutera aurantiaca	+ + +				+ +	
Ipomoea obscura	+ ++ +		+			+
Species group E						
Brachiaria serrata	+ +	+ +	++	++ +	+	
Diplachne fusca		+	+++ +	+ +	+ +	
Plexipus hederaceus	+		+++	+ + +		+
Cyperus margaritaceus	+ +	+	++ ++	+ ++	+	
Dicoma anomala	+ + +	+	+ +	++++		

Species group F

Elephantorrhiza elephantina			+ + +			
Anthephora pubescens			1+11 2	+	+ +	+
Hermannia tomentosa		+	+++ +		+ +	
Stipagrostis uniplumis		+	+1 2			

Species group G

Panicum coloratum					+ + + ++ +	+2+
Oropetium capense	+		+		+++	+ + +

Species group H

Acacia karroo		+	+		+	+ + ++++
Protasparagus laricinus					+ +	+ +++++
Guilleminea densa	+ +	+	+		+	+ ++++
Maytenus heterophylla						++ ++ +
Diospyros lycioides					+	++ + +
Antizoma angustifolia			+		+	++ ++
Delosperma mahonii					+	+++
Pollichia campestris		+			+ +	+++

Species group I

Elionurus muticus	+++1++++11+++1+12	1 11+	++	222	+ 11 2 +	
Cymbopogon plurinodis	11+11111 1112212+	2+11+	+ +++	+111	1 +1 21 + +1	1 +
Anthospermum rigidum	+++ ++++++ ++++ +	+ + +	++1+++	+++++ +	+++ ++	+
Triraphis andropogonoides	+++11++ + +1+ ++	1 +	++++ +	+ ++ +1	1 ++ + +	+

Species group J

Sporobolus africanus		+	1+11+2	+	1 +1 +++++1	++21++1++1

Species group K

Themeda triandra	++++1 1++2+++1++1	++1++	++++ +	1+1++1+	+1 ++++12+++	++ 11+
Aristida congesta	+ ++++++++ + +	+++++	+1+++1	1 + 1+1	++++ +++ +1+	+ +++1+ +
Barleria macrostegia	+++++ + +++++++++	+ +++	++ +	++++++	+ ++++ +	++++++
Eragrostis curvula	+++++++++++++ + +	++ +	+21+ +	1+1+ 1	+11+1+1 11 1+	11 1+1
Setaria sphacelata	+12+++++++1++ 1	++++	+++ +	++1++	++ + + + +	+++ ++++
Eustachys paspaloides	+++1+++1 1+++1+	1+++	++1	+ +1	+ +1 ++++	++ + +
Cynodon dactylon	++ + + ++			+ 2 2	+++ + 1+ + +	211+2111++
Eragrostis lehmanniana	+ +++ +++ ++	++++1	+ 11+	1 1	+ 1 2+ 1++	++ 11+ +1
Felicia muricata	++++ ++ +	+ +		++	+ ++ + +++	+++++1+ +
Solanum supinum	+++ + + + +	++ +	+ +	+ +	++ + ++	++ ++++ +
Digitaria argyrograpta	+ + + + +	++ 1	+++	+ ++++	1 1 11+++	+++ +1+
Hibiscus pusillus	++++++++ +++++	+ +			+++ ++ ++	+ ++
Hermannia depressa	++++++++++++++++	++++		++ +	++++ + +	+
Eragrostis gummiflua	+ +	2+	+ 1	1+ +	+ + + + +	+ 1 +
Dicoma macrocephala	+ + +	++	+	+ + +	+	+ +
Selago welwitschii	+ + ++	+		++ +	+	+ ++

The habitat is mostly waxing slopes on slightly shallower soils than on the plains.

The Variant is characterized by species group H (Table 1), which includes the grass *Eragrostis racemosa* and the forbs *Senecio venosus*, *Ophrestia oblongata* as diagnostic species.

The dominant grass species is *Elionurus muticus* with the grasses *Setaria sphacelata*, *Heteropogon contortus*, *Aristida congesta* and *Themeda triandra* also prominently present.

1.2.3 *Anthephora pubescens* - *Diplachne fusca* Variant

This Variant relates to group 8 (Morris 1973)(Table 3).

The soils of this Variant are mostly deep (0.6 - > 1.0 m) and sandy, which distinguish the habitat of this Variant from the other two Variants (1.2.1 and 1.2.2) in the *Diplachne fusca* - *Cymbopogon excavatus* Grassland.

The Variant is characterized by species group I (Table 1), with the grass *Anthephora pubescens* as the only diagnostic species.

The most prominent grass species are *Setaria sphacelata*, *Heteropogon contortus*, *Eragrostis curvula* and *Eustachys paspaloides* (Table 1).

2 *Themeda triandra* - *Eragrostis superba* Major Grassland (Table 2)

This Major community relates to groups 6b, 7a and 9 (9a, 9b and 9c) (Morris 1973)(Table 3).

The *Themeda triandra* - *Eragrostis superba* Major Grassland is restricted to deeper and often clayey soils originated from Dwyka tillite, or may occur in bottomland situations with clayey soils.

The Grassland is characterised by species group A (Table 2), which includes the diagnostic species the grass *Eragrostis superba* and the forbs *Blepharis integrifolia* and *Lippia scaberrima*. These species have a linked occurrence in the *Aristida diffusa* - *Cymbopogon excavatus* Major Grassland (Community 1, Table 1).

Various communities were identified in this Major Grassland. In all these communities the grass species *Themeda triandra*, *Aristida congesta*, *Eragrostis curvula*, *Setaria sphacelata*, *Eustachys paspaloides*, *Eragrostis lehmanniana* and *Digitaria argyrograpta*, are prominently present (Table 2).

The most constantly present Grassland associated forbs include *Barleria macrostegia*, *Felicia muricata*, *Solanum supinum*, *Hibiscus pusillus* and *Hermannia depressa* (Table 2).

2.1 *Elionurus muticus - Heteropogon contortus* Grassland

This Grassland relates to group 6b but more prominently 7a and 7c (Morris 1973)(Table 3).

It is mostly restricted to deep (0. 8 - 1.0 m) alkaline soils of the Avalon form (Soetmelkvlei series) which occurs on the plains on Dwyka tillite.

The Grassland is characterized by species group B (Table 2), with the grass *Heteropogon contortus* and the forbs *Vernonia oligocephala*, *Gnidia capitata*, *Helichrysum caespititium*, *Crabbea angustifolia*, *Hibiscus micranthus*, *Justicia anagalloides* and *Gazania krebsiana* as the diagnostic species.

The dominant grass species are *Elionurus muticus* and *Cymbopogon plurinodis* and other conspicuous grasses include *Triraphis andropogonoides*, *Eragrostis superba*, *Themeda triandra*, *Aristida congesta*, *Eragrostis curvula*, *Setaria sphacelata* and *Eustachys paspaloides* (Table 2).

Two communities, each with two Variants were recognised in this community (Table 2).

2.1.1 *Aristida canescens - Elionurus muticus* Grassland

This Grassland relates well to group 7a (Morris 1973)(Table 3).

It is mostly restricted to deep, (1.0 m) alkaline soils of the Avalon form (Soetmelkvlei series) which occurs on the plains on Dwyka tillite.

The Grassland is characterized by species group C (Table 2), with the grass *Aristida canescens* and the forbs *Turbina oblongata*, *Nidorella hottentotica*, *Commelina africana*, *Corchorus asplenifolius* and *Crabbea hirsuta* as the diagnostic species.

The dominant grass species are *Elionurus muticus* and *Cymbopogon plurinodis* and other conspicuous species include *Triraphis andropogonoides*, *Eragrostis superba*, *Themeda triandra*, *Aristida congesta*, *Eragrostis curvula*, *Setaria sphacelata* and *Eustachys paspaloides* (Table 2).

Two Variants were recognised in this community (Table 2).

2.1.1.1 *Eragrostis stapfii - Aristida canescens* Variant

This Variant relates to group 7a (Morris 1973)(Table 3).

It is the most typical of the *Aristida canescens - Elionurus muticus* Grassland and occur on similar habitat.

It is further characterized by species group D (Table 2), with the grass *Eragrostis stapfii* and the forbs *Raphionacme hirsuta*, *Blepharis squarrosa*, *Scabiosa columbaria*, *Euphorbia pseudotuberosa*, *Chamaesyce inaequilatera*, *Berkheya onopordifolia*, *Rhynchosia totta*, *Cynoglossum hispidum*, *Sutera aurantiaca* and *Ipomoea obscura* as the diagnostic species.

2.1.1.2 *Cymbopogon plurinodis* - *Aristida canescens* Variant

The relevés of this Variant are scattered amongst groups 5b, 6b, 7a and 9a (Morris 1973)(Table 3), and cannot be related to any particular group.

The habitat is similar to that of the *Aristida canescens* - *Elionurus muticus* Grassland.

The Variant is characterized by the absence of species group D (Table 2).

The most prominent species are the grasses *Elionurus muticus* and *Cymbopogon plurinodis* (Table 2).

2.1.2 *Brachiaria serrata* - *Diplachne fusca* Grassland

This Grassland relates to groups 5b and 7c (Morris 1973)(Table 3).

The habitat is heterogeneous, and mostly occur on moderately deep (0.15 - 0.8 m), acid to neutral soils derived from Ventersdorp lava and quartzite of the Ventersdorp Supergroup.

This Grassland is characterized by species group E (Table 2), with the grasses *Diplachne fusca* and *Brachiaria serrata* and the forbs *Plexipus hederaceus, Cyperus margaritaceus* and *Dicoma anomala* as the diagnostic species.

The dominant grass species are *Elionurus muticus* and *Cymbopogon plurinodis, Eragrostis curvula* and *Themeda triandra* (Table 2).

Two Variants were recognised in this community (Table 2).

2.1.2.1 *Anthephora pubescens* - *Diplachne fusca* Variant

The relevés of this Variant are scattered amongst groups 4b, 5b, 6b, 7c and 9a (Morris 1973)(Table 3) and cannot be related to any particular group.

This Variant occurs on localities with deep sandy acid or neutral soils within the *Brachiaria serrata* - *Diplachne fusca* Grassland.

It is characterized by species group F (Table 2). The diagnostic species for this Variant are the grasses *Anthephora pubescens* and *Stipagrostis uniplumis* and the forbs *Hermannia tomentosa* and *Elephantorrhiza elephantina*. All these species are usually restricted to deep sandy soils (Bezuidenhout *in prep*.(b)).

The prominent species are the grasses *Anthephora pubescens* and *Sporobolus africanus* (Table 2).

2.1.2.2 *Heteropogon contortus* - *Diplachne fusca* Variant

This Variant relates mainly to groups 5b and 7c (Morris 1973)(Table 3).

It is the most typical of the *Aristida canescens* - *Elionurus muticus* Grassland and is mostly restricted to moderately deep (0.5 - 0.8 m) acid clayey soils derived from rocks of the Ventersdorp Supergroup.

The Variant is characterized by the absence of species groups F and G (Table 2).

The prominent species are the grasses *Elionurus muticus*, *Themeda triandra* and *Cymbopogon plurinodis* (Table 2).

2.2 *Panicum coloratum* - *Sporobolus africanus* Grassland and Woodland

This vegetation relates well to group 9 (Morris 1973)(Table 3).

The *Panicum coloratum* - *Sporobolus africanus* Grassland and Woodland is mostly restricted to deep (0.3 - 0.9 m), clayey soils which occurs on the plains or bottomland drainage lines of the Ventersdorp quartzite and lava or Dwyka tillite.

The community is characterized by species group G (Table 2), with the grasses *Panicum coloratum* and *Oropetium capense* as diagnostic species.

The dominant grass species are *Sporobolus africanus* and *Themeda triandra* (Table 2).

Two communities were recognised (Table 2).

2.2.1 *Sporobolus africanus - Cymbopogon plurinodis* Grassland

The relevés are scattered amongst groups 9a, 9b and 9c (Morris 1973)(Table 3).

The *Sporobolus africanus - Cymbopogon plurinodis* Grassland is mostly restricted to deep (0.3 - 0.9 m), clayey soils which occurs on the plains of the Ventersdorp quartzite and lava or Dwyka tillite.

Although no diagnostic species occur, this vegetation is recognized by the presence of species group I (Table 2), which include *Elionurus muticus*, *Cymbopogon plurinodis*, *Anthospermum rigidum* and *Triraphis andropogonoides* showing the affinity of this Grassland to the *Elionurus muticus - Heteropogon contortus* Grassland (community 2.1) as well as species group G (diagnostic for *Panicum coloratum - Sporobolus africanus* Grassland and Woodland) and J.

The most prominent grasses are *Panicum coloratum*, *Cymbopogon plurinodis*, *Sporobolus africanus*, *Themeda triandra* and *Eragrostis curvula* as prominent species.

2.2.2 *Cynodon dactylon - Acacia karroo* Woodland

This woodland relates to groups 9b and 9c (Morris 1973)(Table 3).

The *Cynodon dactylon - Acacia karroo* Woodland is mostly restricted to deep (0.3 - 0.9 m), clayey soils which occur in the bottomlands of the Ventersdorp quartzite and lava or Dwyka tillite.

Table 3: A comparison between the *Cymbopogon-Themeda* Grassland total Association analysis and the Braun-Blanquet classification.

Braun-Blanquet classification

Association analysis

	1.1.1	1.1.2	1.1.3	1.2.1	1.2.2	1.2.3	2.1.1.1	2.1.1.2	2.1.2.1	2.1.2.2	2.2.1	2.2.2	Total
4a						1							1
4b	5	5	9		1				1				21
5a		1											1
5b	1			6	6	2	1	1	1	3			21
6a	1		3		1								5
6b								1	1		1		3
7a							13	1		1			15
7b						2	1						3
7c				3					2	2			7
8				1	2	5	1				1		10
9a				1		1	1	2	1	1	4	1	12
9b											5	5	10
9c						1					2	4	7
Total	7	6	12	11	10	12	17	5	6	7	13	10	116

This Woodland is characterized by species group H (Table 2) with the woody species *Acacia karroo*, *Maytenus heterophylla* and *Diospyros lycioides* and the shrubby species *Protasparagus laricinus* and *Pollichia campestris* and the forbs *Guilleminea densa*, *Antizoma angustifolia*, *Delosperma mahonii* and *Solanum supinum* being diagnostic.

The most common tree, *Acacia karroo* can attain a height of up to 6 meters. The most prominent shrubs are *Maytenus heterophylla* and *Diospyros lycioides* and the dominant grasses are *Sporobolus africanus*, *Cynodon dactylon* and *Eragrostis lehmanniana* (Table 2). This Woodland shows similarities with *Acacia karroo* Woodlands described by Bezuidenhout & Bredenkamp (1991) and Bezuidenhout *et al.* (1993) from other parts of the western Transvaal.

(ii) Comparison of Association Analysis and Braun-Blanquet classifications

The dendrogram produced by the Association Analysis of the vegetation is given in Figure 2. The allocation of relevés from the Association Analysis to the Braun-Blanquet plant communities is given in Table 3. The general structure of this table broadly confirms the subdivision of the *Cymbopogon-Themeda* Grassland vegetation into two Major Grassland communities. Association Analysis groups 4b, 5b, 6a, 7b and 8 mainly represent the *Aristida diffusa* - *Cymbopogon excavatus* Major Grassland (Community 1, Table 1), while groups 6b, 7a, 7c, 9a, 9b and 9c mainly represent the *Themeda triandra* - *Eragrostis superba* Major Grassland (Community 2, Table 2). The comparison between the Association Analysis and the Braun-Blanquet classification shows that 55 of the 116 relevés (47.4 %) were classified in accordance with the *Cymbopogon-Themeda* Grassland Braun-Blanquet classification.

The results indicate that Association group 4b, 5a and 6a represents the three easily recognisable and ecologically interpretable communities (1.1.1, 1.1.2 and 1.1.3 of the *Stipagrostis uniplumis* - *Fingerhuthia africana* Grassland). The relevés of group 5b are scattered amongst eight of the communities of the Braun-Blanquet classification, but together with group 8 mainly represent the *Diplachne fusca* - *Cymbopogon excavatus* Grassland (community 1.2) while group 7b and 7c mainly relate to plant communities 1.2.3 and 1.2.1 respectively. Group 7c also relates to community 2.1.2. Group 6b cannot be reconciled with any of the communities identified by the Braun-Blanquet procedure. Group 9 mainly relates to the *Panicum coloratum* - *Sporobolus africanus* Grassland and Woodland (community 2.2).

Conclusion

Using Association Analysis, Morris (1973, 1976) identified 13 groups in the *Cymbopogon-Themeda* Grassland, but related only 9 of these groups to specific plant communities. Some of these communities are quite heterogeneous in floristic composition and habitat, and it is difficult to interpret them ecologically.

In the present study a hierarchical classification is derived from the Braun-Blanquet analysis, revealing 12 communities or variants, variously grouped into larger more comprehensive vegetation units. Due to limited habitat information provided by Morris (1973, 1976) it was difficult and sometimes impossible to relate all the presently described plant communities to specific habitat conditions. In spite of this limitation, it is clear that this classification of the Lichtenburg data should be reconcilable with other Braun-Blanquet type classifications of the Grassland Biome in the western Transvaal.

Acknowledgement

Thea Bezuidenhout is thanked for assistance in the preparation of the figures.

References

ARNOLD, T.H. & DE WET, B.C. 1993. Plants of southern Africa: names and distribution. *Mem. bot. Surv. S. Afr.* 62: 1 - 825.

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanical Garden. *S. Afr. J. Bot.* 54: 525 - 533.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H. *in prep.*(a). Syntaxonomy and synecology of western Transvaal grasslands, South Africa. Ph.D. dissertation, University of Pretoria, Pretoria.

BEZUIDENHOUT, H. *in prep.*(b). The vegetation of the Vaalbos National Park, Northern Cape.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991. The vegetation of the Bc land type in the western Transvaal Grassland, South Africa. *Phytocoenologia* 19: 497 - 518.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 7: 4 - 9.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. 1993. The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa. *S. Afr. J. Bot.* 59: 319 - 331.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *in prep.*(a). Phytosociological Classes of the western Transvaal grassland, South Africa.

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep.*(b). A Braun-Blanquet reclassification of the Bankenveld Grassland in the Lichtenburg area, south-western Transvaal.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. 1990. The vegetation of the Faan Meintjes Nature Reserve, Transvaal. *S. Afr. J. Bot.* 56: 54 - 64.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom - Fochville - Parys area. *S. Afr. J. Bot.* 55: 199 - 206.

COETZEE, B.J. & WERGER, M.J.A. 1975. An association-analysis and the classification of plant communities. *Vegetatio* 30: 201 - 206.

HILL, M.O. 1979. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

KOOIJ, M.S., SCHEEPERS, J.C., BREDENKAMP, G.J. & THERON, G.K. 1991. The vegetation of the Kroonstad area, Orange Free State I: vlei and bottomland communities. *S. Afr. J. Bot.* 57: 213 - 219.

KOOIJ, M.S., SCHEEPERS, J.C., BREDENKAMP, G.J. & THERON, G.K. 1992. The vegetation of the Kroonstad area: A description of the grassland communities. *S. Afr. J. Bot.* 58: 155 - 164.

LAMBERT, J.M. & WILLIAMS, W.T. 1962. Multivariate methods in plant ecology. IV. Nodal analysis. *J. Ecol.* 50: 775 - 802.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. bot. Surv. S. Afr.* 24: 1 - 106.

MABBUTT, J.A. 1968. Review of concepts of land classification. *In* G.A. Stewart (ed.), Land evaluation. Macmillan, Melbourne. pp. 11 - 28.

MACVICAR, C.M., DE VILLIERS, J.M., LOXTON, R.F., VERSTER, E., LAMBRECHTS, J.J.N., MERRYWEATHER, F.R., LE ROUX, J., VAN ROOYEN, T.H. & HARMSE, H.J. VON M. 1977. Soil classification: A binomial system for South Africa. Dept. Agric. Tech. Serv., Pretoria.

MORRIS, J.W. 1973. Automatic classification and ecological profiles of South-western Transvaal Highveld Grassland. Ph.D. dissertation, University of Natal, Durban.

MORRIS, J.W. 1976. Automatic classification of the highveld grassland of Lichtenburg, south-western Transvaal. *Bothalia* 12: 267 - 292.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

VON BACKSTRÖM, J.W., SCHUMANN, F.W., LE ROUX, H.D., KENT, L.E. & DU TOIT, A.L. 1953. The geology of the area around Lichtenburg. *Explanation sheet 54 (Lichtenburg)*. Geological survey, Pretoria.

WESTHOFF, V. & VAN DER MAAREL, E. 1978. The Braun-Blanquet approach. *In* R.H. Whittaker (ed.), Classification of Plant Communities. W. Junk, London. pp. 287 - 399.

WILLIAMS, W.T. & LAMBERT, J.M. 1959. Multivariate methods in plant ecology. I Association-analysis in plant communities. *J. Ecol*. 47: 83 - 101.

4.11 The vegetation of the Boskop Dam Nature Reserve, Potchefstroom.

* To be *submitted* to: *South African Journal of Botany*

THE VEGETATION OF THE BOSKOP DAM NATURE RESERVE, POTCHEFSTROOM

*G.J. Bredenkamp, #H. Bezuidenhout, +H. Joubert and +C. Naude

*Department of Botany, University of Pretoria, 0002 Pretoria, +Department of Plant Sciences, Potchefstroom University for Christain Higher Education, 2520 Potchefstroom and #Scientific Services, National Parks, P.O.Box 110040, Hadison Park, Kimberley 8306, South Africa

Abstract

The Braun-Blanquet technique, complimented by TWINSPAN, was used for a phytosociological classification of the study area. Thirteen plant communities were recognised and described. A hierarchical classification is suggested, but a formal syntaxonomy avoided. Each community is related to its particular environment.

Uittreksel

Die Braun-Blanquet-tegniek, aangevul deur TWINSPAN, is gebruik vir 'n fitososiologiese klassifikasie van die studiegebied. Dertien plantgemeenskappe is geïdentifiseer en beskryf. 'n Hiërargiese klassifikasie word voorgestel, maar formele sintaksonomie word vermy. Elke plantgemeenskap word met eie besondere omgewing in verband gebring.

Keywords: Conservation area, dolomite, plant communities, vegetation classification, western Transvaal grassland.

Introduction

Vegetation and general ecological surveys of conservation areas are considered to have high priority (Nakor 1979), as a sound knowledge of the ecology of these areas is an essential prerequisite for the establishment of efficient wildlife management programmes (Bredenkamp & Theron 1978, 1990 & 1991). Other studies in conservation areas of the western Transvaal grasslands include the Abe Bailey Reserve near Carletonville (Van Wyk & Bredenkamp 1986) and the Faan Meintjes Nature Reserve near

Klerksdorp (Bredenkamp & Bezuidenhout 1990).

For this reason, and also as part of a survey programme for conservation areas in South Africa, a study of the vegetation of the Boskop Dam Nature Reserve was undertaken. This study also fits in with a comprehensive phytosociological research programme under the Grassland Biome Project (Mentis & Huntley 1982, Scheepers 1987), with the ultimate aim of a phytosociological and syntaxonomical synthesis of the vegetation of the western Transvaal grasslands (Bezuidenhout *et al. in prep.*) as well as the Grassland Biome in South Africa (Bredenkamp *et al.* 1989, Bezuidenhout *et al.* 1993, Fuls *et al.* 1993). In this regard a study of the Boskop Dam Nature Reserve may specifically complement a regional study of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area (Bezuidenhout & Bredenkamp 1990).

The aim of this study is therefore to classify, describe, interpret and determine the location of the vegetation units of the Reserve.

The study area

The Boskop Dam Nature Reserve is located approximately 20 km north of Potchefstroom (Figure 1). The Reserve covers 3 160 hectares, of which the dam extends over 374 hectares. The dam was constructed in the Mooi River, which originates from two perennial springs from the dolomite water reservoir towards the north (Du Toit 1954). The entire area is situated on dolomite of the Malmani Subgroup (Chuniespoort Group, Transvaal Sequence) (SACS 1980), representing the Klipveld (Louw 1951) of the western variation of the Bankenveld (Acocks 1988). Natural vegetation is mostly confined to very shallow, rocky and non-arable soils. The grazing is considered a sour, wiry grassland, virtually ungrazable in winter (Acocks 1988), and is not dominated by a single or few species, but represents a mosaic of many co-dominants (Louw 1951).

According to the Köppen classification the area has a Bs-climate, that is a cool dry steppe with summer rains. The rainfall is erratic but the average annual rainfall measured on

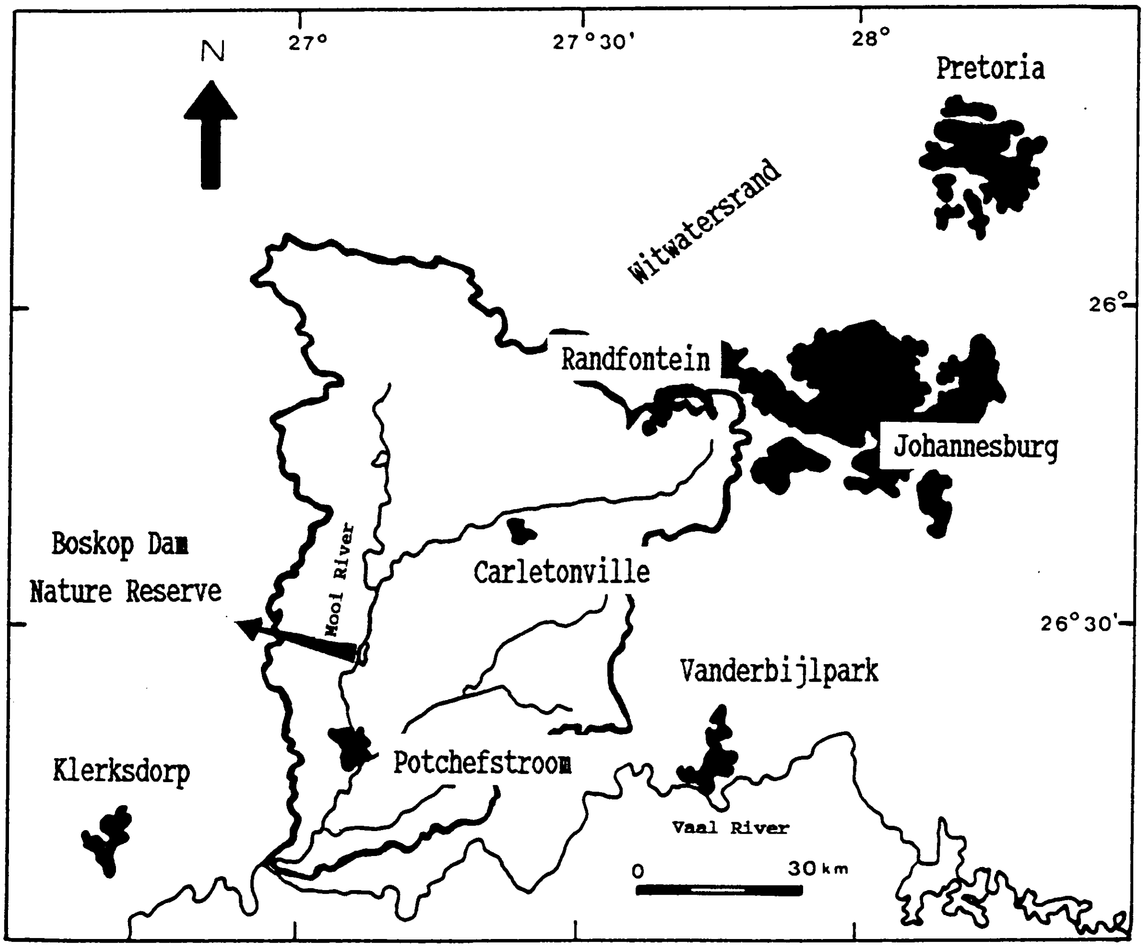


Figure 1: The location of the Boskop Dam Nature Reserve in the Mooi River Catchment Area (▬).

the Reserve for the period 1980-1986 is 621 mm. The long term average rainfall for Potchefstroom over 81 years is 625 mm (Bezuidenhout & Bredenkamp 1990). The mean monthly maximum temperatures are high exceeding 32°C during October to January while mean monthly minimum temperatures are below -1°C during May to September. The winters are severely frosty (Weather Bureau 1986).

Methods

Relevés were compiled in 80 stratified random, 25m² sample plots. Stratification was done on 1 : 10 000 scale aerial orthophotographs, on basis of relatively homogeneous physiographic and physiognomic units. Sample plots were divided among these units *pro-rata* on an area size basis. In each sample plot a list of all species identifiable at the time of the survey (January/February) were made, and the cover-abundance of each species noted using the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). Taxa names conform to those of Arnold & De Wet (1993). Additionally the height (m) and canopy cover (%) of each stratum was noted. Habitat data recorded include topographical position and rockiness of the soil surface.

Two way species indicator analysis (TWINSPAN, Hill 1979) was used to classify the relevés, and the result was refined by application of Braun-Blanquet procedures. This approach proved to produce ecologically reliable results in many phytosociological studies in the Grassland Biome (Bredenkamp *et al.* 1989, Eckhardt *et al.* 1993, Fuls *et al.* 1993).

The results of the final classification are presented in a phytosociological table (Table 1). No attempt was made to formally fix syntaxa names as this is normally avoided in detailed local studies (Coetzee 1983).

Table 1: A phytosociological table of the vegetation of the Boskop Dam Nature Reserve.

Plant communities (in text)	1.1.1	1.1.2	1.2.1	1.2.2	1.3	2.1	2.2	2.3	3.1	3.2	4	5	6
Sample plots	0000000	00000000000000000000	000000000	00000000	00000000	000000	00	000	000000	00000	00	000	0
	0372131	15014114620706487770	111223222	22444473	30537072	674001	56	455	566367	55455	66	333	6
	8680954	09610786762450202371	235890123	45835758	14899717	964396	72	125	668750	03914	41	243	3
Species group A													
Trachypogon spicatus	+A++A31	+++A11B+++B A +BA +	1 + +	+	+								
Diheteropogon amplectens	++ +1+	A+1+++1+++A1++1++++		+ +	+ +								
Eragrostis racemosa	++ + ++	1 ++1+++++1+1+++++++	+	1	+ +				+ +		+		
Triumfetta sonderi	++1+++	+ ++1A++++A+ ++1+A+	++ +	+	+ +	+				+			
Species group B													
Andropogon schirensis	+	B +++++B+++BB+1++BA+		1	A +				+				
Schizachyrium sanguineum	+ +	++++++1+++ +A+++ ++	+		+						+		
Melinis nerviglume		1+++ ++ + + ++ ++++			+	+			+				
Sphenostylis angustifolia	+	+ +1 +++ +++ + 1+		+									
Bulbostylis burchellii		++ +++ ++++1 +		+									
Trichoneura grandiglumis		+ + ++++ + ++++		+ +	+				+++	+			
Senecio venosus	+ +	+ + + + + + ++ + +	+ +		++								
Ursinia nana	+ +	R +++ + + + + +			+	+			+	+			+
Lotononis calycina		+ ++ +++ + +						+		+			
Kohautia amatymbica		+ +++ + ++	+		+ +				+ +				
Tristachya rehmannii		++ + +A1 +									+		
Tephrosia elongata		+ ++ + + +			+								
Dicoma anomala	+	+ + ++		+	+			+	+				
Species group C													
Eragrostis superba	+	+ +	+1++ ++++	++++++ +	+ +	++			+			++	
Eragrostis gummiflua		+ + +	+ A A+11	+++++	1 +	+		+	+	++		+	
Turbina oblongata	+ ++	+ + +	+ +++++++	+++ +++	++				+	+		+	
Microchloa caffra		+ +	++ +++++	+++++		+							
Sporobolus discosporus		+	+ +++	++ +									
Species group D													
Salvia radula			+1+++1	+	+ ++			+	+	++		++	
Hypoxis hemerocalidea	+ +	++	++ + +++		+		+						
Boophane disticha	+ +	+	++ ++	+	+ +						+		
Species group E													
Anthephora pubescens			+ ++	+++++111				+				+	

Species	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
Species group F													
Brachiaria serrata	++++	+ +++ ++++++++++1	+++	++ +	+						+		
Justicia anagalloides	+++ +	++++ + +++ ++ + + + +	+ + ++	+ + +	+	+ +				+			
Chamaecrista biensis	+ +	++++ + +++++++ +	+ +	+ + ++	+ + +				+				
Acalypha angustata	+ +++	++ + + + +++	+ +++	+ +++	+ +					+ +			
Elephantorrhiza elephantina	++	+ ++ + +	++ +++ ++	++ ++	+						+		
Species group G													
Triraphis andropogonoides	+ +1B+1	++++++++A+ ++++1+	+++ + +++	+ ++++A	+ + +1	++ +		++					
Eustachys paspaloides	AA+++	+ A++ + +	++1+++A1A	+1 +++	+ 1+ 1	+	+	+					
Barleria macrostegia	+++ +	+ +1++ ++++ ++	++++ +	+++	+++++			+	+ +				
Vernonia oligocephala	++ +++	+ ++ ++ +	+ +++++	+++ +	+++ +++			+	+	++			
Tylosema esculentum	+++++	++ ++++ + ++	+++ 1+++	1+++++	++ + +			+					
Plexipus hederaceus	+++++	+ ++ +++++++++++++	+ + +	++ +	+++	++			+		+		
Species group H													
Rhus pyroides	+ +			+		+A+1++	++	B				++	
Protasparagus suaveolens		+				+ ++1	++	+ +	+	+			
Grewia flava		+ +	++	+		+ 111A	+	+			+		
Bidens bipinnata						+ +	++						
Felicia muricata						+		+		+			
Opuntia ficus-indica						+	+						
Species group I													
Celtis africana						++1AA+							
Diospyros lycioides	4		3	A		AB+A							+
Sporobolus fimbriatus	+			++		+++		++					
Tragus berteronianus				+		+ + +	+						
Pavonia burchellii						+ + +	+						
Protasparagus africanus						+1+							
Maytenus heterophylla						+ +							
Tribulus terrestris						+ +			+				
Species group J													
Acacia karroo			+				++	B	1		+		
Talinum caffrum	+				+		++						
Acacia caffra							A						+
Species group K													
Hyparrhenia hirta	+	+ +						4	++1 +A	34444			
Helichrysum rugulosum	+	+ + +		+	+++				+ +	+++++	+		
Conyza podocephala									++ ++	+++			
Hermannia depressa		+ + +			+				+ +	++	+		
Tephrosia semiglabra	+		+		+				+ +	++			
Species group L													
Monsonia angustifolia		+			+				+++ +				
Verbena bonariensis		+							+++	+			
Corchorus asplenifolius		+		+	+				+ ++		+		
Walafrida densoflora		+ +			+	+			+ + +		+		

Species group M													
Protasparagus laricinus	+ +	+			+ +	+++1++	A+	+1	1++1++	+		+B+	
Cynodon dactylon		+ +	+		+	+++++	+	1++	1+B+++	++	+		
Schkuhria pinnata	+ +	+ +			+	+ +	++	+ +	+1+	+			
Species group N													
Eragrostis plana	+		1+	+				+	+	++ ++			
Oenothera rosea										+++			
Setaria incrassata										+ A			
Cirsium vulgare										+ +			
Paspalum dilatatum						+			+	++			
Eucalyptus grandis										+ +			
Lactuca serriola					+					+ +	+		
Chaetacanthus burchellii										++	+		
Andropogon eucomus										++			
Species group O													
Zinnia peruviana							+		+		+A		
Haemanthus hirsutus							+				++		
Eleusine coriaca									+		+		
Species group P													
Artemisia afra					+							AA1	
Senecio isatideus		+ +										+3	
Cyperus longus		+						+		+		A	
Species group Q													
Combretum molle													+
Pavetta zeyheri													+
Setaria lindenbergiana													+
Species group R													
Themeda triandra	+1 +++	+++1+ ++A++ +1+1++B	3B3+1A1+	++A11++	1A+AB4B+	+ +	++	+	++++	+	+	++	
Setaria sphacelata	1+++1++	+ 11+++1+1+1++A++11+	++A1++ABB	B+12+	+3++ +1	++	++		+	+	++	+	+
Aristida congesta	++ +	++++ +++++ ++++ +++	++ ++1+++	+A ++++	+++++ +	++ 1++		++	+11+1		1	++	
Cymbopogon plurinodis	++ +	+ 1 1 1 + ++	1+B++ ++A	11+++++	1 ++ +	+ +		+	+	+	+	31	+
Heteropogon contortus	+ +	++ +++++ ++ + +	+ +++	1++1AA+	+ +++ +	+		++	+ B		+	+	
Cucumis hirsutus	+++ +R	+ +++ + ++++ ++ +	+++ ++	++ ++	++ +			+	+++++		+		
Melinis repens	++++++	+ + +++ +++ ++ +++	+ + +	++	+ + +	++A+			+++		A		+
Pollichia campestris	+	+ +++ + ++ +++++	+ ++	++	+	++++++	+	+	+ +++		+		
Aristida canescens	+ ++	+ ++ + +++ 1	+ ++	+ +++A	+++ +		+		+++ +		+	+	
Pogonarthria squarrosa		+ + + ++ + +	+++	+ ++ +++	+ +	++			+	+			
Indigofera comosa	+++	+ + + + +	++ ++	+	++ +				++		+		
Ziziphus zeyheriana	+ ++	+ ++	A+		+ ++ A+	+ ++	++	+	+			+	
Lightfootia denticulata		+ + +	+++ +	+	+ ++	+ +	+	++	+++				
Lippia scaberrima	+ +	R +	+ +	+ +	B +	+	+	+	+ +	+	+	+	
Solanum capensis	+++	+ +	+ +	+ +	++	+		+ +	+ +		+		
Leucas capensis	++	+ + + + +	+	+	+	+			+ +			+	
Eragrostis lehmanniana		+ +	+	+ +	+ + +	+ + +		++	+ +				
Crabbea angustifolia	+	++ + ++		+	++ +				+	+			

Species group R (continued)

Stoebe vulgaris	+	+ +	+ ++	1+	1				+ +	+			
Teucrium trifidum	+	+	+ +	+	++	+			+	+			
Sida dregei		+ +	+ ++	+		+	+	+	+ +				

Species group S

Eragrostis curvula	+++ +	+++ +++++ +++++1+	+++++ ++	+1++ 1+	+ +11+11	++ ++	1+	++	B+A+++	++1	A+	+	+
Ledebouria marginata	++++++	++++++ +1+++++ +++++	+++++++ +	+++++++	+ ++++ +	+ ++	+	+ +	+	++	+		
Cymbopogon excavatus	+++ A	+B+ +++++++++1 1++1	+ +++	+ + ++	++ + 1	++			ABA	1+	1	+	
Digitaria eriantha	+ +	+ ++ + +	++1 B+A	1+ +	1A ++ A	+ ++ +	++	+		1+		+	
Anthospermum rigidum		+ + ++ + + ++ +	+		+++ +	+		+	+	++			
Sporobolus africanus			+ ++	+A	+	+ +			+ +	++ 1		+	
Aristida diffusa	++	++ + + +	+++	+B	1 +						+		
Polygala hottentotta	+ +++	++ +	+ ++ +	+	+ +		+						
Raphionacme hirsuta	+ ++	+ + +	++	+	+					+			
Cyanotis speciosa		++ + +++ +	+++		+ +								
Eragrostis chloromelas	+	+ + A	+	+	+1+	+				++		+	
Crabbea hirsuta		++ + + +	+		+								
Rhynchosia nervosa		+ + +		+	+				++				
Ledebouria ovatifolia		+ +		++	+ +			+					
Aristida stipitata		+ +		+ + +								+	
Thesium utile		+ + + +		+	+								
Rhynchosia venulosa			++	+	+		+			+			
Crassula lanceolata	+	+	+ +	++									
Helichrysum nudifolium	+			+ +					+	+			
Hypoxis rigidula		+		++	+ +								
Berkheya radula			+	++								++	
Sporobolus stapfianus		+	++	++									
Pygmaeothamnus zeyheri		+ ++ +			+								
Ipomoea crassipes		+ + +						+	+				
Rhus magalismontana		+ +					+				+		+
Eragrostis obtusa						+ +					+	++	
Becium grandiflorum		+ +		+						+			
Cynodon hirsutus						1		A	+				

Results

The analyses resulted in the recognition of 12 individual plant communities. The hierarchical classification is as follows:

1 *Triraphis andropogonoides* Grassland Community

- 1.1 *Triraphis andropogonoides-Trachypogon spicatus* Sub-community
  - 1.1.1 *Eustachys paspaloides* Variant
  - 1.1.2 *Schizachyrium sanguineum* Variant
- 1.2 *Triraphis andropogonoides-Eragrostis superba* Sub-community
  - 1.2.1 *Salvia radula* Variant
  - 1.2.2 *Anthephora pubescens* Variant
- 1.3 *Triraphis andropogonoides-Themeda triandra* Sub-community

2 *Rhus pyroides* Woodland Community

- 2.1 *Rhus pyroides-Celtis africana* Bush Community
- 2.2 *Rhus pyroides-Acacia karroo* Bush Community
- 2.3 *Rhus pyroides-Cynodon dactylon* Sub-community

3 *Hyparrhenia hirta* Wetland Community

- 3.1 *Hyparrhenia hirta-Verbena bonariensis* Variant
- 3.2 *Hyparrhenia hirta-Eragrostis plana* Variant

4 *Haemanthus hirsutus-Zinnia peruviana* Community

5 *Senecio isatideus-Artemisia afra* Wetland Community

6 *Setaria lindenbergiana-Combretum molle* Community

1 *Triraphis andropogonoides* Grassland Community

This Community represents the general grassland occurring on the dolomite in the region. This grassland also covers the largest part of the Reserve. It occurs on shallow soils on the upland plains, with numerous dolomite rocky outcrops and rock sheets, typical of the dolomitic area.

This grassland is characterised by species group G (Table 1). The diagnostic species are the grass species *Triraphis andropogonoides* and *Eustachys paspaloides*, while non-grassy herbaceous species, such as *Plexipus hederaceus*, *Tylosema esculentum*, *Barleria macrostegia* and *Vernonia oligocephala* are also diagnostic. Although the species of species group F (*Brachiaria serrata*, *Justicia anagalloides*, *Chamaecrista biensis*, *Acalypha angustata* and *Elephantorrhiza elephantina*) occur only sporadically in one of the communities classified under the Community (the *Triraphis andropogonoides*-*Themeda triandra* Sub-community (1.3)), these species may also be considered as diagnostic for the Community. All these species were also identified as diagnostic of the widespread *Justicia anagalloides*-*Elionurus muticus* grassveld described from the Abe Bailey Nature Reserve (Van Wyk & Bredenkamp 1986), indicating that they could be considered as diagnostic for the general grassland type of the dolomite region in the western Transvaal.

Typical of the grasslands of the dolomite, no single grass species attains dominance (Louw 1951). However, *Triraphis andropogonoides*, *Themeda triandra*, *Setaria sphacelata*, *Aristida congesta* and *Eragrostis curvula* may be locally prominent.

A variety of forb species indicative of degradation occur in places throughout this grassland. Some of the most constantly present include *Cucumis hirsuta*, *Pollichia campestris*, *Lightfootia denticulata*, *Lippia scaberrima* and *Anthospermum rigidum*.

Due to floristic variation, and also heterogeneity in habitat, this Community is divided into various communities and sub-communities. This was also found in the case of the *Justicia anagalloides*-*Elionurus muticus* grassveld described from the Abe

Bailey Nature Reserve (Van Wyk & Bredenkamp 1986) as well as in the *Justicia anagalloides-Elionurus muticus* Grassland Community from the Potchefstroom-Ventersdorp-Randfontein area (Bezuidenhout & Bredenkamp 1990). This Community relates well with the *Trachypogono spicati-Diheteropogonion amplectentis* which was described by Bezuidenhout *et al.* (*submitted*) in the dolomitic and chert grassland in the western Transvaal.

1.1 *Triraphis andropogonoides-Trachypogon spicatus* Sub-community

This Sub-community is restricted to the relatively dry, well drained upland crests or high altitude plains in the undulating landscape. Dolomite rock sheets and gravel cover 10 - 30 % of the soil surface.

This Sub-community is characterised by species group A (Table 1), and the diagnostic species are the prominent grass species *Trachypogon spicatus* and *Diheteropogon amplectens*, as well as *Eragrostis racemosa* and the dwarf shrub *Triumfetta sonderi*. This Sub-community also contains a number of the diagnostic species of the *Justicia anagalloides-Elionurus muticus* grassveld from the Abe Bailey Nature Reserve (Van Wyk & Bredenkamp 1986), and from comparing the floristic data it seems as if the *Triraphis andropogonoides-Trachypogon spicatus* Sub-community represents the typical form of the *Justicia anagalloides-Elionurus muticus* grassveld.

A similar community, the *Schizachyrium sanguineum - Andropogon schirensis* Grassland is described by Bezuidenhout & Bredenkamp (1990) in the Potchefstroom-Ventersdorp-Randfontein area. This Sub-community also relates to the *Loudetio simplicis-Diheteropogonetum amplectentis* from the dolomitic and chert grasslands in the western Transvaal (Bezuidenhout *et al.* *submitted*).

1.1.1 *Eustachys paspaloides* Variant

This Variant is characterised by the absence of species group B (Table 1), and mostly occurs along the north-western boundary, or on local patches where large dolomite rocks cover up to 20 - 30 % of the soil surface.

1.1.2 *Schizachyrium sanguineum* Variant

This Variant is situated in the eastern part of the Reserve, on very shallow (0 - 300 mm) gravelly soil, but with only about 10 % rock cover of the soil surface.

The *Schizachyrium sanguineum* Variant is characterised by species group B (Table 1), which includes the prominent diagnostic grass species *Andropogon schirensis, Schizachyrium sanguineum, Melinis nerviglume, Trichoneura grandiglumis* and *Tristachya rehmannii* and also the forbs *Sphenostylis angustifolia, Senecio venosus, Bulbostylis burchellii, Ursinia nana, Kohautia amatymbica, Lotononis calycina, Tephrosia elongata* and *Dicoma anomala*.

The presence of these diagnostic species and the similarities in habitat (shallow soil and low rock cover) suggests that this Variant is related to the *Setaria sphacelata* Variant of the *Justicia anagalloides-Elionurus muticus-Panicum natalense* grassveld described from the Abe Bailey Nature Reserve (Van Wyk & Bredenkamp 1986).

1.2 *Triraphis andropogonoides-Eragrostis superba* Community

In general this Community is situated on less drained areas in relatively low-lying bottomland situations in the undulating landscape. Wet rock sheets cover large areas (25 - 50 %) and the soil is restricted and extremely shallow (0 - 50 mm).

The Community is characterised by species group C (Table 1), and the diagnostic species include the grasses *Eragrostis superba* and *Eragrostis gummiflua*, the latter being indicative of the waterlogged conditions that may occur from time to time. The diagnostic small grass species *Microchloa caffra* and *Sporobolus discosporus* indicate the extremely shallow soils covering the extensive rock sheets.

In the Potchefstroom-Ventersdorp-Randfontein area a similar community (*Eustachys paspaloides-Setaria flabellata* Grassland) was mentioned by Bezuidenhout & Bredenkamp (1990). The *Triraphis andropogonoides-Eragrostis superba* Community relates to the sub-association of the *Cymbopogono plurinodis-Eragrostidetum* *gummifluae* as was described by Bezuidenhout *et al*. (*submitted*).

1.2.1 *Salvia radula* Variant

This Variant is typically found locally on flat plains with disturbed soils. Rock sheets are not so prominent here.

The shrubby and prominent *Salvia radula* and the conspicuous geophytes *Boophane disticha* and *Hypoxis hemerocalidea* are diagnostic species.

The high cover-abundance of *Setaria sphacelata* is a further conspicuous feature of this Variant.

1.2.2 *Anthephora pubescens* Variant

The *Anthephora pubescens* Variant occurs locally where a sandy deposit overlies the rock sheets. These sandy areas are mostly situated on the south-western boundary of the Reserve.

The only diagnostic species is the grass *Anthephora pubescens* (species group E, Table 1), which is often associated with sandy areas in the western Transvaal (Bezuidenhout *et al*. *in prep*.). *Heteropogon contortus*, *Pogonarthria squarrosa* and *Aristida canescens* are prominent species in this vegetation unit.

1.3 *Triraphis andropogonoides-Themeda triandra* Sub-community

This Community is situated at the relatively lower areas, especially on the lower slopes in the undulating landscape, in the southern parts of the Reserve.

No diagnostic species were identified, and the Community is differentiated from the other Sub-communities or Variants of the *Triraphis andropogonoides* Grassland Community by the absence of species group F (Table 1).

This Community shows some similarities to the *Cymbopogon plurinodis* Variant of low lying areas on the Abe Bailey Nature Reserve (Van Wyk & Bredenkamp 1986), which also lacks diagnostic species and shows a fairly similar species composition.

2 *Rhus pyroides* Woodland Community

This Woodland is restricted to sink holes, rocky hills or drainage lines, all scattered over the area of the Reserve. These areas are mostly disturbed as was also mentioned by Bezuidenhout & Bredenkamp (1990).

This Woodland Community is characterised by species group H (Table 1), and the diagnostic and dominant species are the shrubby small tree *Rhus pyroides,* as well as the shrubs *Grewia flava* and *Protasparagus suaveolens*, and the pioneer species *Bidens bipinnata, Felicia muricata* and the exotic *Opuntia ficus-indica*.

Further characteristics of this Community are the decrease in constancy and abundance of the general and widespread species of species groups R and S (Table 1), and the presence of many other pioneer species, indicating the advanced state of disturbance or degradation. The most prominent of these species are *Protasparagus laricinus, Cynodon dactylon*, and *Schkuhria pinnata* (species group M, Table 1), *Aristida congesta, Melinis repens, Ziziphus zeyheriana* and *Lightfootia denticulata* (species group R, Table 1).

Three different communities were recognised in this Woodland.

Van Wyk & Bredenkamp (1986) also recognised woodland communities on the Abe Bailey Nature Reserve, which are obviously related to this Woodland. A similar *Rhus pyroides* Shrub and Woodland also with three communities, were described by Bezuidenhout & Bredenkamp (1990). This community is related to *Grewio flavae-Rhoion pyroidis* of the dolomitic and chert grassland in the western Transvaal as well (Bezuidenhout *et al. submitted*).

2.1 *Rhus pyroides-Celtis africana* Bush Community

This Bush Community is strongly associated with rocky dolomite areas in and around sink holes and also occurs on the limited rocky dolomite ridges on the Reserve. Woody communities are generally rare on the Reserve, and consequently the game often utilise the shade of the trees, with the result that the herbaceous layer is heavily trampled and disturbed.

This Community is characterised by species group I (Table 1). The diagnostic species include the small trees or shrubs *Celtis africana, Diospyros lycioides* and *Maytenus heterophylla,* the grass species *Sporobolus fimbriatus* and *Tragus berteronianus* and also the forbs *Pavonia burchellii, Tribulus terrestris* and the strangling *Protasparagus africanus.*

Other woody species are those of the *Rhus pyroides* Woodland. Most woody species occur in the very limited soil in the narrow fissures between the dolomite rocks.

As is the case with the *Rhus pyroides* Woodland Communities in general, the *Rhus pyroides-Celtis africana* Bush also appears to be disturbed, with the herbaceous layer dominated by pioneer weedy species. These include *Tragus berteronianus, Aristida congesta, Aristida canescens, Cynodon dactylon* and *Tribulus terrestris.* An increase in the shrubby species *Protasparagus suaveolens, Protasparagus laricinis, Pollichia campestris, Ziziphus zeyheriana, Lippia scaberrima* and *Stoebe vulgaris* is evident of the degradation of these areas. A similar situation was found on the Abe Bailey Nature Reserve (Van Wyk & Bredenkamp 1986). Bezuidenhout & Bredenkamp (1990) mentioned a similar community, the *Protasparagus suaveolens-Rhus pyroides* Woodland, in the Potchefstroom-Ventersdorp-Randfontein area.

2.2 *Rhus pyroides-Acacia karroo* Bush Community

This Community is very limited and restricted to small local calcareous bottomlands where dolomite or chert rocks and gravel cover up to 70 % of the soil surface.

The *Rhus pyroides-Acacia karroo* Bush Community is characterised by species group J (Table 1).

Diagnostic species are the trees *Acacia karroo* and *Acacia caffra* and the weedy succulent forb *Talinum caffrum.*

Other woody species of the *Rhus pyroides* Woodland Communities, such as *Rhus pyroides* and *Grewia flava* do occur locally.

This Community has a conspicuous low species richness, and especially the herbaceous layer is poorly developed, but the grasses *Eragrostis chloromelas, Digitaria eriantha, Themeda triandra* and *Setaria sphacelata* are constantly present, though with low cover-abundance values. The increase of species such as *Protasparagus suaveolens, P. laricinus* and *Aloe davyana* is often associated with *Acacia karroo* Communities in the western Transvaal (Friedel 1987, Bredenkamp *et al.* 1989, Bredenkamp & Bezuidenhout 1990). The *Rhus pyroides-Acacia karroo* Woodland of the Potchefstroom-Ventersdorp-Randfontein area is similar to this Community (Bezuidenhout & Bredenkamp 1990).

2.3 *Rhus pyroides-Cynodon dactylon* Sub-community

This is a very limited woody community, occurring only locally at very disturbed spots.

The Community is very poor in species composition, and is not characterised by any diagnostic species group, but the presence of species group H, and the absence of species groups I and J (Table 1) could be considered as characteristic features.

Woody species such as *Rhus pyroides, Grewia flava* and *Acacia karroo* are found scattered in these areas, and the encroacher species *Protasparagus suaveolens* and *Protasparagus laricinus* are conspicuously present.

The herbaceous layer is dominated by the pioneer grass species *Cynodon dactylon,* while other species include weedy pioneers such as *Aristida congesta, Schkuhria pinnata* and *Cynodon hirsutus.*

Similar plant communities, the *Eustachys paspaloides-Rhus pyroides* Secondary Savanna as well as the *Digitaria eriantha-Rhus pyroides* Shrubveld are respectively mentioned by Bezuidenhout & Bredenkamp (1990) and Bezuidenhout *et al.* (*submitted*).

3 *Hyparrhenia hirta* Wetland Community

This Wetland Community occurs in bottomland situations, especially along the disturbed, and often flooded, banks of the Boskop Dam.

This Community is characterised by species group K (Table 1), and the diagnostic species include the tall growing and dominant grass *Hyparrhenia hirta*, as well as weedy and pioneer species such as *Helichrysum rugulosum, Conyza podocephala, Hermannia depressa* and *Tephrosia semiglabra*.

Bezuidenhout & Bredenkamp (1990) described a similar community, *Themeda triandra-Hyparrhenia hirta* Grassland Major Community with similar variants in the Potchefstroom-Ventersdorp-Randfontein area. This Wetland relates strongly to the *Paspalo dilatati-Hyparrhenietum hirtae* (Bezuidenhout *et al. submitted*).

Two Variants were recognised.

3.1 *Hyparrhenia hirta-Verbena bonariensis* Variant

This wetland has a restricted distribution and is present at local depressions, especially where man-made ditches have been constructed, or at other severely disturbed wet bottomland localities.

This Variant is characterised by species group L (Table 1), which includes the pioneer species *Monsonia angustifolia, Verbena bonariensis, Corchorus asplenifolius* and *Walafrida densiflora.*

These areas tend to be related to the other communities on the Reserve, as indicated by the presence of species group R (Table 1), and especially to the *Rhus pyroides* Woodland Communities though the presence of the species of species group M (Table 1).

The vegetation is mostly dominated by dense stands of the 2 m tall *Protasparagus laricinus* and also the tall-growing grass *Hyparrhenia hirta.*

Other species prominently present include the grasses *Eragrostis chloromelas, Cynodon dactylon, Cymbopogon excavatus* and *Heteropogon contortus.*

3.2 *Hyparrhenia hirta-Eragrostis plana* Variant

This Variant represents the typical wetlands which occur on the moist banks of the Dam.

The Variant is characterised by species group N (Table 1), which includes the following hygrophilous species: the grasses *Eragrostis plana, Paspalum dilatatum, Setaria incrassata* and *Andropogon eucomus,* the weedy forbs *Oenothera rosea, Cirsium vulgare* and *Lactuca serriola,* and also the planted exotic tree *Eucalyptus grandis.*

This vegetation is entirely dominated by *Hyparrhenia hirta.*

The general absence of the widespread species of species group R (Table 1) is a further conspicuous feature of this Wetland Community.

4 *Haemanthus hirsutus-Zinnia peruviana* Community

This is a very local and limited community occurring on a small rocky chert outcrop in the southern part of the Reserve.

The diagnostic species are the relatively rare geophyte *Haemanthus hirsutus* and the weedy *Eleusine coriaca* and *Zinnia peruviana* (species group O, Table 1).

Other prominent species are the grasses *Eragrostis chloromelas, Setaria sphacelata, Melinis repens* and *Cymbopogon excavatus.*

5 *Senecio isatideus-Artemisia afra* Wetland Community

This Wetland is restricted to a fairly dry vlei in the southern part of the Reserve.

The vegetation is characterised by species group P (Table 1), with the hygrophilous *Senecio isatideus, Cyperus longus* and *Artemisia afra.*

Other conspicuous species are the grasses *Cymbopogon plurinodis, Themeda triandra* and *Aristida congesta.*

6 *Setaria lindenbergiana-Combretum molle* Community

This is a very local and limited community occurring on a small rocky outcrop in the southern part of the Reserve. This community is so limited that it could only be surveyed by a single sample plot. It is however included in the description, as it represents a very rare community in the area, which should be included in the management programme of the Reserve.

The diagnostic species are the trees *Combretum molle* and *Pavetta zeyheri* and the grass *Setaria lindenbergiana* (species group Q, Table 1). No similar community was described by Bezuidenhout & Bredenkamp (1990) in the Potchefstroom-Ventersdorp-Randfontein area but in the Vredefort Dome northwest of Parys a similar community, *Nuxia congesta-Combretum molle*-savanne was described by Bezuidenhout *et al.* (1988).

Concluding remarks

This report could serve as a basis for the compilation of a management programme for the Boskop Dam Nature Reserve. Each of the communities described represents a separate ecosystem with its own unique potential in terms of carrying capacity for game, and the habitat and grazing potential of each community should be assessed.

From the floristic data and habitat interpretation it is evident that many of the communities of the Boskop Dam Nature Reserve are quite similar to those found on the Abe Bailey Nature Reserve (Van Wyk & Bredenkamp 1986) and Potchefstroom-Ventersdorp-Randfontein area (Bezuidenhout & Bredenkamp 1990). For the Grassland syntaxa it seems as if the vegetation of the dolomite area in the western Tranvaal is adequately conserved in these two Reserves but the Woodland syntaxa, especially the *Rhoo lanceae-Acacietum eriolobae* need to be conserved as was also mentioned by Bezuidenhout *et al.* (*submitted*).

From a syntaxonomical point of view, it is clear that the knowledge of some plant communities recognised in small local areas such as nature reserves is too scanty to fix formal syntaxonomic ranks and names according to the Code for

Syntaxonomical Nomenclature (Barkman *et al.* 1986). However, some of the plant communities recognised do fit in with the syntaxa recognised from the regional classification. More or less all the Communities of the Boskop Dam Nature Reserve can be related to one or other syntaxa of the dolomitic and chert grassland in the western Transvaal (Bezuidenhout *et al. submitted*). This study should contribute to the ultimate goal of a comprehensive syntaxonomical synthesis for the western Transvaal grasslands and the South African grasslands.

References

ACOCKS, J.P.H. 1988. Veld types of South Africa 3rd edn. *Mem. bot. Surv. S. Afr.* 57: 1 - 146.

ARNOLD, T.H. & DE WET, B.C. 1993. Plants of southern Africa: names and distribution. *Mem bot. Surv. S. Afr.* 62: 1 - 825.

BARKMAN, J.J., MORAVEC, J. & RAUCHERT, S. 1986. Code for syntaxonomical nomenclature, 2nd edn. *Vegetatio* 67: 145 - 195.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region of the Potchefstroom-Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* 18: 387 - 403.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet an aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 7: 4 - 9.

BEZUIDENHOUT, H. BREDENKAMP, G.J. & THERON, G.K. 1993. The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa. *S. Afr. J. Bot.* 59: 319 - 331.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted*. The vegetation of the western Transvaal dolomitic and chert grassland, South Africa. (*S. Afr. J. Bot.*)

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *in prep.* Phytosociological Classes of the western Transvaal grassland, South Africa.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. 1990. The vegetation of the Faan Meintjes nature reserve, western Transvaal. *S. Afr. J. Bot.* 56: 54 - 64.

BREDENKAMP, G.J. JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area. *S. Afr. J. Bot.* 55: 199 - 206.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve. I. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 - 529.

BREDENKAMP, G.J. & THERON, G.K. 1990. The vegetation of the fersiallitic soils of the Manyeleti Game Reserve. *Coenoses* 5: 167 - 175.

BREDENKAMP, G.J. & THERON, G.K. 1991. The *Eucleo divinori-Acacietum nigricentis*, a new association from the calcareous bottomlands of the Manyeleti Game Reserve, eastern Transvaal Lowveld, Gazankulu, South Africa. *Vegetatio* 93: 119 - 130.

COETZEE, B.J. 1983. Phytosociology, vegetation structure and landscapes of the Central District, Kruger National Park. Dissertationes Botanicae 69. Cramer, Vaduz.

DU TOIT, A.C. 1954. The geology of South Africa. Oliver & Boyd, Edinburgh.

ECKHARDT, H.C., VAN ROOYEN, N. & BREDENKAMP, G.J. 1993. The phytosociology of thicket and woodland vegetation of the north-eastern Orange Free State. *S. Afr. J. Bot.* 59: 401 - 409.

FRIEDEL, M.H. 1987. A preliminary investigation of woody plant increase in western Transvaal and implications for veld assessment. *J. Grassl. Soc. South. Afr.* 4: 25 - 30.

FULS, E.R., BREDENKAMP, G.J. & VAN ROOYEN, N. 1993. The grassland communities of the footslopes in the northern Orange Free State, South Africa. *S. Afr. J. Bot.* 59: 485 - 490.

HILL, M.O. 1979. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. bot. Surv. S. Afr.* 24: 1 - 106.

MENTIS, M.T. & HUNTLEY, B.J. 1982. A description of the grassland biome project. *S. Afr. Nat. Sci. Prog.* 62: 1 - 29.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

NAKOR, 1979. National Plan for nature conservation. Dept. of Environmental planning and Conservation, Pretoria.

SACS, 1980. Stratigraphy of South Africa. Part 1. *Handbook of the geological surveys of South Africa* 8.

SCHEEPERS, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on classification and mapping. *Ecosystems Prog. Occas. Report Series* 16: 1 - 31.

VAN WYK, S. & BREDENKAMP, G.J. 1986. A Braun-Blanquet classification of the vegetation of the Abe Bailey reserve. *S. Afr. J. Bot.* 52: 321 - 331.

WEATHER BUREAU, 1986. Climate of South Africa. *WB* 40. Government Printer, Pretoria.

CHAPTER 5

PLANT COMMUNITIES OF THE MOOI RIVER CATCHMENT AREA

PAGE

5.1 A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa.

Page

* Published: *Phytocoenologia*
18(2/3): 387 - 403.

Phytocoenologia	18 (2/3)	387 – 403	Berlin-Stuttgart, March 30, 1990

A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa

by H. Bezuidenhout, Potchefstroom, and G.J. Bredenkamp, Pretoria

with 5 figures and 1 table

Abstract. As part of a phytosociological research programme on the synthesis of the vegetation of the western Grassland Biome in South Africa, the plant communities of the dolomite region in the Potchefstroom-Ventersdorp-Randfontein area were investigated. A numerical classification technique (TWINSPAN) was used to derive a first approximation of a vegetation classification. This classification was refined by Braun-Blanquet procedures. In this way an ordered phytosociological table was constructed effectively, and the analysis revealed ten plant communities. A hierarchical classification, description and ecological interpretation of the plant communities are presented. Although most of the distinguished plant communities have never been described before, a formal syntaxonomical classification is avoided, as too little is presently known of the phytosociology of the western grasslands of South Africa. This classification should however contribute to the ultimate goal of a comprehensive syntaxonomical synthesis of the South African grasslands.

Introduction

A phytosociological research programme, which included a number of projects on the classification and description of the western Grassland Biome vegetation of South Africa, was initiated during 1984 (Bosch & Janse van Rensburg 1987; Bredenkamp, Joubert & Bezuidenhout 1989). One of the first priorities of the western Grassland Biome Project, was to determine the location and extent of the major vegetation types within the Biome (Mentis & Huntley 1982). In order to formulate a management policy, proper land should be emphasized, and for this purpose a classification of the vegetation is essential (Van Rooyen, Theron & Grobbelaar 1981). The first step in the synthesis of the vegetation was to initiate and create a phytosociological data base for the western Grassland Biome. From this information areas lacking phytosociological data were identified. Suitable phytosociological data from the dolomitic area were available only for limited areas from Lichtenburg (Morris 1973, 1977), the Abe Bailey Nature Reserve (Van Wyk 1983, Van Wyk & Bredenkamp 1986) and the Jack Scott Nature Reserve (Coetzee 1972, 1974). Broad, regional accounts of the vegetation are given by Acocks (1988) and Louw

0340-269X/90/0018-0387 $ 4.50

(1951). As no data existed for the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area in the western Transvaal, this area was identified as a priority area for reconnaissance phytosociological surveying. The project forms part of a phytosociological study in the western Transvaal (BEZUIDENHOUT 1988). In this report the results of a reconnaissance survey of the vegetation of this region are presented. The aim of the study was to identify, characterize and describe the plant communities of the dolomitic region in the western Transvaal. The results should contribute significantly to the ultimate aim of a phytosociological and syntaxonomical synthesis of the western Grassland Biome.

The study area

The area is situated in the triangle formed by the towns Potchefstroom in the south, Ventersdorp in the northwest and Randfontein in the northeast

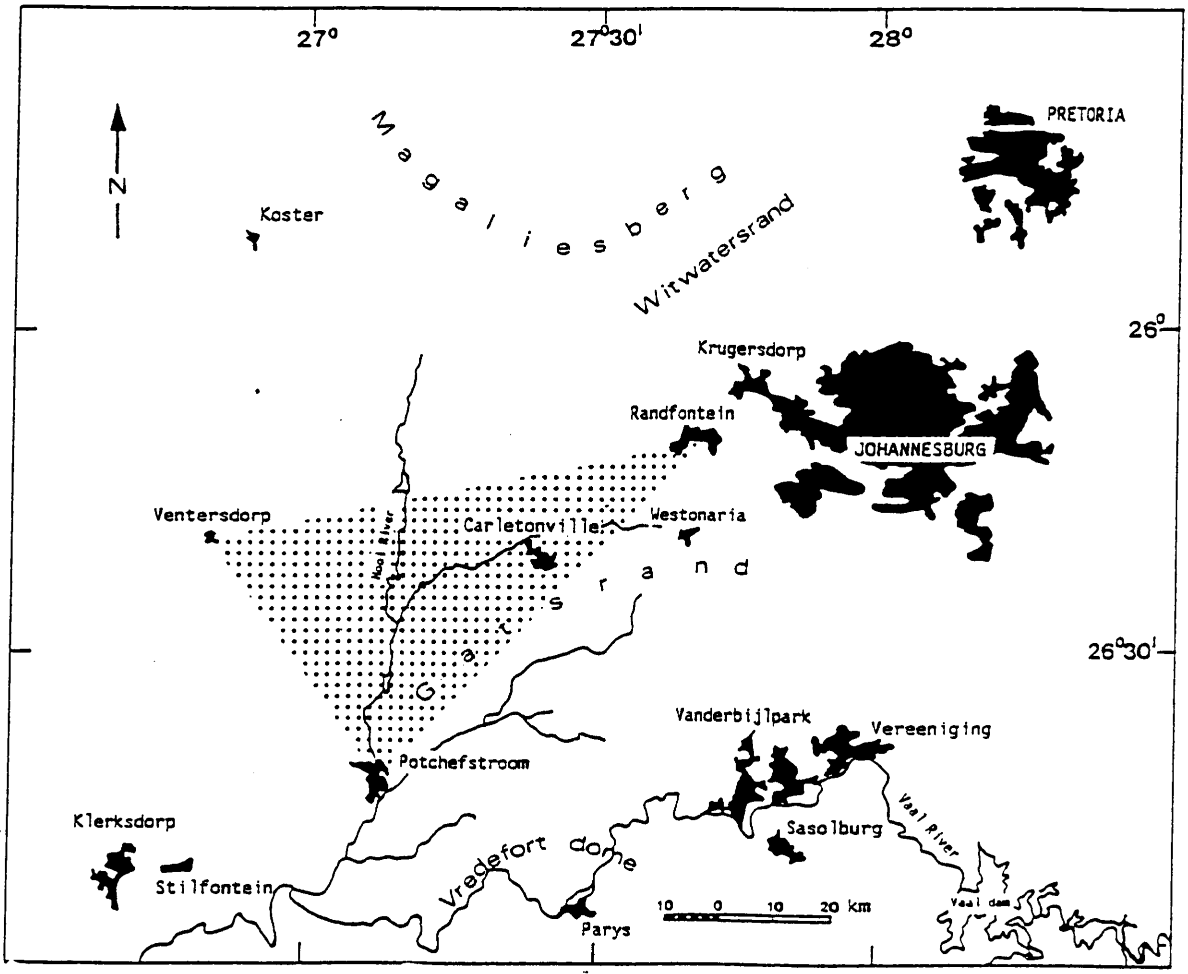


Fig.1. Location of the study area.

(Fig. 1). The area covers approximately 121 729 hectares. Dolomite and chert of the Chuniespoort Group (Transvaal Sequence) are the main rock types which underly the area. Natural vegetation is mostly confined to shallow, rocky, non-arable soils, hence the name Klipveld (LOUW 1951). The vegetation is a sour, wiry grassland, virtually ungrazable in winter (ACOCKS 1988), and is not dominated by a single or few species, but represents a mosaic of many co-dominants (LOUW 1951). The vegetation is often burned during winter or early spring. In a land-use classification system based on terrain form, soil pattern and climate, this area was classified as the Fa land type (LAND TYPE SURVEY STAFF 1984). In this land type exposed rock and shallow, mostly red soils without carbonate predominate (LOUW 1951, LAND TYPE SURVEY STAFF 1984). The vegetation is, as are the soils, distributed in a complex mosaic pattern (KRUGER 1971, MORRIS 1977, VAN WYK & BREDENKAMP 1986).

According to the Köppen climate classification system two climatic regions, namely a cool dry steppe with summer rains (BS) and a warm temperate climate with summer rains (CW) are represented in the study area (Fig. 2). Average rainfall exceeds 600 mm (Potchefstroom 625 mm and Carletonville 670 mm). The summer temperatures are high, the mean maximum monthly temperatures exceed 32 °C during October to January, while the mean minimum monthly temperatures are below −1 °C during May to September (WEATHER BUREAU 1988). Climate diagrams (Fig. 3) summarize climatic conditions of the area. The winters are severely frosty.

The sources of the Mooi River are two springs which originate from the dolomite water reservoir in the northern part of the area (DU TOIT 1954). The entire study area is drained by this river system and its tributaries. The flat or slightly undulating plains are dissected by prominent rocky chert ridges. The terrain is situated at altitudes of 1350 m to 1450 m above sea-level.

Soil types that abound in the high-lying areas of the region are the Hutton, Mispah and Glenrosa soil forms (MACVICAR et al. 1977). These soils are usually too shallow for maize cultivation. The Valsrivier, Westleigh and Willowbrook soil forms occur in the bottomlands (LAND TYPE SURVEY STAFF 1984).

Methods

Relevés were compiled in 49 stratified sample plots. As the flat to slightly undulating plains are relatively monotonous, stratification was based on topographical position, using terrain types, which include crest (1), scarp (2), midslope (3), footslope (4) and floodplain (5) (Fig. 4) (LAND TYPE SURVEY STAFF 1984). In accordance with BREDENKAMP & THERON (1978), plot sizes were fixed on 16 m² for the grassland vegetation and 100 m² for wooded vegetation. For cover the Braun-Blanquet cover abundance scale as given by MUELLER-DOMBOIS & ELLENBERG (1974) was used. In addition the general height and cover of the tree, shrub and herbaceous layers were noted. All height and cover values of the vegetation layers referred to in the text, represent average values for the particular communities. Environmental information included rock type, terrain type, soil type, soil depth and rockiness of the soil surface.

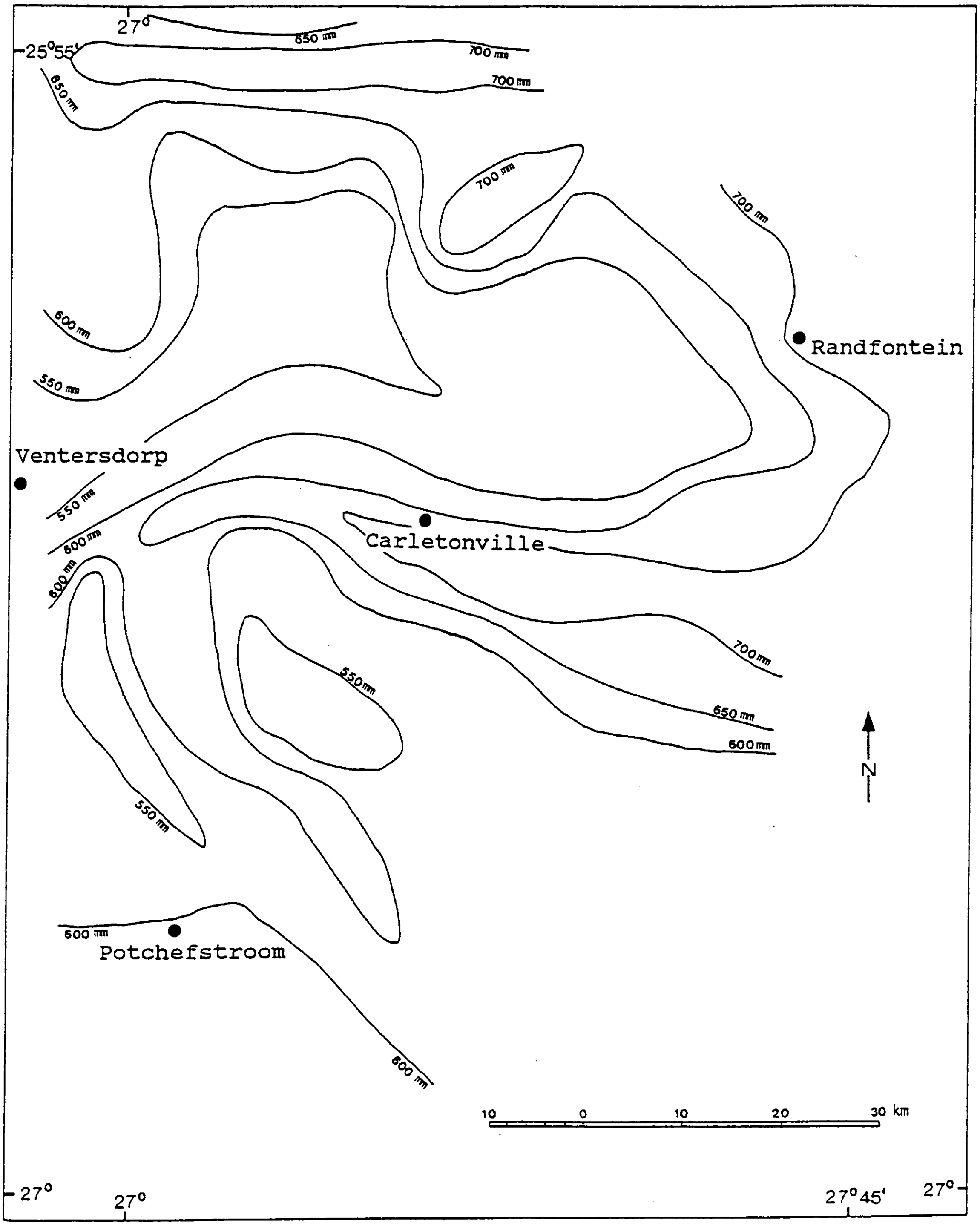
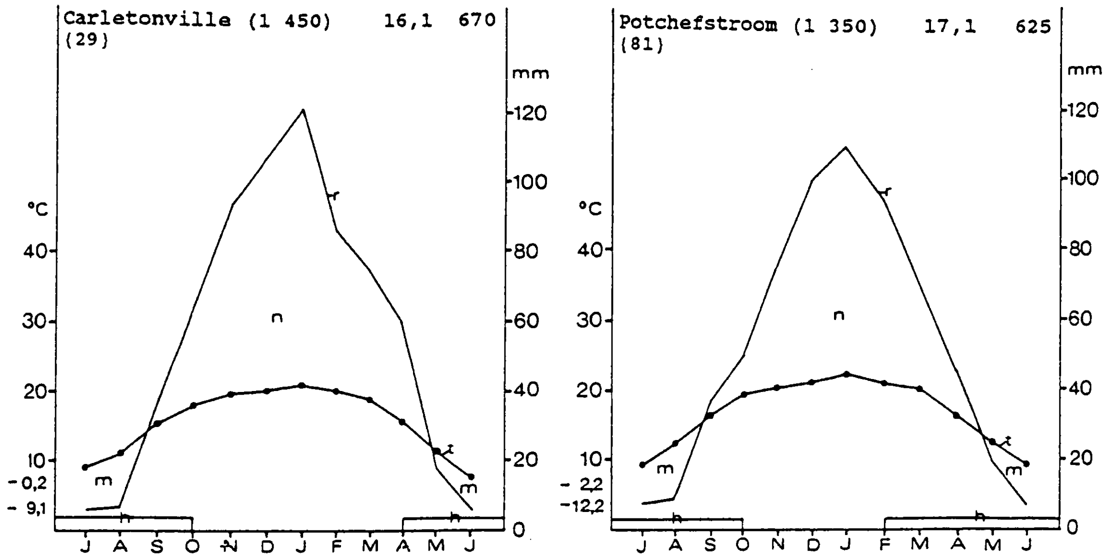
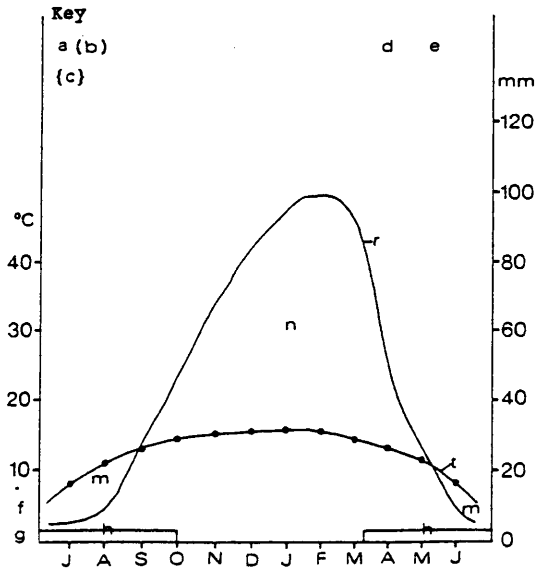


Fig.2. The distribution of rainfall in the study area.

An objective statistical classification technique, TWINSPAN (HILL 1979), was used complementary to the Braun-Blanquet technique for processing the raw data. The results of the objective classification were refined by applying





Key:
a - name of town
(b) - altitude (m)
{c} - period with data (years)
d - mean annual temperature
e - mean annual rainfall
f - mean daily minimum of coldest month
g - absolute minimum temperature
h - months with absolute minimum temperature below 0 °C
m - dry period
n - wet period
r - mean monthly rainfall
t - mean monthly temperature

Fig. 3. Climate diagrams for selected towns in the study area.

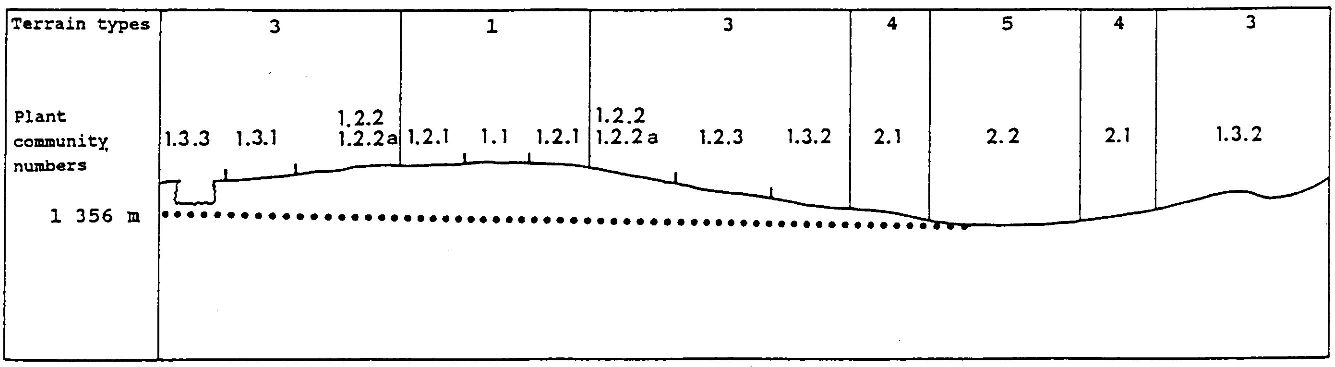


Fig. 4. The location of plant communities on topographical terrain types.

the Braun-Blanquet procedures. This procedure was successfully applied by BEHR & BREDENKAMP (1988) and BREDENKAMP, JOUBERT & BEZUIDENHOUT (1989). Final results are presented in a phytosociological table (Table 1). Taxa names mostly conform to those of GIBBS-RUSSELL et al. (1985, 1987). Although most of the communities were never described before and represents new syntaxa, formal syntaxonomical names were avoided as too little is presently known of the vegetation of the entire western Grassland Biome of South Africa.

Results

Classification

In the analysis of the vegetation, ten plant communities were identified (Table 1). The hierarchical classification of the vegetation stresses the correlation between habitat and communities in the study area, as well as the relationships between communities (Fig. 5). The vegetation of the dolomitic region can be described as an *Eragrostis curvula-Elionurus muticus* Grassland.

The communities of this grassland are classified as follows:

1. *Justicia anagalloides-Elionurus muticus* Grassland
    - 1.1 *Schizachyrium sanguineum-Andropogon schirensis* Grassland
    - 1.2 *Eragrostis racemosa-Brachiaria serrata* Grassland
        - 1.1.1 *Tristachya leucothrix-Alloteropsis semialata* Grassland
        - 1.1.2 *Aristida diffusa-Cymbopogon excavatus* Grassland
            - 1.2.2a *Becium obovatum* Variant
        - 1.1.3 *Eustachys paspaloides-Setaria flabellata* Grassland
    - 1.3 *Rhus pyroides-Acacia karroo* Woodland
        - 1.3.1 *Rhus pyroides-Acacia karroo* Woodland
        - 1.3.2 *Eustachys paspaloides-Rhus pyroides* Shrubland
        - 1.3.3 *Protasparagus suaveolens-Rhus pyroides* Bush
2. *Themeda triandra-Hyparrhenia hirta* Grassland
    - 2.1 *Eragrostis curvula-Hyparrhenia hirta* Grassland
    - 2.2 *Eragrostis plana-Hyparrhenia hirta* Grassland

Description of the plant communities

The broad vegetation type of the entire dolomitic region can be described as an *Eragrostis curvula-Elionurus muticus* Grassland.

The species of species group M are generally found in this extensive grassland vegetation. Predominant grasses are *Eragrostis curvula*, *Elionurus muticus*, *Themeda triandra*, *Digitaria eriantha*, *Aristida congesta*, *Cymbopogon plurinodis*, *Rhynchelytrum repens* and *Cynodon dactylon*. The vegetation is often overgrazed by cattle and sheep. The presence and high constancy of pioneer grasses such as *Aristida congesta*, *Cynodon dactylon* and *Rhynchelytrum repens* emphasize the generally degraded condition of this vegetation.

This grassland is classified into two major types, namely:

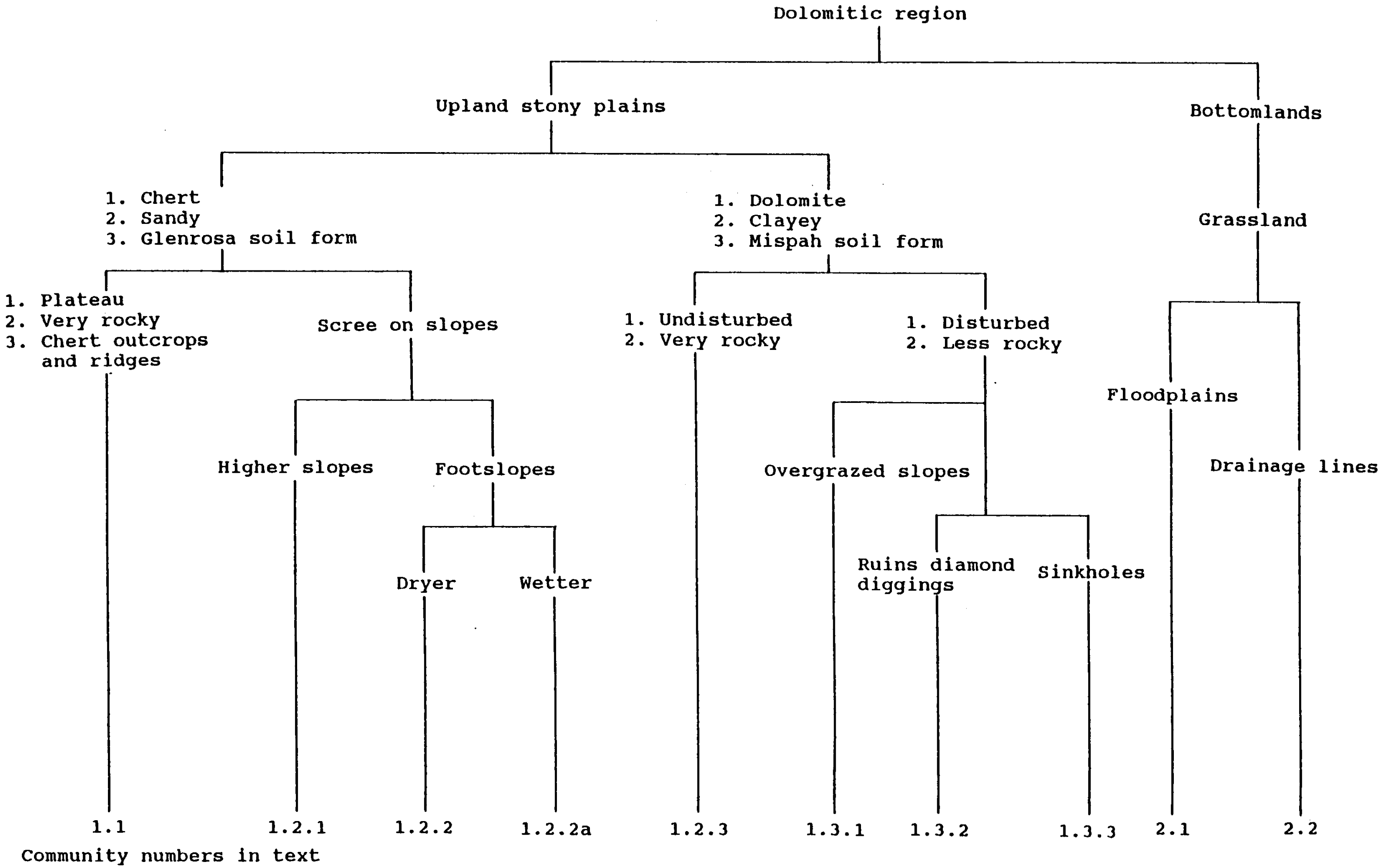


Fig. 5. Dendogram to illustrate the habitat relationships of the plant communities.

Table 1. A phytosociological table of the dolomitic region, western Transvaal.

```
                               11111 2112212 0012 111 11112111211 1111 11 111 01211 11222
RELEVE NO.                     33322 0971050 2051 852 86860669229 8444 88 429 23323 24001
                               87989 7960165 8977 201 86748758970 1342 09 001 95056 61606

SPECIES GROUP A
SOLANUM CAPENSIS              |+++++|       |    |   |         + | ++ |  |   |     |     |
HELICHRYSUM CAESPITITIUM      |+++++|       |    |   |       +   |   +|  |   |  ++ |     |
HELICHRYSUM CHIONOSPHAERUM    |+++  |       |   +|   |   +       |   +|  |   | +   |     |
DIHETEROPOGON AMPLECTENS      |++ + | + +   |   +|  +|+   +      |   4|  |   | +   | +   |
SCHIZACHYRIUM SANGUINEUM      |++ + |   +   |    |  3|           |   +|  |   |     |     |
KYPHOCARPA ANGUSTIFOLIA       | +++ |    +  |    |   |         + |    |  |   |   + |     |
HERMANNIA LANCIFOLIA          |+++  |      +|  + |   |         + |    |  |   |  +  |     |

SPECIES GROUP B
TRISTACHYA HISPIDA            |     | +++22 |    |+  |       ++  |    |  |   |     |     |
PANICUM COLORATUM             |     |+++++ +|    |   |           |    |  |   |     |  4  |
IPOMOEA SP.                   |     |++ ++ +|    |   |   +       |    |  |   |     |     |
PENTANISIA ANGUSTIFOLIA       |     |+++ +  |    |+ +|           |    |  |   |     |     |
SPOROBOLUS PECTINATUS         |     |+ +++  |    |   |          +|    |  |   |     |     |
ALLOTEROPSIS SEMIALATA        |     |2+2    |    |   |           |    |  |   |     | +   |

SPECIES GROUP C
ARISTIDA DIFFUSA              |     |     + |+22+|++ |++    + +  |    | +|   |     |     |
CYMBOPOGON EXCAVATUS          |     |       |1+  |2 +|    +      |   +|  |   |+ +  |     |
LIPPIA SCABERRIMA             | +   |       |+ + |++ |   +++   + | +  |  |   |     |+    |

SPECIES GROUP D
DIANTHUS MOOIENSIS            |++   |+++    |    |+++|    +      |    |  |   |     |     |
BECIUM OBOVATUM               |     |+ +   +|    |+++|    +      |    |  |   |     | +   |
GEIGERIA BURKEI               |     |    +  |+   |++ |          +|   +|  |   |     |     |

SPECIES GROUP E
EUSTACHYS PASPALOIDES         |   ++|    ++ | ++ |+  |+2++2+++2++|++  |3+| + | +   |     |
CRABBEA ANGUSTIFOLIA          |+ ++ |  ++   |   +|   |+++++++++++|+   |++|  +|  ++ |   + |
SALVIA RADULA                 |     |       |    |   |+++++++++ +|  + |++|   | ++ +|   + |
MARISCUS INDECORUS            |     |   + + |    |+  |++++  ++  +|    |++|  +|   + |     |

SPECIES GROUP F
SENECIO CORONATUS             | +   |   ++  |    |   | + +  ++++ | + +|  |   |     | + + |
TYLOSEMA ESCULENTUM           |     |       |    | + |++++ ++  + | ++ | +|   |     |     |
TEPHROSIA LUPINIFOLIA         |     |       |    |   |  +  + +   |    |  |   |     |     |

SPECIES GROUP G
BRACHIARIA SERRATA            |++   |++2 ++ |+  +|+++|+++++++++  | +  |+ |   |     |   + |
ERAGROSTIS RACEMOSA           |     |+++++++|1+ +|+++| + ++ +++  |   +|  |   |     |   + |
ELEPHANTHORRHIZA ELEPHANTINA  | ++  |+  +  +|   +|+++| ++++ +++++|+   |  |   |     |     |
ACALYPHA ANGUSTIFOLIA         |    +|+++  ++|+   |++ | ++++   ++ |   +|  |   |+    |     |
PYMAEOTHAMNUS ZEYHERI         |     |+ +    |   +|++ |+ + +++++  |+   |+ |  +|     |     |
SPHENOSTYLIS ANGUSTIFOLIA     |++   |+++ +  |   +|+ +|++ ++      |    |  |   |     |     |
OXYGONUM DREGEANUM            |     |+   ++ |   +|++ | ++++  +   |    |  |   |     |     |

SPECIES GROUP H
ACACIA KARROO                 |     |       |    |   |           |322+|  | + |     | +   |
GOMPHRENA CELOSIOIDES         |   + |     + |    |++ |           |+++ |  |   | ++  |     |
ZIZIPHUS MUCRONATA            |     |       |    |++ |           |+++ |  |   |     |     |

SPECIES GROUP I
RHUS PYROIDES                 | +   |    +  |    |+2 |         + |+ +2|24|3++|     |+  + |
PROTASPARAGUS LARICINUS       |     |       |    |+  |         + |++++|+ |+++|   + | +   |
PROTASPARAGUS SUAVEOLENS      |     |       |    |+  |           |++++| +|2++|     |     |
GREWIA FLAVA                  | + + |       |    |+  |           |++  |++|++ |     |     |
DIOSPYROS LYCIOIDES           | +   |   ++2 |    |   |           |+   | 2|3 +|     |     |
CELTIS AFRICANA               |     |       |    |   |           |+   |++|+  |     |     |

SPECIES GROUP J
SCHKRUHRIA PINNATA            |     |+    + |    | + |         + |    |  |  +|     |+++++|
ERAGROSTIS PLANA              |     |+  ++  |    |   |           |    |  |   |    +|2+++ |
PASPALUM DILATATUM            |     |       |    |   |           |    |  |   |     | +3+ |
CHLORIS PYCNOTHRIX            |     |       |    |   |           |    |  |   |     |  + +|
BERKHEYA SP.                  |     |       |    |   |           |    |  |   |     |++   |

SPECIES GROUP K
HYPARRHENIA HIRTA             |     |      +|    |   |           |    |  |   |1 4+ |25+ 4|
HELICHRYSUM RUGULOSUM         |     |       | ++ |   |           |    | +| ++|+++++|++   |
VERBENA BONARIENSIS           |     |       |    |  +|           |    |  |   |++   |+++ +|
WALAFRIDA DENSIFLORA          |+ +  |  + +  |    | + |       + +   |    | +|   | ++ +|+ + +|

SPECIES GROUP L
JUSTICIA ANAGALLOIDES         |+++++|+++++  |+ ++|++ |++++++++++ |++ +| +| ++| +   |   + |
CASSIA MIMOSOIDES             |+++++| ++++  |   +|+++|+ ++++ + ++| + +|++|   | +++ |   + |
VERNONIA OLIGOCEPHALA         |+   +|       |+ + |++ | ++++++++++|+  +|+ |+++|++ ++|     |
SETARIA FLABELLATA            |+  ++| ++  2 | +++|2  |23+ + 2+  +|++++|  |  +|++ + |     |
CYANOTIS SPECIOSA             |    +| ++  + | +  |++ |+++++   +  |+   |++|  +| + + |   + |
BARLERIA MACROSTEGIA          |+++++|       |    |   |++ ++ +++++| ++ |  | + | + ++|     |
TRIRAPHIS ANDROPOGONOIDES     |2+32+|       |++  |   |    +  +++ | ++ |  |++ |++ + |     |
RAPHIONACME HIRSUTUS          |++++ | +     |+   |++ |      +++++|+ + |+ |  +|   + |   + |
TRICHONEURA GRANDIGLUMIS      |++ ++| + ++  |++ +| ++|  +      + | +  |  |   | +2+ |     |
HETEROPOGON CONTORTUS         |+    |   ++  |1+  |+  |  ++   +  +| + +|++|   |   2 |     |
```

Table 1. (cont.)

RELEVE NO.	11111 33322 87989	2112212 0971050 7960165	0012 2051 8977	111 852 201	11112111211 86860669229 86748758970	1111 8444 1342	11 88 09	111 429 001	01211 23323 95056	11222 24001 61606
SPECIES GROUP M										
ERAGROSTIS CURVULA	++2+2	++ +++2	+34	++	++2+++++++2	+23+	+2	+++	++233	+++
ELIONURUS MUTICUS	+++++	22+22	+++	2++	+++222+3 +	+++2	+	+	+++	+ +
THEMEDA TRIANDRA	+++	++++	++ +	+	2224+3+2	2+++		++	+ 25	++ 4+
ANTHOSPERMUM HISPIDULUM	+++++	+++ +	++	++	++++ +++	+ +	+	++	++	+++++
DIGITARIA ERIANTHA	++	+ +++	+++	+	+ ++ +3+	++		+42	1+ +	++
ARISTIDA CONGESTA	+++ 3	+	++ +	++	+ + + ++	4+		+	+++++	++ ++
LAMIACEAE SPESIE	+ + +	+++ ++	+	++	++ ++ +	+ ++	++	+	++	+ +
CYMBOPOGON PLURINODIS	2 +3+	++	++	+	+++2+ ++++	2+	2+	++	+	++
RHYNCHELYTRUM REPENS	++ ++	+ +++	+	+++	++2 2	+	++	+	+++	+
CYNODON DACTYLON	+ +	++	+	+	+ +++ +	+++		++	+++	+ +++
SENECIO VENOSUS		++++ ++	+ +	+ +	+ ++ +++	+ +		+	+ +	+
CHAMAESYCE SP.	+ ++			++	+ ++ + +	++	+		++++	++
LACTUCA SERRIOLA	+	+ +++		+	+ ++ ++ +			+	+++ +	++
CRABBEA ACAULIS		+	+++		++ + ++	+		++	++ ++	+++
TRACHYPOGON SPICATUS	++	++	++4	++	+ + +	+ +	+		++	+
HELICHRYSUM NUDIFOLIUM		+++	+		+ + +++		+	+	++++	+ ++
PLEXIPUS HEDERACEUS	+ +	+ +	+	+++	++++++ +	+ +	++			
ERAGROSTIS SUPERBA		++	+ ++		+ + + 2+ 2	+++	++			+
HERMANNIA DEPRESSA	+		++	+	+++ + +		+	++	++ +	+
HIBISCUS TRIONUM	+ +	+	+	++	+ + + +	+	+		+	
CYPERUS SP.	+	+ ++		++	+ ++ ++ +		++			+
THESIUM UTILE	+	+ + +	+		+++++	+ +	+			+
SOLANUM INCANUM	+ +	+ +	+	+++	+ +	+ ++			+	+
ERAGROSTIS LEHMANNIANA	4	+++ +			+ +	+		+4	+	++
SIDA DREGEI				+	+ + + +	+	+	++	+ +	+ ++
COMMELINA AFRICANA		++++	++	+	+ ++			+ +		
STOEBE VULGARIS	+	+ 2	++		+ + +			+	++	+ +
FELICIA MURICATA		+	+		+ + ++	+		+	++	+ +
RHYNCHOSIA NERVOSA		++++ ++		+++	+	+				
SETARIA SPHACELATA	+	+ ++		+	2 ++			2		+ ++
CORCHORUS ASPLENIFOLIUS	+ +		+	+	+ + ++	+	++			
BULBOSTYLIS BURCHELLII	+	++++ +	+	+ +	+					
HELICHRYSUM CORIACEUM	+ +	+		++	+ +++ +		+			
ERAGROSTIS GUMMIFLUA	++				+ 3 +	+		+	4+++	
ZIZIPHUS ZEYHERIANA	+ +		+		+ + + + +		+	+	+	
TEPHROSIA LONGIPES	+	+ + +		+	+ +	+			++	
SOLANUM PANDURIFORME	+	+		+	++	+	+	+	+	+
DICOMA ANOMALA	++	+	+	+	+ + +	++				
INDIGOFERA COMOSA	+++	+ +			+	+ +			+	+
POGONARTHRIA SQUARROSA	+ +			+ +	+ +				+ +	+
OXALIS SP.		+			+ +	+		+++	+	+
ARISTIDA CANESCENS	2		++		+ +	2			++	+
TURBINA OBLONGATA	+			+	+ + ++		+		+	
POLLICHIA CAMPESTRIS	+	+ +		+		++				+
GNIDIA CAPITATA		+ + +		+	+ +			+	+	
LIGHTFOOTIA DENTICULATA		++ +			++				+	+
DICOMA GERRARDII	++		+		+	+		+	+ +	
BLEPHARIS ANGUSTIFOLIA				+	+	++ +		+	+	
HELICHRYSUM CALLICOMUM	+	+	+		+		+		++	
TRUIMFETTA SONDERI	++		+	+ +	+	+				
MICROCHLOA CAFFRA		+ ++			+ ++					
MONSONIA ANGUSTIFOLIA	++				+ +				++	+
SCABIOSA COLUMBARIA				++				+	+	++
IPOMOEA BATHYCOLPOS	+ +				+	+ +	+			
LOTONONIS FOLIOSA	++	+					+		++	
IPOMOEA OBSCURA				+	++		+		+	+
ARISTIDA STIPITATA	+		++		+					+
BRAYULINEA DENSA	+							+	+	+
ZORNIA GLOCHIDIATA	+	+ +			+ +					
CRASSULA SCHIMPERI	+				+	+				
TEUCRIUM TRIFIDUM	+	+			+			+		+
STACHYS SPATHULA			+	+	+		+			
CONYZA PODOCEPHALA								+	++	+
LIMEUM SP.	++				+	+				
HIBISCUS PUSILLUS			+		+	+		+		
TEPHROSIA SEMIGLABRA		+ +			+		+			
GRADERIA SCABRA		+ +			+		+			
HELICHRYSUM PARVIFLORUM	+			+	+ +					
LEUCAS CAPENSIS		+				++			+	
COMMELINA BENGALENSIS	++			+						+
PROTASPARAGUS AFRICANUS	+	+		+				+		

* NON-DIAGNOSTIC SPECIES WITH A FREQUENCY OF <4 ARE OMITTED FROM THE TABLE

- the zonal *Justicia anagalloides-Elionurus muticus* Grassland of the upland stony plains and
- the azonal *Themeda triandra-Hyparrhenia hirta* Grassland of the bottomland floodplains.

1. The Justicia anagalloides-Elionurus muticus Grassland Community

This community includes all zonal plant communities of the flat or slightly undulating stony plains of upland areas. The vegetation is characterized by species group L (Table 1). These species are typical for the relatively dry upland areas, but normally they do not occur on the floodplains or other relatively wet bottomland situations.

1.1 The Schizachyrium sanguineum-Andropogon schirensis Grassland

This community is associated with the rocky outcrops of chert ridges on crests in the undulating landscape (Fig. 4 and 5). The soils of these situations are shallow and very rocky, mostly of the Mispah form, with a shallow orthic A horizon on chert bedrock.

Diagnostic species of this community include *Solanum capensis*, *Helichrysum caespitosum*, *H. chionosphaerum*, *Diheteropogon amplectens*, *Schizachyrium sanguineum*, *Kyphocarpa angustifolia* and *Hermannia lancifolia* (Species group A, Table 1). An average of 43 species was recorded per sample plot.

A tree stratum is absent and the shrub layer covers less than 10 % of the area. The shrub layer is 1.2 m tall. The prominent shrub species are the deciduous *Rhus pyroides* and *Grewia flava*, together with the occasional semi-woody *Protasparagus africanus*.

The herbaceous layer is well developed, with a cover of 55 % and a height of 0.95 m. Grass species often found in this community include *Diheteropogon amplectens*, *Schizachyrium sanguineum*, *Setaria flabellata*, *Triraphis andropogonoides*, *Trichoneura grandiglumis*, *Eragrostis curvula*, *Elionurus muticus*, *Themeda triandra*, *Aristida congesta*, *Cymbopogon plurinodis* and *Rhynchelytrum repens*. Forbs present include *Solanum capensis*, *Helichrysum caespitosum*, *H. chionosphaerum*, *Kyphocarpa angustifolia*, *Hermannia lancifolia*, *Crabbea angustifolia*, *Justicia anagalloides*, *Raphionacme hirsutus*, *Anthospermum hispidulum* and the semi-woody *Indigofera comosa*.

1.2 The Eragrostis racemosa-Brachiaria serrata Grassland

This grassland community covers extensive parts of the dolomitic region. This major community is generally associated with the vast high-lying, stony dolomitic landscape. Within this major community three communities and one variant are identified.

The *Eragrostis curvula-Brachiaria serrata* grassland is characterized by species group G (Table 1). The diagnostic species are *Brachiaria serrata*, *Eragrostis racemosa*, *Elephanthorrhiza elephantina*, *Acalypha angustifolia*, *Pygmaeothamnus zeyheri*, *Sphenostylis angustifolia* and *Oxygonum dregeanum*.

1.2.1 The Tristachya leucothrix-Alloteropsis semialata Grassland

The *Tristachya leucothrix-Alloteropsis semialata* Grassland occurs high up on gradual stony slopes, just below the crest area (Figs. 4 and 5). Large chert rocks cover 30–60 % of the soil surface. The soils of this community mostly represent the Glenrosa form, with a shallow A horizon and an extremely rocky lithocutanic B horizon.

This community is characterized by species group B, with the diagnostic species *Tristachya leucothrix*, *Panicum coloratum*, *Pentanisia angustifolia*, *Sporobolus pectinatus*, *Alloteropsis semialata* and an *Ipomoea* species (Table 1). An average of 43 species was recorded per sample plot.

A tree stratum is absent and a scanty shrubby layer is present in only one sample plot. The herbaceous layer is 0.75 m tall and covers 50 %. Prominent grasses are *Tristachya leucothrix*, *Panicum coloratum*, *Sporobolus pectinatus*, *Alloteropsis semialata*, *Brachiaria serrata*, *Eragrostis racemosa*, *E. curvula*, *E. lehmanniana*, *Elionurus muticus*, *Themeda triandra*, *Digitaria eriantha* and *Rhynchelytrum repens*. Forbs that are constantly present in this community are an *Ipomoea* species, *Pentanisia angustifolia*, *Justicia anagalloides*, *Senecio venosus*, *Lactuca serriola*, *Commelina africana*, *Rhynchosia nervosa* and *Bulbostylis burchellii*.

This community resembles the *Alloteropsis semialata* Variant of the *Justicia anagalloides-Elionurus muticus-Panicum natalense* Grassland described by Van Wyk & Bredenkamp (1986) from the Abe Bailey Nature Reserve near Carletonville, situated within the present study area.

1.2.2 The Aristida diffusa-Cymbopogon excavatus Grassland

This community is also found on stony chert slopes, but it is situated downslope, below the *Tristachya leucothrix-Alloteropsis semialata* Grassland (Figs. 4 and 5). In its distribution pattern, it forms a mosaic with the *Becium obovatum* Variant, but generally its soils are shallower and drier than that of the variant.

The community is characterized by species group C (Table 1). Diagnostic species are *Aristida diffusa*, *Cymbopogon excavatus* and *Lippia scaberrima*. An average of 30 species was recorded per sample plot.

Both tree and shrub strata are absent. The herbaceous layer is well developed, is 0.7 m tall and covers 62 %. Prominent grasses are *Aristida diffusa*, *Cymbopogon excavatus*, *Eragrostis racemosa*, *E. curvula*, *E. superba*, *Setaria flabellata*, *Trichoneura grandiglumis*, *Elionurus muticus*, *Themeda triandra*, *Digitaria eriantha*, *Aristida congesta* and *Trachypogon spicatus*. Prominent forbs are *Lippia scaberrima*, *Justicia anagalloides* and *Crabbea acaulis*.

1.2.2.a The Becium obovatum Variant

The location of this community is similar to that of the *Aristida diffusa-Cymbopogon excavatus* community, but the soils of the variant are deeper and moister.

Species group D characterizes this variant and *Dianthus mooiensis*, *Becium obovatum* and *Geigeria burkei* are diagnostic species (Table 1). An average of 47 species was recorded per sample plot.

The tree stratum is 3.0 m tall and has a cover of 10 %, with scattered individuals of *Rhus pyroides* and *Ziziphus mucronata*. The prominent shrub species are *Grewia flava* and smaller individuals of *Rhus pyroides*. The shrub stratum is 0.5 m tall and covers about 8 % of the area.

The herbaceous stratum is well developed, is 0.8 m tall and cover 70 %. Grasses are dominant and grass species constantly present in this community are *Aristida diffusa*, *Cymbopogon excavatus*, *Brachiaria serrata*, *Eragrostis racemosa*, *E. curvula*, *Trichoneura grandiglumis*, *Elionurus muticus*, *Rhynchelytrum repens* and *Aristida congesta*. The forbs are rich in variety, and constantly present species include *Dianthus mooiensis*, *Lippia scaberrima*, *Becium obovatum*, *Solanum incanum*, *Geigeria burkei*, *Plexipus hederaceus*, *Elephanthorrhiza elephantina*, *Acalypha angustifolia*, *Pygmaeothamnus zeyheri*, *Sphenostylis angustifolia*, *Oxygonum dregeana*, *Gomphrena celosioides*, *Cyanotis speciosa*, *Justicia anagalloides*, *Cassia mimosoides*, *Vernonia oligocephala*, *Anthospermum hispidulum* and *Rhynchosia nervosa*.

1.2.3 The Eustachys paspaloides-Setaria flabellata Grassland

This community occurs on the high-lying, rocky, flat dolomite plains. Outcrops of dolomite rock are abundantly exposed and a rock sheet occurs just beneath the soil surface. The soils are therefore extremely shallow and represent the Mispah or shallow Hutton soil forms. Due to the rock sheet and flat terrain, the surface drainage of water tends to be very slow.

This grassland is characterized by species groups E and F. The diagnostic species include *Eustachys paspaloides*, *Crabbea angustifolia*, *Salvia radula*, *Mariscus indecorus*, *Senecio coronatus*, *Tylosema esculentum* and *Tephrosia lupinifolia* (Table 1).

The absence of a tree and shrub layer is typical of this community. The herbaceous layer is well developed and is 0.78 m tall with a cover of 55 %. This relatively low cover is due to the large area covered by rock. Although the vegetation is not very dense, this community is relatively rich in species. An average of 42 species ws recorded per sample plot.

The following grasses are prominent in this community: *Eustachys paspaloides*, *Brachiaria serrata*, *Eragrostis racemosa*, *E. curvula*, *E. superba*, *Setaria flabellata*, *Elionurus muticus*, *Themeda triandra*, *Digitaria eriantha*, *Cymbopogon plurinodis*, *Rhynchelytrum repens* and *Cynodon dactylon*. Prominent forbs include *Crabbea angustifolia*, *Plexipus hederaceus*, *Mariscus indecorus*, *Salvia radula*, *Senecio coronatus*, *Tylosema esculentum*, *Tephrosia lupinifolia*, *Elephanthorrhiza elephantina*, *Acalypha angustifolia*, *Pygmaeothamnus zeyheri*, *Oxygonum dregeana*, *Justicia anagalloides*, *Cassia mimosoides*, *Vernonia oligo-*

cephala, Barleria macrostegia, Anthospermum hispidulum, Senecio venosus, Lactuca serriola, Crabbea acaulis and *Hermannia depressa*.

1.3 The Rhus pyroides Shrub and Woodland

This community represents most of the woody plant communities within the study area. All these communities are restricted to specific habitat conditions, which usually relate to one or other form of disturbance. The encroachment of woody species into grassland areas as a result of disturbance is mentioned by FRIEDEL (1987), BREDENKAMP, JOUBERT & BEZUIDENHOUT (1989) and BREDENKAMP & BEZUIDENHOUT (1989).

The *Rhus pyroides* Shrub and Woodland is characterized by species group I, which includes the following woody and semi-woody species: *Rhus pyroides, Protasparagus laricinus, P. suaveolens, Grewia flava, Diospyros lycioides* and *Celtis africana*.

Three distinct communities were identified.

1.3.1. The Rhus pyroides-Acacia karroo Woodland

This woodland typically occurs on the footslopes or midslopes of the prominent chert ridges. The soils are relatively deep with regard to other soils of the dolomitic region, and also less rocky as stones cover less than 10 % of the soil surface. This community is rare in the dolomitic area, but is related to similar, more widespread *Acacia karroo* Woodland communities described from deeper clayey alluvial or colluvial soils on gradual footslopes of quartzite hills and ridges (BREDENKAMP, JOUBERT & BEZUIDENHOUT 1989; BREDENKAMP & BEZUIDENHOUT 1989). As mentioned by the latter authors, the encroachment of *Acacia karroo* Woodland into areas not previously occupied by woody vegetation, and the increase of *Acacia karroo* and associated species in areas where they have held a subordinate position in the floristic composition, hamper the habitat interpretation of this community. This encroachment is usually due to overgrazing or other forms of disturbance of the vegetation.

The diagnostic species (species group H) which characterize this community, are *Acacia karroo, Gomphrena celosioides* and *Ziziphus mucronata* (Table 1). An average of 39 species was recorded per sample plot.

The tree stratum is well developed with a cover of 22 % and a height of 5.8 m. The trees include the diagnostic *Rhus pyroides* and *Acacia karroo* with *Acacia caffra, Celtis africana* and *Ziziphus mucronata* also prominently present. The shrub layer covers 12 % of the area and is 2.4 m tall. Prominent shrubs include *Grewia flava* and smaller individuals of the tree species *Rhus pyroides*, and *Ziziphus mucronata*. The semi-woody shrubs *Protasparagus laricinus* and *P. suaveolens* are also typically present in the shrub layer. The presence of these two species emphasize the degraded state of the vegetation (see also FRIEDEL 1987 and BREDENKAMP, JOUBERT & BEZUIDENHOUT 1989).

The herbaceous layer is degraded and has a ground cover of only 50 %. Prominent grasses are *Setaria flabellata, Heteropogon contortus, Triraphis an-*

dropogonoides, *Eragrostis curvula*, *E. superba*, *E. lehmanniana*, *Elionurus muticus*, *Themeda triandra*, *Digitaria eriantha*, *Aristida congesta*, *Cymbopogon plurinodis* and *Cynodon dactylon*. Forbs that are also present in this community are *Gomphrena celosioides*, *Justicia anagalloides*, *Cassia mimosoides*, *Vernonia oligocephala*, *Barleria macrostegia*, *Raphionacme hirsutus* and *Anthospermum hispidulum*.

1.3.2 The Eustachys paspaloides-Rhus pyroides Secondary Savanna

This community is associated with ruins and debris of old diamond diggings. These ruins cover a large area of an ancient river valley, which is now situated in an extensive, slightly concave depression on the usually high-lying area of the dolomitic region. The *Eustachys paspaloides-Rhus pyroides* Secondary Savanna is specifically restricted to this habitat (Fig. 4). Surface rock is usually the old diamond mine debris. The soils were overturned and disturbed by the diggings, and are therefore deeper and have a higher clay content than the soils normally found in the upland dolomitic region.

The simultaneous presence of species groups E and I characterize this community (Table 1). Distinctive species are *Eustachys paspaloides*, *Crabbea angustifolia*, *Mariscus indecorus*, *Salvia radula*, *Rhus pyroides*, *Grewia flava*, *Protasparagus laricinus*, *P. suaveolens*, *Diospyros lycioides* and *Celtis africana*. An average of 38 species was recorded per sample plot.

The tree stratum covers 12.5 % of the area and is 4.5 m tall. The most prominent trees are *Rhus pyroides* and *Celtis africana*. The shrub layer is well developed, 2.5 m tall, with a cover of 17 %. Shrubs present in this community are *Rhus pyroides*, *Grewia flava* and *Diospyros lycioides* as well as the semi-woody *Protasparagus laricinus* and *P. suaveolens*.

The herbaceous layer covers 50 % and is 0.85 m tall. The most prominent grass species are *Eustachys paspaloides*, *Heteropogon contortus*, *Eragrostis curvula*, *Cymbopogon plurinodis*, *Rhynchelytrum repens* and *Eragrostis superba*. The following forbs occur constantly in this plant community: *Crabbea angustifolia*, *Plexipus hederaceus*, *Mariscus indecorus*, *Bulbostylis burchellii* and *Cyperus* spp.

1.3.3 The Protasparagus suaveolens-Rhus pyroides Woodland

The *Protasparagus suaveolens-Rhus pyroides* Woodland is usually associated with sinkholes in the high-lying dolomitic region. These sinkholes are characteristically present in areas underlain by dolomite. The older sinkholes are deeper or shallower depressions, often filled with aeolian sand or alluvial clayey soils. On the edges of the holes rocky outcrops of dolomite usually occur.

The presence of species group I and the absence of species group E and H characterize this community. An average of 39 species was recorded per sample plot. The following species are the main components of species group I: *Rhus pyroides*, *Protasparagus laricinus*, *P. suaveolens*, *Grewia flava*, *Diospyros lycioides* and *Celtis africana*.

The tree stratum is well developed, 5.5 m tall, covers 35 % and is dominated by *Rhus pyroides*, *R. lancea*, *Acacia karroo* and *Celtis africana*. The shrub stratum is also well developed, 2.5 m tall, covers 35 % and is dominated by *Rhus pyroides*, *Diospyros lycioides*, *Grewia flava*, *Protasparagus laricinus* and *P. suaveolens*. The presence of some of these species suggests an affinity to temperate forests (ACOCKS 1988).

The herbaceous layer covers 58 % and is 0.45 m tall. Prominent grasses are *Triraphis andropogonoides*, *Eragrostis curvula*, *E. lehmanniana*, *Themeda triandra*, *Digitaria eriantha*, *Cymbopogon plurinodis* and *Cynodon dactylon*. Typical forbs present in this community are *Helichrysum rugulosum*, *Justicia anagalloides*, *Vernonia oligocephala*, *Anthospermum hispidulum*, *Crabbea acaulis*, *Hermannia depressa* and *Sida dregei*.

2 The Themeda triandra-Hyparrhenia hirta Grassland Major Community

This major community represents azonal marsh-like vegetation and is present in depressions, valley floors or other bottomland situations in the dolomitic region. These bottomland situations have soils with a higher clay content than those of upland areas. Soil types include the Valsrivier, Westleigh and Willowbrook forms (MACVICAR et al. 1977). The area has poor drainage regime.

Species group K characterizes this community (Table 1) and diagnostic species are *Hyparrhenia hirta*, *Helichrysum rugulosum*, *Verbena bonariensis* and *Walafrida densiflora*.

Two variations of this community were distinguished.

2.1 The Eragrostis curvula-Hyparrhenia hirta Grassland

This community is found on the drier, slightly raised areas in the low-lying floodplains, and can be identified by the absence of species group J (Table 1). These areas are often heavily grazed by cattle and sheep. An average of 36 species was recorded per sample plot.

Both tree and shrub layers are absent. The herbaceous layer is well developed, is 0.95 m tall and covers 60 %. The most prominent grass species are *Hyparrhenia hirta*, *Setaria flabellata*, *Triraphis andropogonoides*, *Trichoneura grandiglumis*, *Eragrostis curvula*, *E. gummiflua*, *Themeda triandra*, *Digitaria eriantha*, *Aristida congesta*, *Rhynchelytrum repens* and *Cynodon dactylon*. Prominent forbs are *Helichrysum rugulosum*, *Verbena bonariensis*, *Walafrida densiflora*, *Cassia mimosoides*, *Vernonia oligocephala*, *Barleria macrostegia*, *Lactuca serriola*, *Crabbea acaulis*, *Helichrysum nudifolium* and *Hibiscus trionum*.

2.2 The Eragrostis plana-Hyparrhenia hirta Grassland

This bottomland grassland community occurs on seasonally wet, poorly drained, clayey soils. This habitat is fairly unstable due to seasonal flooding and drying, which together with the frequent overgrazing of these sites causes the advanced state of degradation of the vegetation.

Species group J is characteristic of this community, and diagnostic species include *Sckhuhria pinnata*, *Eragrostis plana*, *Paspalum dilatatum*, *Chloris pycnothrix* and *Berkheya* sp. An average of only 27 species was recorded per sample plot.

The tree stratum is absent while *Rhus pyroides* is the most prominent shrub in a poorly developed shrub layer. Shrubs cover less than 5 % and are about 1.5 m tall. Shrubs of *Acacia karroo* and *Protasparagus laricinus* are also present in the shrub layer.

The herbaceous layer is well developed, covers 68 % and is 0.98 m tall. The prominent grasses are the hygrophilous *Eragrostis plana*, *Paspalum dilatatum* and *Setaria sphacelata* and also *Chloris pycnothrix*, *Eragrostis curvula*, *Hyparrhenia hirta*, *Themeda triandra* and *Aristida congesta*. The forbs that occur in this community are *Schkuhria pinnata*, *Berkheya* sp., *Anthospermum hispidulum*, *Crabbea acaulis*, *Helichrysum nudifolium* and *Commelina africana*.

Concluding remarks

The aim of this study was to identify, characterize and interpret ecologically, by using habitat properties, the major vegetation units and their variations that occur in the dolomitic region of the western Transvaal, South Africa. As ecologically sound plant communities were distinguished in this reconnaissance survey, the general description and proposed classification of the vegetation should serve as a basis for further detailed phytosociological investigations in the western Grassland Biome. The descriptions and ecological interpretations of the distinguished plant communities contribute significantly to the present knowledge of the western Transvaal grasslands, and should contribute to the ultimate goal of a comprehensive syntaxonomical synthesis for the South African grasslands.

Acknowledgement. The Foundation for Research Development, Council for Scientific and Industrial Research is thanked for financial assistance. Part of this research was used for a M.Sc.-dissertation at the Potchefstroom University for Christian Higher Education.

References

Acocks, J.P.H. (1988): Veld types of South Africa. - Mem. Bot. Surv. S. Afr. 57: 1–146.

Behr, C.M. & Bredenkamp, G.J. (1988): A phytosociological classification of the Witwatersrand National Botanic Garden. - S. Afr. J. Bot. 54: 525–533.

Bezuidenhout, H. (1988): 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. - M.Sc.-thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

Bosch, O.J.H. & Janse van Rensburg, F.P. (1987): Ecological status of species on grazing gradients on the shallow soils of the western grassland biome in South Africa. - J. Grassl. Soc. South. Afr. 4: 143–147.

Bredenkamp, G.J. & Bezuidenhout, H. (1989): The vegetation of the Faan Meintjes Nature Reserve, Transvaal. - S. Afr. J. Bot. 56.

Bredenkamp, G.J., Joubert, A.F. & Bezuidenhout, H. (1989): A reconnaissance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area. - S. Afr. J. Bot. 55: 199–206.

Bredenkamp, G.J. & Theron, G.K. (1978): A synecological account of the Suikerbosrand Nature Reserve. 1. The phytosociology of the Witwatersrand geological system. - Bothalia 12: 513–529.

Coetzee, B.J. (1972): 'n Plantsosiologiese studie van die Jack Scott-natuurreservaat. - M.Sc.-thesis, University of Pretoria, Pretoria.

— (1974): A phytosociological classification of the Jack Scott Nature Reserve. - Bothalia 11: 329–374.

Du Toit, A.C. (1954): The geology of South Africa. - Oliver & Boyd, Edinburgh.

Friedel, M.H. (1987): A preliminary investigation of the woody plant increase in the western Transvaal and implications for veld assessment. - J. Grassl. Soc. South. Afr. 4: 25–30.

Gibbs-Russell, G.E., Reid, C., Van Rooy, J. & Smook, L. (1985): List of species of Southern African plants. Ed. 2 Part 1. - Mem. Bot. Surv. S. Afr. 51: 1–152.

Gibbs-Russell, G.E. & co-workers (1987): List of species of Southern African plants. Ed. 2 Part 2. - Mem. Bot. Surv. S. Afr. 56: 1–270.

Hill, M.O. (1979): TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. - Cornell University, New York.

Kruger, J.A. (1971): 'n Ekologiese odersoek van die plantegroei van die plaas Somerville 53 en omgewing, met besondere aandag aan bodemkundige aspek. - M.Sc.-thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

Land Type Survey Staff (1984): Land types of the maps 2626 West Rand and 2726 Kroonstad. - Mem. agric. nat. Resour. S. Afr. 4: 1–441.

Louw, W.J. (1951): An ecological account of the vegetation of the Potchefstroom area. - Mem. Bot. Surv. S. Afr. 24: 1-105.

MacVicar, C.N. & co-workers (1977): Soil classification - A binomial system for South Africa. - Dept. Agricultural-technical services, Pretoria.

Mentis, M.T. & Huntley, B.J. (1982): A description of the Grassland Biome Project. - S. Afr. Nat. Sci. Prog. 62: 1–29.

Morris, J.W. (1973): Automatic classification and ecological profiles of south-western Transvaal Highveld grassland. - Ph.D.-thesis, University of Natal, Pietermaritzburg.

— (1977): Automatic classification of the Highveld grassland of Lichtenburg, south-western Transvaal. - Bothalia 12: 547–551.

Mueller-Dombois, D. & Ellenberg, H. (1974): Aims and methods of vegetation ecology. - Wiley, New York.

Van Rooyen, N., Theron, G.K. & Grobbelaar, N. (1981): A floristic description and structural analysis of the plant communities of the Punda Milia-Pafuri-Wambiya area in the Kruger National Park. 1. The hygrophilous communities. - J. S. Afr. Bot. 47: 213–246.

Van Wyk, S. (1983): 'n Plantekologiese studie van die Abe Bailey-natuurreservaat. - M.Sc.-thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

Van Wyk, S. & Bredenkamp, G.J. (1986): 'n Braun-Blanquet-klassifikasie van die plantegroei van die Abe Bailey-natuurreservaat. - S. Afr. J. Bot. 52: 321-331.

Weather Bureau (1988): Climate of South Africa. - WB 40: 1–475. Government Printer, Pretoria.

Addresses of the authors:
(Please address all correspondence to the second author.)
Mr. H. Bezuidenhout, Grassland Research Centre, c/o Highveld Agricultural Region, Private Bag x804, Potchefstroom, 2520, Republic of South Africa.
Prof. G.J. Bredenkamp, Dept. of Botany, University of Pretoria, Pretoria, 0002, Republic of South Africa.

5.2 **Plantegroeiklassifikasie van die A-landtipe van die Mooirivieropvanggebied, Transvaal.**

Page

* Published: *S.A. Tydskrif vir Natuurwetenskap en Tegnologie* 10(1): 4 - 11.

 ISSN 0254-3486 = *S.A. Tydskrif vir Natuurwetenskap en Tegnologie* **10**, no. 1 1991

Plantegroeiklassifikasie van die A-landtipe van die Mooirivier-opvanggebied, Transvaal

H. Bezuidenhout*
Navorsingsentrum vir Weiding, Privaatsak X05, Lynn East 0039

G.J. Bredenkamp
Departement Plantkunde, Universiteit van Pretoria, Pretoria 0001

Ontvang 20 Februarie 1990; aanvaar 7 November 1990

UITTREKSEL

Die doel van hierdie studie was om hoofplantegroei-eenhede en hulle variasies, van die A-landtipe, te identifiseer, karakteriseer en aan die hand van die habitat ekologies te interpreteer. Vyf plantgemeenskappe is deur die toepassing van 'n numeriese klassifikasie en Braun-Blanquet-prosedures geïdentifiseer en elk is met 'n spesifieke habitat gekorreleer. 'n Duidelike onderskeid is tussen die hoogliggende en die laagliggende plantgemeenskappe gemaak. Plantegroeigradiënte en geassosieerde gradiënte in habitat is deur toepassing van 'n ordeningstegniek geïdentifiseer. Die studie beklemtoon die belangrikheid van topografie en grondtipe vir die afbakening van plantegroei-bestuurseenhede vir boerdery of natuurbewaring.

ABSTRACT

Classification of the vegetation of the A land type in the Mooi River catchment area, Transvaal

The aim of this study was to identify, characterize and interpret ecologically, by using habitat characteristics, the major vegetation units and their variations of the A land type. Five plant communities were successfully distinguished by applying a numerical classification and Braun-Blanquet procedures. The plant communities could easily be correlated with specific habitat types. A clear distinction could be made between plant communities of the upland and lowland areas. Vegetation gradients and associated gradients in habitat were identified by using an ordination technique. The study emphasized the importance of topography and soil type for the delimitation of management units for farming or nature conservation practices.

INLEIDING

Kennis oor die plantegroei van die grasveldbioom het belangrik geword met die inisiëring van die grasveldbioomprojek.[1] As deel van hierdie projek is 'n aantal navorsingsprogramme in die westelike deel van die grasveldbioom geïnisieer en uitgevoer.[3, 4 en 5] Die identifisering van die hoof- en subplantegroeitipes wat in die grasveldbioom aangetref word, en die bepaling van die omvang en die grootte van elke tipe geniet telkens die hoofklem.[1, 23]

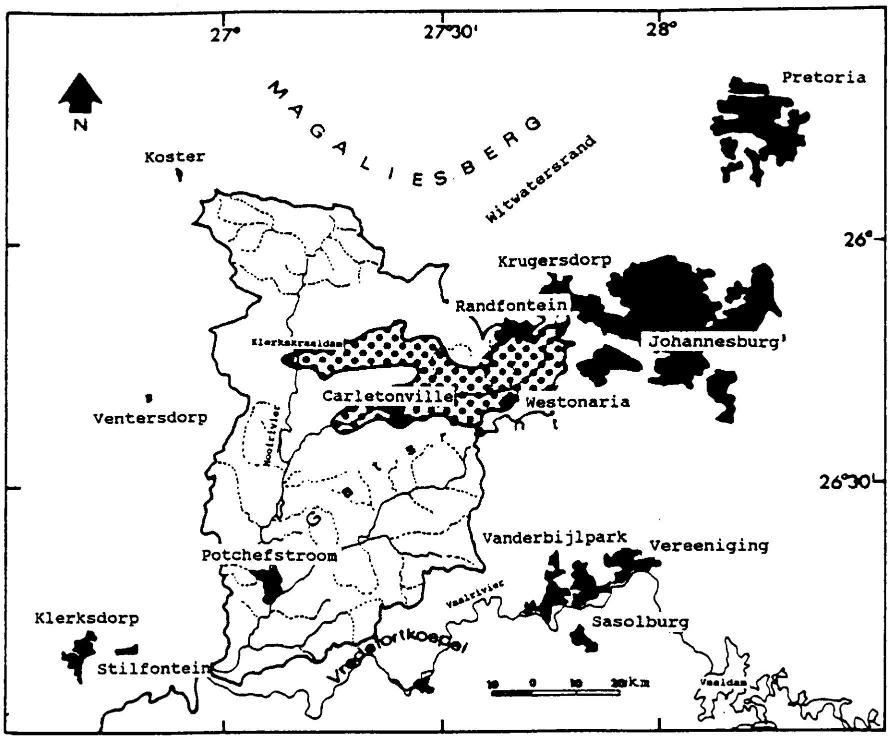
Om sinvolle aanbevelings oor bestuurspraktyke te kan maak, is dit noodsaaklik dat 'n grondige kennis van die ekologie van die gebied verkry word.[6] Die daarstelling van relatief homogene plantegroei-cum-habitat-eenhede behoort 'n wetenskaplik gebaseerde riglyn te verskaf vir die afbakening van homogene bestuurseenhede.

Daar is min oor die plantegroei van die A-landtipe bekend. Van Wyk en Bredenkamp[10] het 'n lokale studie op die Abe Bailey-natuurreservaat, op die dolomietveld, wat aan die westekant van die gebied grens, uitgevoer. Louw[11] bied 'n oorsigtelike verslag oor die plantegroei van die Potchefstroomgebied aan. Uit die studie van die Mooirivieropvanggebied[5] het dit geblyk dat die plantegroei van die landtipes in 'n mindere of meerdere mate van mekaar verskil.

Verder: weens die feit dat die natuurlike plantegroei van die A-landtipe tot 'n groot mate deur die maak van landerye vernietig is en verteenwoordigende plantgemeenskappe dus bedreig is, behoort 'n studie van die plantegroei van hierdie landtipe lig te werp op die identifikasie van moontlike bewaringsgebiede

STUDIEGEBIED

Die ligging van die A-landtipe in die Mooirivieropvanggebied word in figuur 1 aangedui. 'n Landtipe word as 'n eenheid gedefinieer op 'n skaal van 1:250 000, wat eenvormig is ten opsigte van terreinvorm, grondpatrone en klimaat. Grondtipes wat in die A-landtipe voorkom, is oorwegend rooi en goedgedreineer. Die A-landtipe beslaan ongeveer 73 750 hektaar en is tussen 1 350 en 1 450 m bo seespieël geleë.[2] Die A-landtipe word hoofsaaklik deur chert en dolomietgesteentes van die Chuniespoort Groep (Transvaal Opeenvolging) onderlê. Bo-op die gesteentes is meestal diep, rooi apedale (struktuurlose) grond neergelê.[2] Volgens Köppen se klassifikasiesisteem word die gebied as 'n BS-klimaat – dit is 'n koel, droë steppe met somerreëns – beskryf.[7] Groot klimaatskontraste tussen somer en winter en uiterstes soos droogtes, oorstromings, hael en ryp is kenmerkend van die streek.[8] Die gemiddelde



FIGUUR 1: Die ligging van die studiegebied (kolletjies) in die Mooirivieropvanggebied.

jaarlikse reënval (aangeteken oor 'n periode van ten minste tien jaar) wissel van Randfontein 732 mm, Carletonville 670 mm, en Klerkskraal 573 mm per jaar.[9] Gedurende die somermaande, veral Januarie en Desember, is die gemiddelde daaglikse maksimum temperature meer as 30° C, terwyl die lae gemiddelde daaglikse minimum temperature van −4° C[9] 'n aanduiding is van die temperatuuruiterstes wat oor 'n jaar aangeteken is.

Die Glenrosa-, Mispah- en Huttongrondvorms[16] is dominant in die A-landtipe. Die Mispah- en Glenrosavorms is dominant teen en bo-op die heuwels, terwyl die Huttonvorm die dominante grondtipe op die vlaktes is (figuur 3). Die vlaktes, wat naastenby 90% van die landtipe uitmaak, verteenwoordig meestal akkerbougrond wat geploeg word, en gevolglik is natuurlike plantegroei meestal tot vlakker grond op die chert- en kwartsietheuwels en riwwe beperk.[2] Volgens Acocks[12] se klassifikasie verteenwoordig die gebied die sentrale variasie van die Bankenveld.

METODES

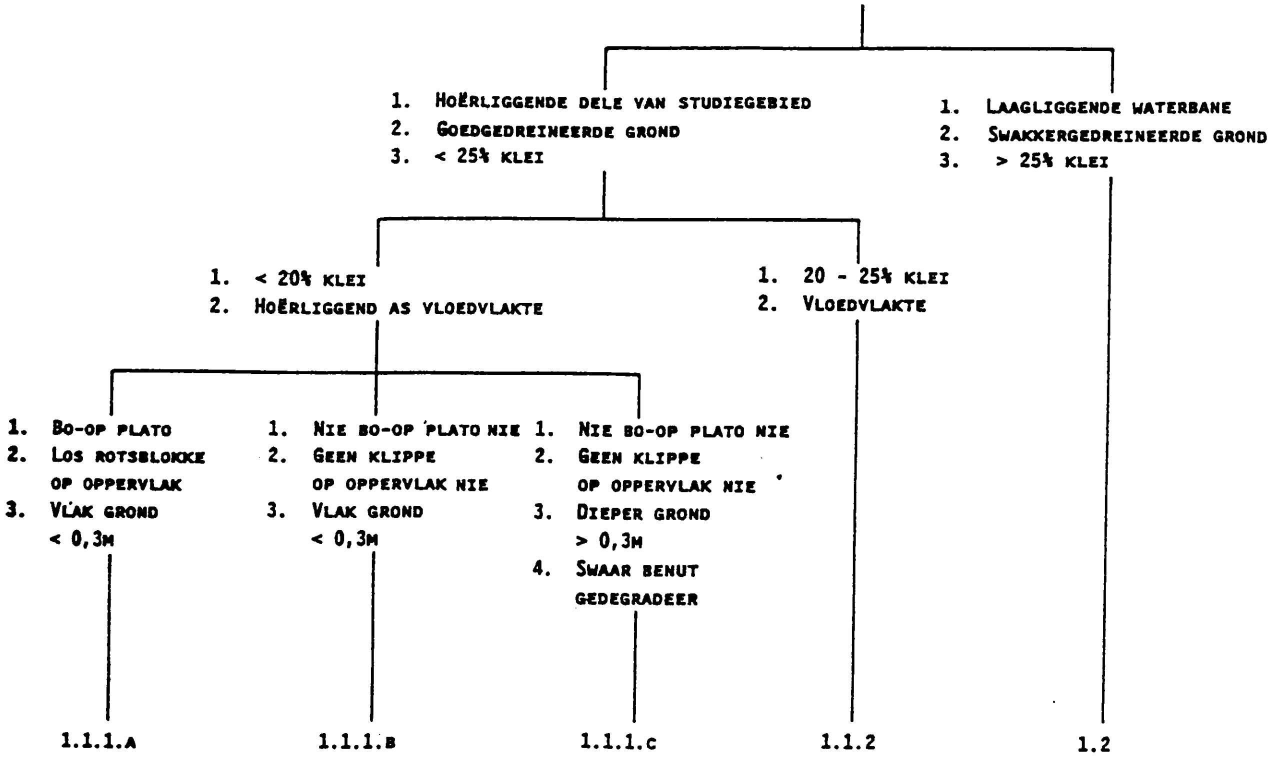
Landtipe-eenhede[2] is as eerste stratifisering van die Mooirivieropvanggebied gebruik, ten einde die plantegroei doeltreffend te monster.[5] In hierdie omvattende studie is vyf landtipes onderskei. Die natuurlike plantegroei op die A-landtipe is hoofsaaklik tot vlakker, ongeploegde grond beperk. Weens die beperkte verspreiding van hierdie plantegroei verteenwoordig slegs 15 uit 'n totaal van 222 monsterpersele die plantegroei van die A-landtipe. Die gebied is verder gestratifiseer op grond van terreinvorm en homogene plantegroei, sodat alle ekotope[18] met natuurlike plantegroei verteenwoordigend gemonster is.

Die monsterpersele is ewekansig in die eenhede uitgeplaas. Plantegroei-opnames is volgens die Braun-Blanquet-prosedure uitgevoer.[13] In elke monsterperseel is 'n volledige floristiese opname gemaak. Bedekkinggetalsterktewaardes is soos volg vir elke plantspesie wat in die perseel aangetref is, volgens die Braun-Blanquet-bedekkinggetalsterkteskaal[14] aangeteken:

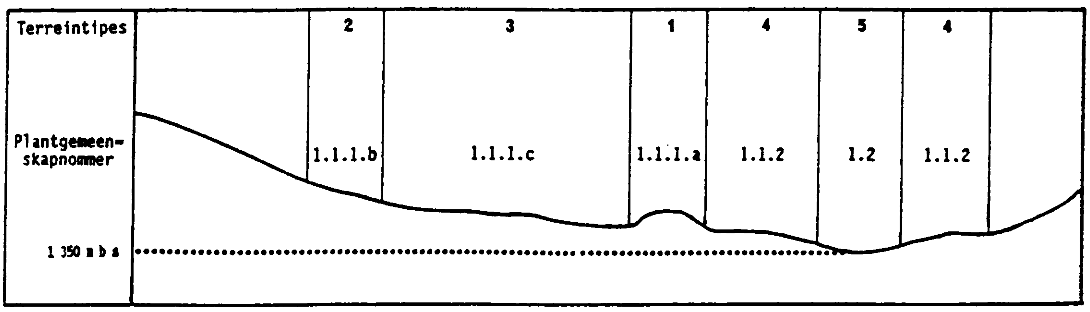
R – teenwoordig, maar nie volop nie, met 'n kroonbedekking van minder as 1% van die monsterperseeloppervlakte.
\+ – volop, met 'n kroonbedekking van tussen 1% en 5% van die monsterperseeloppervlakte.
1 – enige aantal indiwidue met 'n kroonbedekking van groter as 5% tot 12% van die monsterperseeloppervlakte.
2 – enige aantal indiwidue met 'n kroonbedekking van groter as 12% tot 25% van die monsterperseeloppervlakte.
3 – enige aantal indiwidue met 'n kroonbedekking van groter as 25% tot 50% van die monsterperseeloppervlakte.
4 – enige aantal indiwidue met 'n kroonbedekking van groter as 50% tot 75% van die monsterperseeloppervlakte.
5 – enige aantal indiwidue met 'n kroonbedekking van meer as 75% van die monsterperseeloppervlakte. Hierdie bedekkinggetalsterktewaardes vorm die matriks van tabel 1.

Verder is gemiddelde hoogte en kroonbedekking van die boom-, struik- en kruidstratum addisioneel in die persele aangeteken. Die habitatopname sluit tipe gesteente, aspek, persentasie klipperigheid van die grondoppervlak en ook grondtipe in. Meer inligting oor die grondtipes is uit die literatuur[2,8] verkry.

In 'n poging om sinvolle, ekologies verantwoorde plantgemeenskappe te onderskei, is die floristiese datastel aan 'n numeriese klassifikasie, naamlik Tweerigting-spesie-indikator-analise (TWINSPAN)[15] onderwerp. Die resultaat is deur die toepassing van die Braun-Blanquet-prosedure verfyn en die finale resultaat van die klassifikasie word as 'n fitososiologiese tabel aangebied. Die plant-



FIGUUR 2: 'n Ekologiese interpretasie van die plantgemeenskappe van die A-landtipe in die Mooirivieropvanggebied.



FIGUUR 3: 'n Terreinvormskets van die A-landtipe met die posisie van die onderskeie plantgemeenskappe.

gemeenskappe wat onderskei is, is hierna aan die hand van die beskikbare habitatdata ekologies geïnterpreteer. Met behulp van 'n terreinvormskets word die ligging van die plantgemeenskappe in die landskap aangedui. Die name van taksons is in ooreenstemming met Gibbs Russell et al.[19,20] Daar is egter 'n onderskeid gemaak tussen *Setaria flabellata* Stapf. en *Setaria sphacelata* (Schumach.) Moss. Hierdie twee taksons word in Gibbs-Russell et al.[19] as 'n enkele spesie beskou. Plantegroeigradiënte met geassosieerde gradiënte in habitat is deur middel van 'n indirekte gradiëntanalise, naamlik ontneigde ooreenstemminganalise (DECORANA)[21] bepaal. Die beskrywing van die plantgemeenskappe is in ooreenstemming met die Internasionale Kode van Sintaksonomie,[22] maar sintaksonrange word nie aan die gemeenskappe toegeken nie, weens te min inligting oor die grasveld in die geheel.

RESULTAAT

Die plantegroei van die A-landtipe word as 'n *Eragrostis curvula-Themeda triandra*-grasveld beskou. Die afwesigheid van 'n boomstratum sowel as struikstratum is 'n kenmerk van die meeste van die plantgemeenskappe in die A-landtipe. Hierdie grasveld word deur spesiegroep 12 gekarakteriseer (tabel 1). Die prominente spesies is die grasse *Eragrostis curvula* en *Themeda triandra*, terwyl kruide soos *Salvia radula*, *Crabbea acaulis* en *Helichrysum nudifolium* dikwels aangetref word. Die ontleding van die floristiese data het tot die identifikasie van vyf plantgemeenskappe gelei, wat op grond van twee hoofhabitattipes geskei kan word. Hierdie onderverdeling van die plantegroei in effens hoërliggende, droër gebiede en die relatief laerliggende vloedgebiede en valleivloere met waterbane word in die dendrogram (figuur 2) geïllustreer. Die vol-

TABEL 1

'n Fitososiologiese tabel van die A-landtipe in die Mooirivieropvanggebied

Relevès	146	161	172	170	162	171	177	179	175	151	178	147	145	209	174
SPESIEGROEP 1															
Eragrostis racemosa	2	+		2	+	2	+								
Mariscus indecorus	+	+		+		+	+	+		+	+		+		
Brachiaria serrata	+		+	2	+		+	+			+				
Elephantorrhiza elephantina		+	+	+	+	+	+	+		2					
Trachypogon spicatus	5		+	+	+	+		+		+					
SPESIEGROEP 2															
Acalypha angustata	+	+			+	+	+								
Leucas capensis	+	+	+									+	+		
Lightfootia denticulata	+	+											+		
Schizachyrium sanguineum	4														
Stachys spathulata		4													
SPESIEGROEP 3															
Cyperus spesie		+	+	+	+					+	2				
Sphenostylis angustifolia			+	+	+	+									
Dianthus mooiensis	+			+	+					+					
SPESIEGROEP 4															
Eustachys paspaloides		+			+		+	+		+	+				
Ziziphus zeyheriana		+					+	+	+		+				
Protasparagus suaveolens									+	+					
Rhus pyroides									3	+					
Gnidia capitata				+				+	+		2				
Cymbopogon plurinodis								+	+						
Tristachya leucothrix						+			+						
SPESIEGROEP 5															
Felicia muricata				+	+	+	+	+				+			
Oxygonum dregeanum				+	+		+			+					
Raphionacme hirsuta					+	+	+	+							
SPESIEGROEP 6															
Aristida congesta			+					+			2	+	+		
Aristida stipitata						+					+	+	+		
Eragrostis gummiflua											+	2	+		+
Crassula schimperi												+	+		
Dicoma anomala											+		+		
Eragrostis lehmanniana									+		+	+			
Helichrysum caespititium												+	+		
Hibiscus trionum											+		+		
Tylosema esculentum										+		+	+		
SPESIEGROEP 7															
Pollichia campestris						+	+		+			+	+		
Barleria macrostegia							+	+		3		+	+		
SPESIEGROEP 8															
Elionurus muticus	2	+	3	+	4		+	+		+	+	+	+		
Justicia anagalloides	+	+		+	+			+	+	+	+	+	+		
Setaria flabellata		+		2	2	+	2	2	2	+	+	+	+		
Vernonia oligocephala	+	+			+	+	+	+	+	+	+				
Senecio venosus	+	+		+	+	+	+					+	+		
Pygmaeothamnus zeyheri		+	+	+	+		+	+			+	+	+		
Crabbea angustifolia	+	+			+			+	+		+	+			
Cyanotis speciosa	+				+	+				+	+				
SPESIEGROEP 9															
Eragrostis plana									+	+				3	4
Setaria sphacelata	+													2	2
Schkuhria pinnata									+					+	+
Senecio coronatus	+	+				+								+	+
Tephrosia semiglabra								+						+	+
Verbena bonariensis														+	+
Oenothera rosea															+
Berkheya radula														+	
SPESIEGROEP 10															
Lactuca serriola						+		+	+	+				+	
Oxalis spesie						+	+		+					+	
Scabiosa columbaria						+			+	+					+
Eragrostis capensis						+		+						+	+
Helichrysum rugulosum						+			+						+
Sida dregei								+	+					+	
SPESIEGROEP 11															
Cynodon dactylon						+	+		+		+	+	+		+
Digitaria eriantha			+				+	+			+	+	+	+	+
Anthospermum hispidulum		+				+		+				+	+		+
Helichrysum callicomum								+						+	
SPESIEGROEP 12															
Eragrostis curvula	+	2	2	+	+	+	+		3	+	2	4	2	2	+
Helichrysum nudifolium	+	+		+	+	+	+	+		+		+	+	+	2
Themeda triandra		+	2	2		2	+	+	+	+	+	2	3	2	
Salvia radula		+					+	+		+	+		+	+	
Crabbea acaulis	+	+				+		+					+	+	
Cassia mimosoides		+		+	+			+			+		+		
Trichoneura grandiglumis						+					+	2			
Heteropogon contortus	+				+		+						+		
Thesium utile		+			+			+			+				+
Polygala hottentotta					+			+						+	
Hermannia lancifolia		+				+									
Pogonarthria squarrosa			+									+	+		
Becium obovatum				+			+		+						
Hermannia depressa						+			+						
Solanum panduriforme						+			+		+				

* **ALGEMENE OF NIE—DIAGNOSTIESE SPESIES WAT MINDER AS 3 KEER AANGETREF IS, IS NIE IN DIE TABEL INGESLUIT NIE.**

gende plantgemeenskappe is onderskei.

1.1 Die *Elionurus muticus-Themeda triandra*-grasveld op die hoërliggende, goedgedreineerde gebiede.

1.1.1 Die *Elionurus muticus-Themeda trianda-Trachypogon spicatus*-grasveld op vlak, klipperige grond of nie-klipperige, dieper, sanderige grond.

(a) *Lightfootia denticulata*-variant op vlak, klipperige grond bo-op die kruine van die bulte.

(b) *Sphenostylis angustifolia*-variant op vlak (< 0,3 m), nie-klipperige grond met harde rots of litokutaniese B-horison.[16]

(c) *Ziziphus zeyheriana*-variant op nie-klipperige, dieper (> 0,3 m), sanderige grond.

1.1.2 *Elionurus muticus-Themeda triandra-Aristida stipitata*-grasveld op nie-klipperige, kleierige grond.

1.2 Die *Eragrostis plana-Setaria sphacelata*-grasveld op die laerliggende, swakkergedreineerde waterbane.

BESPREKING

1.1 Die *Elionurus muticus-Themeda triandra*-grasveld.
Hierdie grasveld word op die hoërliggende, goedgedreineerde gebiede aangetref en beslaan die grootste gedeelte van die natuurlike plantegroei wat op die A-landtipe aangetref word. Opvallende spesies van die diagnostiese spesiegroep 8 is *Elionurus muticus* en *Setaria flabellata*, terwyl *Justicia anagalloides*, *Vernonia oligocephala*, *Senecio venosus*, *Pygmaeothamnus zeyheri*, *Crabbea angustifolia* en *Cyanotis speciosa* ook prominent aangetref word (tabel 1).

1.1.1 *Elionurus muticus-Themeda triandra-Trachypogon spicatus*-grasveld.
Hierdie gemeenskap word geassosieer met goedgedreineerde grond en word deur spesiegroep 1 (tabel 1) gekarakteriseer (tabel 1). Diagnostiese grasspesies is *Eragrostis racemosa, Trachypogon spicatus* en *Brachiaria serrata*, terwyl *Elephantorrhiza elephantina* en *Mariscus indecorus* diagnostiese kruidspesies is.

1.1.1 (a) Die *Lightfootia denticulata*-variant.
Die variant word bo-op die kruine van die lae bulte in die A-landtipe aangetref (nommer 1; figuur 3) en word deur spesiegroep 2 (tabel 1) gekarakteriseer. Diagnostiese spesies van die variant is *Acalypha angustata, Leucas capensis, Schizachyrium sanguineum, Stachys spathulata* en *Lightfootia denticulata*. 'n Gemiddeld van 35 spesies per monsterperseel is aangeteken. Die variant word ook soms op dolomietdagsome wat plate vorm, aangetref. Klein chert- en kwartsietklippe, saam met dolomietrotsblokke, bedek 40% van die grondoppervlak. 'n Aantal grondkenmerke word in tabel 2 weergegee. Die grondtipe wissel van 'n Mispah- tot 'n Glenrosavorm.[2] Die suur (pH 4,6), sanderige (5,1 — 10% klei) grond is vlak (200 mm) en is dus nie geskik vir ploeg nie. Die dreinering van die grond is goed en dit skep 'n droë habitat vir die plantegroei. Die natrium-, kalium-, kalsium- en magnesiuminhoud en die S-waarde is baie laag. Dit gee ook aanleiding tot die lae baseversadiging (tabel 2).

Die kruidstratum is goed ontwikkel, met 'n gemiddelde kroonbedekking van 60%. Die gemiddelde hoogte van die grasse en kruide is 0,9 m. Prominente grasspesies wat in die variant aangetref word, is *Trachypogon spicatus, Schizachyrium sanguineum, Eragrostis racemosa, Eragrostis curvula* en *Elionurus muticus*. Prominente kruide is *Mariscus indecorus, Acalypha angustata, Leucas capensis, Lightfootia denticulata, Helichrysum nudifolium* en *Stachys spathulata*. Die meeste van die spesies van spesiegroepe 1, 8 en 12 kom ook in hierdie variant voor.

TABEL 2
Grondkenmerke van die dominante grondvorms van die A-landtipe in die Mooirivieropvanggebied

Grondvorm	Rensburg	Hutton		Glenrosa
Grondserie	Rensburg (20)	Swartfontein (34)		Platt (14)
Gronddiepte (maks) (mm)	300	1 220		200
Terreintipe (figuur 3)	5	3		1
Totale uitruilbare katione (me/100g)	A-horison	A-horison	B-horison	A-horison
Na	0,4	0,1	0,1	0,2
K	0,2	0,1	0,1	0,1
Ca	>12,5	2,0	1,4	0,0
Mg	4,8	0,8	1,0	0,2
S-waarde	>17,9	3,0	2,6	0,5
Baseversadiging (100 g klei)	53,6	40,5	19,4	5,3
pH (H_2O)	6,6	5,5	5,7	4,6
Klei (%)	35,1 — 45	5,1 — 10	10,1 — 15	5,1 — 10

1.1.1 (b) Die *Sphenostylis angustifolia*-variant.
Hoewel die grond van die variant ook vlak en klipperig is, en dus nie geploeg kan word nie, is daar feitlik geen klippe op die grondoppervlak teenwoordig nie. Hierdie variant word deur nommer 2 op die terreinvormskets voorgestel (figuur 3). Die topografie is hier betreklik gelykliggend. Grondvorms wat by die monsterpersele aangetref is, is Glenrosa- en Huttonvorms. Die grond se dreinering is goed.

Soos in die geval van die vorige variant is die boom- en struikstratums ook afwesig. Die kruidstratum is goed ontwikkel en die gemiddelde hoogte van die prominente grasse en kruide is 0,85 m. Die gemiddelde kroonbedekking is 55%. Spesiegroep 3 (tabel 1) is tot 'n groot mate beperk tot die variant in die A-landtipe en die diagnostiese spesies is *Sphenostylis angustifolia, Dianthus mooiensis* en 'n *Cyperus*-spesie. Ander spesiegroepe wat ook in die variant voorkom, is spesiegroepe 1, 5, 8 en 12. Prominente grasse sluit *Elionurus muticus, Brachiaria serrata, Eragrostis racemosa, Trachypogon spicatus, Setaria flabellata, Eragrostis curvula* en *Themeda triandra* in. Kruide wat prominent in die variant vertoon, is *Elephantorrhiza elephantina, Felicia muricata, Oxygonum dregeanum, Sphenostylis angustifolia, Pygmaeothamnus zeyheri, Dianthus mooiensis* en 'n *Cyperus*-spesie. 'n Gemiddeld van 27 spesies is per monsterperseel aangeteken.

1.1.1 (c) Die *Ziziphus zeyheriana*-variant.
Volgens die strukturele klassifikasie van Edwards[17] kan hierdie variant as 'n yl struikveld beskou word. Die yl struikveld word in die A-landtipe op versteurde habitat aangetref. By die monsterpersele is miershope en meerkatgate aangetref. Die posisie van die variant (nommer 3; figuur 3) in die landskap stem baie ooreen met dié van die vorige variant, maar is oor die algemeen effens laer in die landskap geleë. Die nie-klipperige grond van die relevès verteenwoordig die Glenrosavorm en soms word Hutton- en Mispahvorms ook aangetref. Behalwe vir fyn ysterkonkresies kom daar geen of min oppervlakklip in die variant voor. Hoewel hierdie variant aan plantegroei van die klipperige grond (spesiegroep 5; tabel 1) verwant is, toon spesiegroepe 10 en 11 dat dié variant 'n floristiese verwantskap met die plantegroei van waterbane toon.

Die boomstratum word deur enkele *Acacia caffra*-bome met 'n hoogte van 6 m en 'n kroonbedekking van 20% verteenwoordig. Die boomstratum is veral by sinkgate opvallend, by die res van die variant is die boomstratum afwesig.

Die struikstratum, wat deur *Rhus pyroides* oorheers word, is gemiddeld 1,5 m hoog en het 'n gemiddelde kroonbedekking van 15%. Spesiegroep 4 (tabel 1) is diagnosties van die variant, terwyl spesiegroepe 1, 5, 7, 8, 10, 11 en 12 ook in die variant voorkom, maar nie beperk is tot die variant nie. Diagnostiese spesies sluit *Eustachys paspaloides, Ziziphus zeyheriana, Protasparagus suaveolens, Rhus pyroides, Gnidia capitata, Cymbopogon plurinodis* en *Tristachya leucothrix* in. *Acacia karroo* kom as 'n struik in die variant voor.

Die kruidstratum, met 'n gemiddelde hoogte van 0,6 m en 'n 65% kroonbedekking, is goed ontwikkel. Opvallende grasse soos *Setaria flabellata, Eragrostis curvula, Themeda triandra, Trachypogon spicatus, Eustachys paspaloides, Tristachya leucothrix, Elionurus muticus* en *Cymbopogon* *plurinodis* word in die variant aangetref. Twee grasspesies *Cynodon dactylon* en *Digitaria eriantha* (spesiegroep 11; tabel 1), meer tipies van laerliggende habitat, kom ook in die variant voor. Drie spesies, naamlik *Ziziphus zeyheriana*, *Protasparagus suaveolens* en *Elephantorrhiza elephantina*, is struikagtige spesies wat opvallend in die variant is. Prominente kruide soos *Raphionacme hirsuta*, *Barleria macrostegia*, *Justicia anagalloides*, *Scabiosa columbaria* en *Helichrysum nudifolium* word in die variant aangetref. 'n Gemiddeld van 36 spesies is per monsterperseel aangeteken.

Die teenwoordigheid van sekere spesies, byvoorbeeld *Felicia muricata*, *Ziziphus zeyheriana*, *Protasparagus suaveolens*, *Pollichia campestris* en *Cynodon dactylon* in die variant, toon aan dat dit versteurde en oorbeweide veld is.[3] Die effens dieper (> 0,3 m) grond van die variant verteenwoordig 'n wye verskeidenheid spesies, terwyl die teenwoordigheid van relatiewe smaaklike grasse soos *Eustachys paspaloides*, *Setaria flabellata*, *Digitaria eriantha*, *Eragrostis curvula* en *Themeda triandra* daarop dui dat die grasveld 'n goeie weidingspotensiaal kan hê.[4] Die variant se habitat is meestal versteur of andersins heeltemal vernietig, deurdat die grootste deel van die habitat geploeg is.

1.1.2. Die *Elionurus muticus-Themeda triandra-Aristida stipitata*-grasveld.

Die plantgemeenskap word langs die waterbane op die vloedvlaktes aangetref (nommer 4; figuur 3). Die topografie van die habitat is gelykliggend tot effens golwend. Die dominantste grondvorm in die plantgemeenskap is die Huttonvorm. Die klei-inhoud (10 − 15%) van die suur (pH 5,6) en dieper (> 1 200 mm) grond is hoër as dié van die vorige drie plantgemeenskappe. Die natrium-, kalium-, kalsium- en magnesiuminhoud sowel as die S-waarde is hoër as dié van die vorige plantgemeenskappe (tabel 2). Daar is geen klippe op die grondoppervlak nie. Spesiegroep 6 (tabel 1) is feitlik beperk tot hierdie plantgemeenskap en die diagnostiese spesies is *Aristida congesta*, *A. stipitata*, *Eragrostis gummiflua*, *E. lehmanniana*, *Helichrysum caespititium*, *Hibiscus trionum*, *Trichoneura grandiglumis* en *Tylosema esculentum*. Spesiegroepe 7, 8, 11 en 12 is ook goed in die plantgemeenskap verteenwoordig. 'n Groot verskeidenheid spesies, tussen 37 en 42, is per monsterperseel aangeteken.

Die boom- en struikstratum is hier afwesig. Die kruidstratum is gemiddeld 0,7 m hoog en die gemiddelde kroonbedekking is slegs 40%. Die prominente grasse in die stratum is *Eragrostis curvula*, *E. gummiflua*, *E. lehmanniana*, *Themeda triandra*, *Aristida congesta*, *A. stipitata*, *Trichoneura grandiglumis*, *Elionurus muticus*, *Setaria flabellata*, *Cynodon dactylon* en *Digitaria eriantha*. Die opvallendste kruide is *Dicoma anomala*, *Hibiscus trionum*, *Helichrysum caespititium*, *Crassula schimperi*, *Justicia anagalloides*, *Pygmaeothamnus zeyheri* en die rankerkruid *Tylosema esculentum*.

Die grond word meestal nie geploeg nie en die natuurlike plantegroei moet die vee dus dra. Gedurende die droë siklus waarin die opnames gemaak is, is die plantgemeenskap swaar bewei. Die lae ekologiese status[4] van 'n groot aantal van die diagnostiese spesies (spesiegroep 6; tabel 1) dui op die mate van oorbeweiding wat hier plaasgevind het.

1.2 Die *Eragrostis plana-Setaria sphacelata*-grasveld.

Hierdie plantgemeenskap is uitsluitlik beperk tot die relatief laagliggende waterbane van die A-landtipe. In figuur 3 dui die nommer 5 die ligging van die habitat aan. Die grondtipes wissel van 'n Rensburg- tot 'n Valsriviervorm.[16] Die minder suur (pH 6,6) en vlak (300 mm) grond wat hier voorkom, is kleieriger (35 − 45%) en is seisoenaal 'n natter habitat as by die vorige plantgemeenskappe. Die natrium-, kalium-, kalsium- en magnesiuminhoud en S-waarde is hoog. Dit gee aanleiding tot 'n hoë baseversadiging (tabel 2). Die topografie is liggolwend tot gelykliggend. Opvallend in die waterbane is die beperkte aantal spesies wat in die plantgemeenskap teenwoordig is. 'n Gemiddeld van slegs 23 spesies per monsterperseel is gevind. Spesiegroep 9 (tabel 1) is beperk tot die habitat van die plantgemeenskap en karakteriseer die plantgemeenskap. Diagnostiese spesies is *Eragrostis plana*, *Setaria sphacelata*, *Schkuhria pinnata*, *Senecio coronatus*, *Tephrosia semiglabra*, *Berkheya radula*, *Oenothera rosea* en *Verbena bonariensis*. Spesiegroepe 10, 11 en 12 word ook in die plantgemeenskap aangetref.

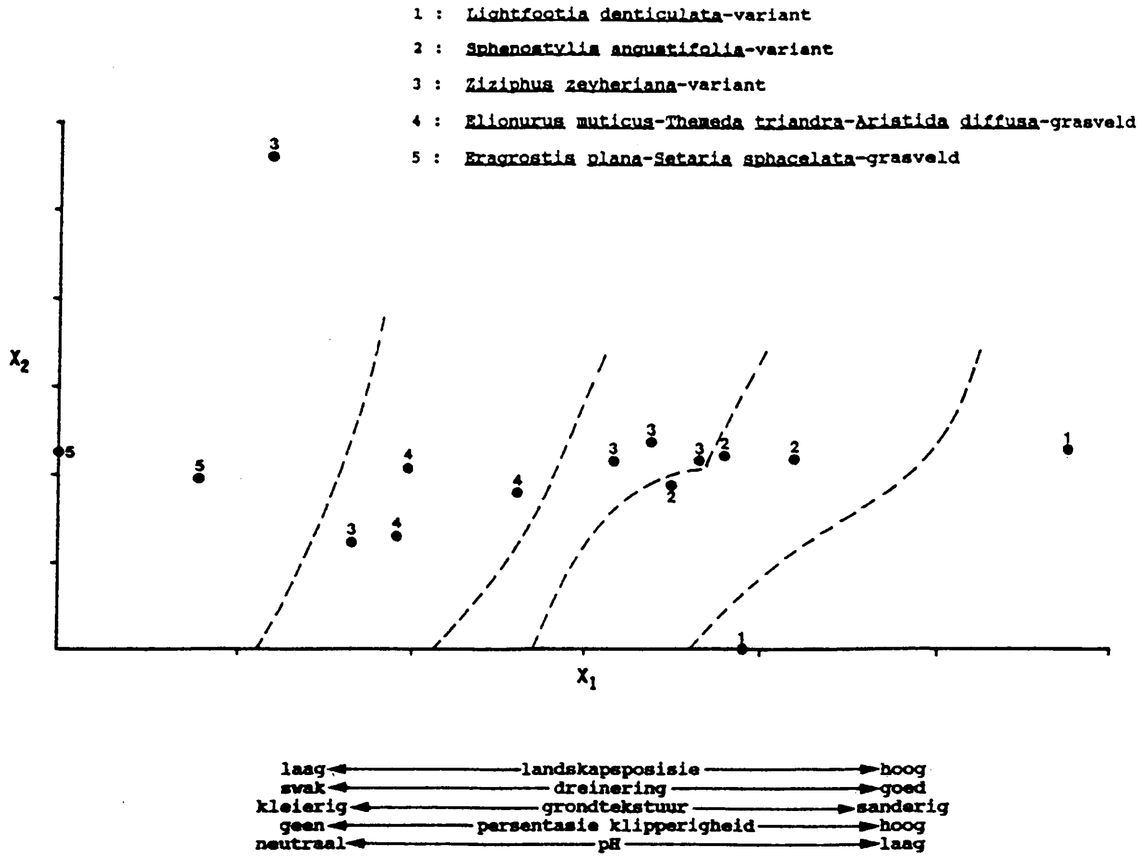
Geen struike of bome word in die plantgemeenskap aangetref nie. Die kruidstratum bedek 80 − 100% van die grondoppervlak. Die gemiddelde hoogte van die grasse is 0,65 m. Grasse is die dominante groeivorm in die kruidstratum van die plantgemeenskap. Die prominente grasse is *Eragrostis plana* en *Setaria sphacelata*. Ander grasse wat ook in die plantgemeenskap aangetref word, is *Eragrostis capensis*, *E. curvula*, *Themeda triandra*, *Digitaria eriantha* en *Cynodon dactylon*. Prominente kruide in die plantgemeenskappe is *Senecio coronatus*, *Schkuhria pinnata*, *Tephrosia semiglabra* en *Verbena bonariensis*.

Die teenwoordigheid van *Schkuhria pinnata* dui op 'n mate van versteuring wat deur oorbeweiding veroorsaak is. Die waterbane is geskik vir beweiding, is meestal naby water en word dikwels oorbewei.

ORDENING

Die verspreiding van die relevès langs die eerste en tweede asse van die ordening word in figuur 4 aangedui. Hoewel geen duidelike diskontinuïteit in die verspreiding van die relevès waargeneem kan word nie, is die onderskeie plantgemeenskappe tog tot sekere streke in die strooiingsdiagram beperk. Die opeenvolging van die plantgemeenskappe langs die eerste as van die ordening (figuur 4) kan geassosieer word met gradiënte in topografiese posisies, gronddiepte, grondtekstuur, dreinering, klipperigheid van die grondoppervlak en ook chemiese grondkenmerke soos pH (H_2O), baseversadiging, kalsiuminhoud van die grond en S-waarde (vergelyk tabel 2).

Die plantgemeenskappe wat na regs op die strooiingsdiagram geleë is, is op hoogliggende, goedgedreineerde, sanderige, suur grond met 'n lae kalsiuminhoud en lae S-waarde geleë. Daarenteen is die plantgemeenskappe wat na links op die diagram geleë is, geassosieer met 'n relatiewe laagliggende habitat met swakker gedreineerde, kleierige, minder suur grond met 'n hoër kalsium-inhoud en hoë S-waardes. Die gradiënte in habitat is dus geassosieer met die gradiënt in plantegroei, en is in ooreenstemming met die habitatinterpretasie wat in figuur 3 aangedui word.



FIGUUR 4: Die verspreiding van die onderskeie plantgemeenskappe langs die eerste en tweede asse van ordening, met geassosieerde habitatgradiënte teen die eerste as.

GEVOLGTREKKING

Ten spyte van die relatief min natuurlike plantegroei wat op die A-landtipe aangetref word, is die plantgemeenskappe wat onderskei is, ekologies verantwoordbaar en vorm dit deel van die basis vir plantegroeibestuurseenhede in die Mooirivieropvanggebied. Die studie beklemtoon die belang van topografie (topografiese posisie) en grondtipe vir die afbakening van plantgemeenskappe. Die ondersoek lewer ook 'n bydrae tot 'n omvattende hiërargiese klassifikasie van die grasveldbioom.

Erkenning

Die SNO word bedank vir finansiële steun om die projek te kan uitvoer.

Mev. D. Bezuidenhout, Dept. Plantkunde, Universiteit van Pretoria word bedank vir haar positiewe kommentaar op die manuskrip en ook die opstel van die figure.

LITERATUURVERWYSINGS

1. Mentis, M.T. & Huntley, B. (1982). A description of the Grassland Biome Project, *S. Afr. Nat. Sci. Prog. Report*, 62, (CSIR, Pretoria).
2. Landtipe-opnamepersoneel. (1984). Landtipes van die kaarte 2626 Wes-Rand, 2726 Kroonstad, *Memoirs oor die Natuurlike Landbouhulpbronne van Suid-Afrika*, 4, 1–441.
3. Bredenkamp, G.J., Joubert, A.F. & Bezuidenhout, H. (1989). A reconnaissance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area, *S. Afr. J. Bot.*, 55 (2), 199–206.
4. Bosch, O.J.H. & Janse van Rensburg, F.P. (1987). Ecological status of species on grazing gradients on shallow soils of the western grassland biome in South Africa, *J. Grassl. Soc. South. Afr.*, 4, 143–147.
5. Bezuidenhout, H. (1988). *'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal* (M.Sc.-verhandeling, PU vir CHO Potchefstroom).
6. Edwards, D. (1972). Botanical survey and agriculture, *Proceedings of the Grassland Society of South Africa*, 7, 15 – 19.
7. Schulze, R.E. & McGee, O.S. (1978). Climate indices and classifications in relation to the biogeography of Southern Africa. In *Biogeography and ecology of Southern Africa*, Werger, M.J.A. ed. Vol 1. (Junk, The Hague) p. 240.
8. Van Wyk, S. (1983). *'n Plantekologiese studie van die Abe Bailey-natuurreservaat* (M.Sc.-verhandeling, PU vir CHO, Potchefstroom).
9. Weerburo. (1988). Klimaat van Suid-Afrika, Staatsdrukker, Pretoria, WB 40, 1–475.
10. Van Wyk, S. & Bredenkamp, G.J. (1986). 'n Braun-Blanquet-klassifikasie van die plantegroei van die Abe Bailey-natuurreservaat, *S. Afr. J. Bot.*, 52, 321–331.
11. Louw, W.J. (1951). An ecological account of the vegetation of the Pochefstroom area, *Mem. Bot. Surv. S.Afr.*, 24, 1–105.
12. Acocks, J.P.H. (1975). Veld types of South Africa, *Mem. Bot. Surv. S. Afr.*, 40, 1–128.
13. Westhoff, V. & Van der Maarel, E. (1978). The Braun-Blanquet approach. In *Classification of plant communities*, Whittaker, R.H. ed. (Junk, The Hague) p. 399.

14. Mueller-Dombois, D. & Ellenberg, H. (1974). *Aims and methods of vegetation ecology* (Wiley, New York).
15. Hill, M.O. (1979). *TWINSPAN – a Fortran program for arranging multi-variate data in an ordered two way table by the classification of individuals and attributes* (Cornell University, Ithaca, New York).
16. MacVicar, C.N., Loxton, R.F., Lambrechts, J.J.N., Le Roux, J., De Villiers, J.M., Verster, E., Merryweather, F.R., Van Rooyen, T.H. & Harmse H.J. Von M. (1977). *Grondklassifikasie, 'n binomiese sisteem vir Suid-Afrika* (Staatsdrukker, Pretoria).
17. Edwards, D. (1983). A broad-scale structural classification of vegetation for practical purposes, *Bothalia*, 14, 3 & 4, 705–812.
18. De Beer, A.S. (1988). *Plantspesievoorkeure van vleisbeeste in die Hoëveldstreek onder 'n stelsel van beheerde selektiewe beweiding* (M.Sc. (Agric) -verhandeling, Universiteit van Pretoria, Pretoria).
19. Gibbs Russell, G.E., Reid, C., Van Rooyen, J. & Smook, L. (1985). List of Species of Southern African Plants, edition 2, part 1., *Mem. Bot. Surv. S. Afr.*, 51, 1–152.
20. Gibbs Russell, G.E., Welman, W.G., Retief, E., Immelman, K.L., Germishuizen, G., Pienaar, B.J., Van Wyk, M., Nicholas, A., De Wet, C., Mogford, J.C. & Mulvena, J. (1987). List of Species of Southern African Plants, edition 2, part 2. *Mem. Bot. Surv. S. Afr.*, 56, 1–270.
21. Hill, M.O. (1979). *DECORANA – a Fortran program for detrended correspondence analysis and reciprocal averaging* (Cornell University, Ithaca, New York).
22. Barkman, J.J., Moravec, J. & Rauschert, S. (1986). Code of phytosociological nomenclature, 2nd edition. *Vegetatio*, 67, 145–195.
23. Scheepers, J.C. (1987). Grassland Biome Project: Proceedings of the workshop on classification and mapping, *Occasional Report*, 16, 1–31 (CSIR, Pretoria).

*Outeur aan wie korrespondensie gerig kan word se huidige adres: Simonweg 19, Hadisonpark, Kimberley 8301.

5.3 Die plantgemeenskappe van die Ba-landtipe in die Mooirivieropvanggebied, Transvaal.

Page

* Published: *S.A. Tydskrif vir Natuurwetenskap en Tegnologie* 10(2): 85 - 92.

Die plantgemeenskappe van die Ba-landtipe in die Mooirivieropvanggebied, Transvaal

H. Bezuidenhout*
Binnelandse Nasionale Parke, Posbus 2696, Kimberley 8300

G.J. Bredenkamp
Departement Plantkunde, Universiteit van Pretoria, Pretoria 0001

Ontvang 28 Mei 1990; aanvaar 7 November 1990

UITTREKSEL

Die doel van hierdie studie was om hoofplantegroei-eenhede en hulle variasies — van die Ba-landtipe — te identifiseer, karakteriseer en aan die hand van die habitat ekologies te interpreteer. Ses plantgemeenskappe is deur toepassing van 'n numeriese klassifikasie (TWINSPAN) en Braun-Blanquet-prosedures geïdentifiseer en elk is met 'n spesifieke habitat gekorreleer. 'n Duidelike onderskeid is tussen die hoogliggende en die laagliggende plantgemeenskappe gemaak. Plantegroeigradiënte en geassosieerde gradiënte in habitat is deur toepassing van 'n ordeningstegniek (DECORANA) geïdentifiseer. Die studie beklemtoon die belangrikheid van topografie en grondtipe vir die afbakening van plantegroei-bestuurseenhede vir boerdery of natuurbewaring.

ABSTRACT

Classification of the vegetation of the Ba land type in the Mooi River catchment area, Transvaal

The aim of this study was to identify, characterize and interpret ecologically, by using habitat characteristics, the major vegetation units and their variations of the Ba land type. Six plant communities were successfully distinguished through applying a numerical classification (TWINSPAN) and Braun-Blanquet procedures. The plant communities could easily be correlated with specific habitat types. A clear distinction could be made between plant communities of the upland and lowland areas. Vegetation gradients and associated gradients in habitat were identified by using an ordination technique (DECORANA). The study emphasized the importance of topography and soil type for the delimitation of management units for farming or nature conservation practices.

INLEIDING

'n Gebrek aan kennis oor die plantegroei van die grasveldbioom het gelei tot die inisiëring van die grasveldbioomprojek.[1] As deel van hierdie projek is 'n aantal navorsingsprogramme in die westelike deel van die grasveldbioom geïnisieer en uitgevoer.[3, 4 en 5]

Daar is min oor die plantegroei van die Ba-landtipe bekend. Louw[11] bied 'n oorsigtelike verslag oor die plantegroei van die Potchefstroom-gebied aan. Volgens Acocks[12] se klassifikasie verteenwoordig die gebied die sentrale variasie van die Bankenveld. Die behoefte om die hoof- en subplantegroeitipes wat in die grasveldbioom aangetref word te identifiseer en om die ligging, omvang en habitatskenmerke van elke tipe te bepaal, word telkens beklemtoon.[1, 23]

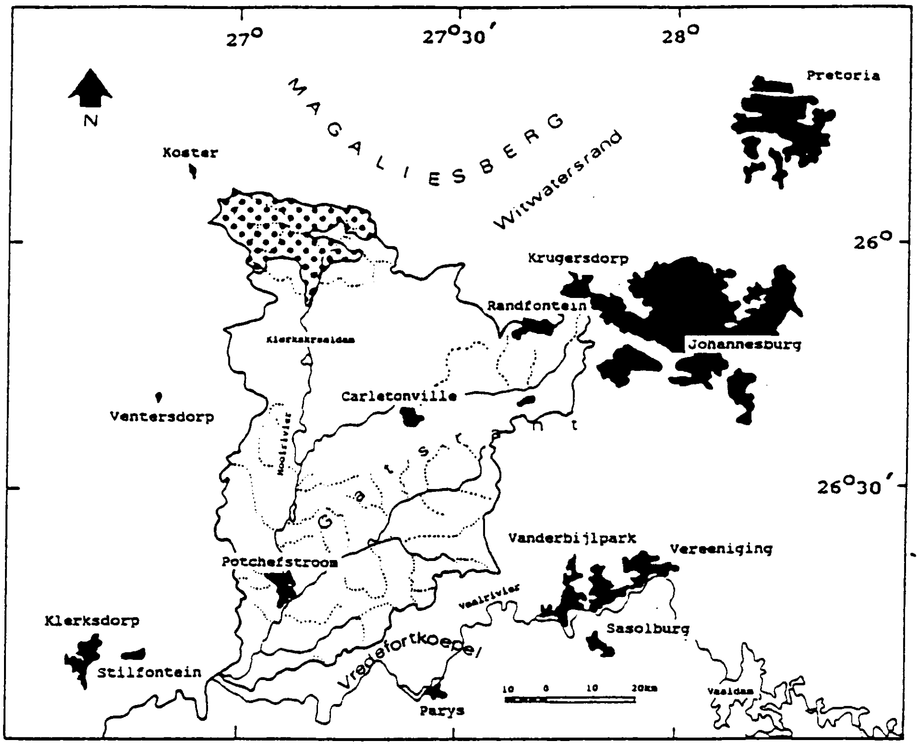
Om sinvolle aanbevelings oor veldbestuurspraktyke en beplanning te kan maak, is dit noodsaaklik dat 'n grondige kennis van die ekologie van die gebied verkry word.[6] Die daarstelling van relatief homogene plantegroei-cum-habitat-eenhede behoort ook 'n wetenskaplik gebaseerde riglyn vir die afbakening van veldbestuurseenhede te verskaf.

Verder, weens die feit dat die natuurlike plantegroei van die Ba-landtipe tot 'n groot mate deur die maak van lan derye vernietig is, en voortbestaan van verteenwoordigende plantgemeenskappe dus bedreig is, behoort 'n studie van die plantegroei van hierdie landtipe lig op die identifikasie van moontlike bewaringsgebiede te werp. Van besondere belang is dat hierdie ondersoek deel uitmaak van 'n uitgebreide sintese van die plantegroei van die grasveldbioom, wat daartoe sal lei dat 'n formele, omvattende hiërargiese sintaksonomie opgestel kan word.[3, 24, 25] So 'n sintese sal 'n bydrae tot fitososiologie in Suider-Afrika lewer. Die plantegroei van die A-landtipe in die Mooirivieropvanggebied is reeds geklassifiseer en beskryf.[10] In hierdie verslag word die klassifikasie, beskrywing en ekologiese interpretasie van die Ba-landtipe aangebied.

STUDIEGEBIED

Die ligging van die A-landtipe in die Mooirivieropvanggebied word in figuur 1 aangedui. Uit 'n fitososiologiese studie van die Moorivieropvanggebied[5] het dit geblyk dat die plantegroei van die landtipes in 'n mindere of meerdere mate van mekaar verskil. Die Landtipe-opnamepersoneel[2] definieer 'n landtipe as 'n eenheid wat 'n gebied verteenwoordig op 'n skaal van 1:250 000, wat eenvormig is ten opsigte van terreinvorm, grondpatrone en klimaat. Die Ba-landtipe beslaan ongeveer 84 750 hektaar en is tussen 1 440 en 1 600 m bo seespieël geleë.[2] Die Ba-landtipe

*Outeur aan wie korrespondensie gerig kan word.



FIGUUR 1: Die ligging van die studiegebied (kolletjies) in die Mooirivieropvanggebied.

word hoofsaaklik deur skalies, leie, kwartsiete en Hekpoortlawa van die Pretoria Groep (Transvaal Opeenvolging) onderlê. Die grondtipe wat in die Ba-landtipe voorkom, is rooi of geel, distrofies en/of mesotrofies en apedaal (struktuurloos).[2] Op die relatiewe hoogliggende gebiede is die Hutton-, Glenrosa- en Mispahgrondvorms[16] dominant. Die Hutton-, Clovelly- en Glencoegrondvorms is die dominante grondtipe teen die middelhange, wat meestal vir akkerbou aangewend word. Hierdie grondtipe is dikwels geploeg en gevolglik is die natuurlike plantegroei meestal tot vlakker, klipperige grond beperk. Die vloedvlaktes word deur die Westleigh-, Clovelly- en Glencoegrondvorms verteenwoordig, terwyl die dominante grondtipe in die waterbane, die Rensburgvorm is.[2]

Volgens Köppen se klassifikasiesisteem word die gebied as 'n CW-klimaat — dit is 'n warm, gematigde klimaat met somerreëns — beskryf.[7] Groot klimaatskontraste tussen somer en winter en uiterstes soos droogtes, oorstromings, hael en ryp is kenmerkend van die streek.[8] Die gemiddelde jaarlikse reënval (aangeteken oor ten minste vyftig jaar) varieer nie aansienlik nie, naamlik vanaf 656,7 mm by Koster, 653,7 mm by Magaliesburg tot 639,9 mm by Boons.[9] Gedurende die somermaande, veral Januarie en Desember, is die gemiddelde daaglikse maksimum temperature tot 30,6° C, terwyl die lae gemiddelde daaglikse minimum temperature van tot −1,8° C in die wintermaande[9] duidelik die temperatuuruiterstes wat oor 'n jaar aangeteken is, aantoon.

METODES

In 'n plantegroeiklassifikasie-navorsingsprogram[5] is landtipe-eenhede[2] gebruik as eerste stratifisering van die Mooirivieropvanggebied, met die doel om die plantegroei doeltreffend te monster. In hierdie omvattende studie is vyf landtipes onderskei. Monsterpersele is *pro-rata* op 'n areagroottebasis tussen die landtipes verdeel.

Natuurlike plantegroei is op die Ba-landtipe hoofsaaklik tot vlakker en/of klipperige, ongeploegde grond beperk. In hierdie Ba-landtipe is vier en twintig monsterpersele uitgeplaas. Binne die landtipe is die gebied verder gestratifiseer op grond van terreinvorm en homogene plantegroei, sodat alle ekotope[18] waarop natuurlike plantegroei voorkom, verteenwoordigend gemonster is.

Die monsterpersele is ewekansig in die eenhede uitgeplaas. Plantegroei-opnames is volgens die Braun-Blanquet-prosedure uitgevoer.[13] 'n Volledige floristiese opname is in elke monsterperseel gemaak. Bedekkinggetalsterktewaardes[14] is soos volg vir elke plantspesie wat in die perseel voorkom, aangeteken:

R — teenwoordig, maar nie volop nie, met 'n kroonbedekking van minder as 1% van die monsterperseeloppervlakte;
+ — volop, met 'n kroonbedekking van tussen 1% en 5% van die monsterperseeloppervlakte;
1 — enige aantal indiwidue met 'n kroonbedekking van groter as 5% tot 12% van die monsterperseeloppervlakte;
2 — enige aantal indiwidue met 'n kroonbedekking van groter as 12% tot 25% van die monsterperseeloppervlakte;
3 — enige aantal indiwidue met 'n kroonbedekking van groter as 25% tot 50% van die monsterperseeloppervlakte;
4 — enige aantal indiwidue met 'n kroonbedekking van groter as 50% tot 75% van die monsterperseeloppervlakte;
5 — enige aantal indiwidue met 'n kroonbedekking meer as 75% van die monsterperseeloppervlakte. Hierdie bedekkinggetalsterktewaardes vorm die matriks van tabel 1.

Verder is 'n gemiddelde hoogte en kroonbedekking van die boom-, struik- en kruidstratum addisioneel in die persele aangeteken. Die habitatopname sluit hoogte bo seespieël, tipe gesteente, aspek, persentasie klipperigheid van die grondoppervlak en ook grondtipe in. Meer inligting oor die grondtipes is uit bestaande beskrywings[2] verkry.

In 'n poging om sinvolle, ekologies verantwoorde plantgemeenskappe te onderskei, is die floristiese datastel aan 'n numeriese klassifikasie, naamlik Tweerigtingspesie-indikatoranalise (TWINSPAN)[15] onderwerp. Die resultaat is deur die toepassing van die Braun-Blanquet-prosedure verfyn en die finale resultaat van die klassifikasie word as 'n fitososiologiese tabel aangebied. Die plantgemeenskappe wat onderskei is, is hierna aan die hand van die beskikbare habitatdata ekologies geïnterpreteer. Met behulp van 'n terreinvormskets word die ligging van die plantgemeenskappe in die landskap aangedui. Plantegroeigradiënte met geassosieerde gradiënte in habitat is deur middel van 'n indirekte gradiëntanalise, naamlik Ontneigde Ooreenstemminganalise (DECORANA)[21] bepaal. Die name van taksons is in ooreenstemming met Gibbs-Russell et al.[19,20] Daar is egter 'n onderskeid tussen *Setaria flabellata* Stapf. en *Setaria sphacelata* (Schumach.) Moss. gemaak. Hierdie twee taksons word in Gibbs-Russell et al.[19] as 'n enkele spesie beskou. Die beskrywing van die plantgemeenskappe is in ooreenstemming met die Internasio-

TABEL 1

'n Fitososiologiese tabel van die Ba-landtipe in die Mooirivieropvanggebied

MONSTERPERSELE	55555 45444 90034	21 07 43	111145 588334 945072	11 33 12	122 591 541	145151 834843 681353
SPESIEGROEP 1						
Trachypogon spicatus	++++1	++				+
Pogonarthria squarrosa	+ +++	++				
Tristachya leucothrix	+ ++	3	+ +			
SPESIEGROEP 2						
Diheteropogon amplectens	++1 +			+		+
Pearsonia cajanifolia	+++				+	
Pentanisia angustifolia	+++	+	+			
Becium obovatum	+ ++	+			+	
Bewsia biflora	++					
SPESIEGROEP 3						
Cassia mimosoides		++	+			
Elephantorrhiza elephantina	+	++			+	
Zornia glochidiata		++	+ +			
Protea caffra		2				
SPESIEGROEP 4						
Acacia caffra			3 +			
Anthospermum hispidulum	+		+ +++	+		
Polygala hottentotta			++ +			+
Acacia robusta			++			
Aloe transvaalensis			++			
SPESIEGROEP 5						
Brachiaria serrata	+ + +	++	+ +		+	+
Eragrostis racemosa	+++1+	++	2	+		+
Acalypha angustata	++	+	+++ +			
Justicia anagalloides	+ +++		++++		+	+
Gnidia capitata	++	+	+ + +			
Cyanotis speciosa	++	+	+ +++		+	
Hermannia lancifolia	++	++	+ +			
SPESIEGROEP 6						
Schizachyrium sanguineum	+		+	2 +		
Vangueria infausta				++		
Rhus magalismontana			+	++		
Pellaea calomelanos	+			+	+	
Zanthoxylum capense			+	+		
SPESIEGROEP 7						
Diospyros lycioides		++	2 +	2 2	+	
Trichoneura grandiglumis	+	++	++	++		
Helichrysum nudifolium		++	++ +	++		+
Tephrosia longipes		++	+	++		
Commelina africana		+	+	+		
SPESIEGROEP 8						
Aristida congesta	+ +++		+ ++	+ 3	+	+
Rhynchelytrum repens	+ +	+	+ +	2 +	+	+
Dicoma anomala	+ +	++	+ +	+		
Loudetia simplex	+ 3	2		++		
Setaria flabellata	+++		2 + + +	++		1
SPESIEGROEP 9						
Grewia flava					++	
Monsonia angustifolia					++	+
Hibiscus pusillus					++	
Crabbea angustifolia	+++		+		++	
Tarchonanthus camphoratus					2	
SPESIEGROEP 10						
Acacia karroo			2 4	+	4 4 +	
Rhus pyroides			2 +	+	+ +	
Protasparagus suaveolens			++ +	++	+++	+
Protasparagus laricinus			++	++	+ 2 +	
Eustachys paspaloides			2	+	++	
SPESIEGROEP 11						
Eragrostis plana			++	2	+	2 2 3 + 5
Hyparrhenia hirta	+ ++	+			+	+ + 1 3 2
SPESIEGROEP 12						
Scabiosa columbaria		+	+		+++	+ +++
Digitaria eriantha	++	+	1		2 +	+++ +
Ziziphus zeyheriana	+		+	+	+ 3 +	+ +
Setaria sphacelata			+ +		2	+ 1 + +
Oxalis-spesie			+		++	++ +
SPESIEGROEP 13						
Chamaesyce hirta			+++		++	++ +
Hermannia depressa	+		++++ +		+++	+ ++
Helichrysum rugulosum	+		++ +		+	+ ++
Sida dregei			+++		++	+ +
SPESIEGROEP 14						
Eragrostis curvula	1 + 1 1	++	2 2 + + 3 1	+	2 + 3	+ 2 3 + 2
Themeda triandra	1 3 + 1	++	2 2 5 + 3		2	+ 1 1 1 +
Elionurus muticus	1 1 1 1	+ 2	+ 1 +	+	++	1
Lactuca serriola	+	++	+ ++ +		+	+ + +
Senecio venosus	+ ++	++	+++ +		+	++
Cynodon dactylon	+	+	2 + + 3 +	++	++	+++
Vernonia oligocephala	++		+ +		++	++
Walafrida densiflora	+ ++	+	+	+	+	
Teucrium trifidum		+	++ +		+++	
Solanum incanum			+ ++		+ +	
Solanum panduriforme			+ + +		+	+
Raphionacme hirsuta	+		+ + +		++	
Lippia scaberrima			++	+		+ +
Gomphrena celosioides			++ +			+ +
Heteropogon contortus	+		++	+		+ +
Schkuhria pinnata		+	+ +			+ +
Felicia muricata		+	++	+	+	
Mariscus indecorus	+	+	++	+		+
Panicum coloratum		++	+		+	+
Solanum capensisi	+		++ +			
Helichrysum callicomum	+ +	+		+		+
Hibiscus trionum			+ +		+	
Cymbopogon plurinodis	1		+		+	+
Eragrostis lehmanniana	+	+			+	+ +
Senecio coronatus	+	++	+			+
Bulbostylis burchellii	++	++				
				+		
Protasparagus africanus			++		+	
Ipomoea obscura			+		+	+
Dianthus mooiensis	+	+	+			

*Algemene of nie-diagnostiese spesies wat minder as drie keer aangetref is. is nie in die tabel ingesluit nie.

nale Kode van Sintaksonomie,[22] maar sintaksonrange word nie aan die gemeenskappe toegeken nie, weens te min fitososiologiese inligting oor die grasveld in die geheel.

RESULTAAT

a. KLASSIFIKASIE

Die plantegroei van die Ba-landtipe word as 'n *Eragrostis curvula-Themeda triandra* plantegroei-eenheid beskou.[5] Hierdie plantegroei-eenheid word deur spesiegroep 14 gekarakteriseer (tabel 1). Bome wat in die die-Ba-landtipe prominent is, is *Acacia caffra*, *A. karroo* en *Diospyros lycioides*. Algemene gras- en nie-grasagtige kruidspesies soos *Eragrostis curvula*, *Themeda triandra*, *Elionurus muticus*, *Cynodon dactylon*, *Lactuca serriola*, *Senecio venosus* en *Walafrida densiflora* word algemeen in dié plantegroei-eenheid aangetref. Die ontleding van die floristiese data het tot die identifikasie van ses plantgemeenskappe gelei, wat op grond van twee hoof habitattipes geskei kan word. Hierdie onderverdeling van die plantegroei in relatief hoërliggende, droër gebiede en die relatief laerliggende vloedgebiede en valleivloere met waterbane word in die dendrogram (figuur 2) geïllustreer. Die volgende plantgemeenskappe is onderskei:

1.1 Die *Loudetia simplex-Trachypogon spicatus*-grasveld op die hoërliggende, goedgedreineerde gebiede.
1.1.1 Die *Diheteropogon amplectens-Trachypogon spicatus*-variant op hoogliggende, vlak, klipperige grond, wat gelykliggend en blootgestel is.
1.1.2 Die *Trachypogon spicatus-Protea caffra*-variant op hoogliggende, klipperige, goedgedreineerde grond teen glooiings, met groot, los rotsblokke op die oppervlak.
1.2 Die *Diospyros lycioides — Acacia caffra*-boomveld op middelhange (figuur 2 en 3) met diep grond (> 0,3 m).
1.3 Die *Schizachyrium sanguineum — Vangueria infausta*-struikveld op kwartsiet dagsome.
1.4 Die *Grewia flava — Acacia karroo*-boomveld op die laerliggende, swakgedreineerde vloedvlaktes.
1.5 Die *Hyparrhenia hirta — Eragrostis plana*-grasveld in die laerliggende, swakgedreineerde waterbane.

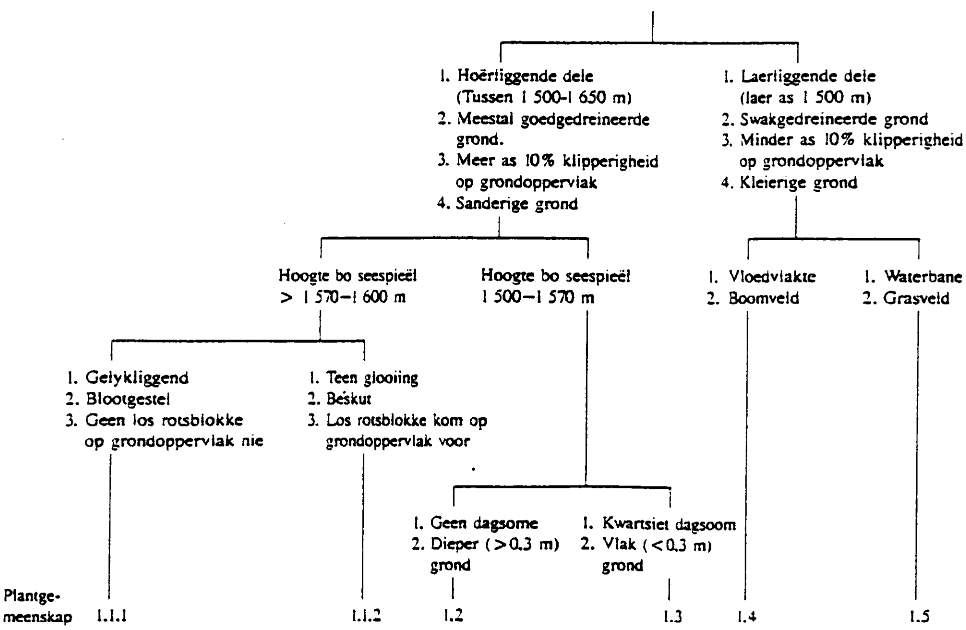
b. BESKRYWING VAN DIE PLANTGEMEENSKAPPE

1.1 Die *Loudetia simplex — Trachypogon spicatus*-grasveld.

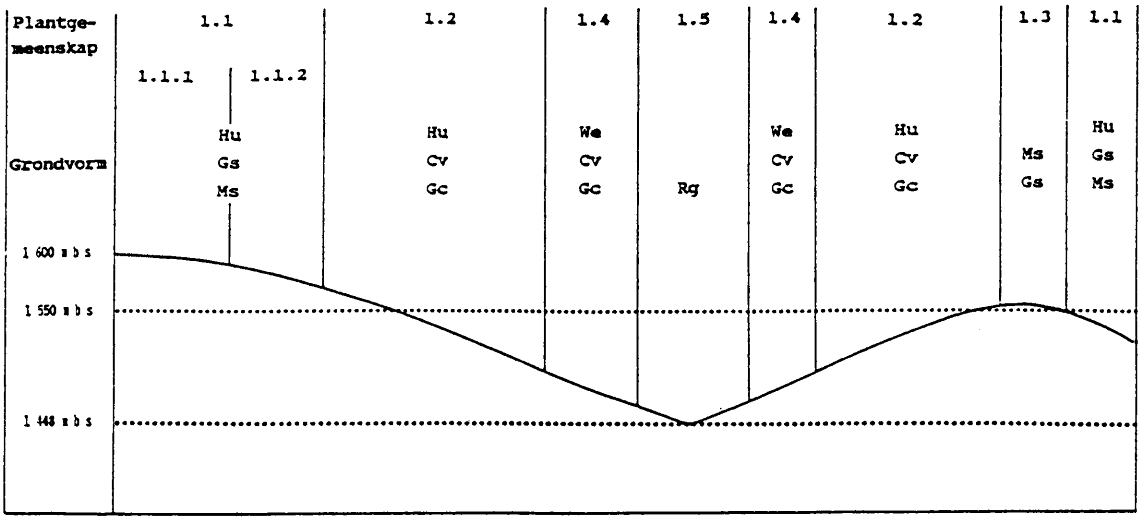
Hierdie grasveld word op die hoërliggende (1 570 – 1 600 m bo seespieël), goedgedreineerde, klipperige gebiede aangetref (figuur 3). 'n Groot gedeelte van die natuurlike plantegroei van die Ba-landtipe word deur hierdie plantgemeenskap verteenwoordig. Diagnostiese spesies van hierdie grasveld (spesiegroep 1, tabel 1) is die grasse *Trachypogon spicatus*, *Pogonarthria squarrosa* en *Tristachya leucothrix*. Spesies van spesiegroepe 2, 3, 5, 7, 8 en 14 kom in die plantgemeenskap voor (tabel 1). Die dominante grondtipe waarmee die gemeenskap geassosieer word, is die Mispah-, Glenrosa- en Huttongrondvorms.[16] Twee variante is onderskei: naamlik die *Diheteropogon amplectens-Trachypogon spicatus*-variant en die *Trachypogon spicatus-Protea caffra*-variant.

1.1.1 Die *Diheteropogon amplectens-Trachypogon spicatus*-variant.

Die habitat van dié variant is gelykliggend en blootgestel, met geen los rotsblokke op die grondoppervlak nie (figure 2 en 3). *Diheteropogon amplectens*, *Pearsonia cajanifolia*, *Pentanisia angustifolia*, *Becium obovatum* en *Bewsia biflora* is die diagnostiese spesies van die variant (spesiegroep 2, tabel 1). Spesies van spesiegroepe 1, 5, 8 en 14 kom ook in die variant voor.



FIGUUR 2: 'n Ekologiese interpretasie van die plantgemeenskappe van die Ba-landtipe in die Mooirivieropvanggebied.



Plantgemeenskappe

1.1	*Loudetia simplex-Trachypogon spicatus*-grasveld
1.1.1	*Diheteropogon amplectens-Trachypogon spicatus*-variant
1.1.2	*Trachypogon spicatus-Protea caffra*-variant
1.2	*Diospyros lycioides-Acacia caffra*-boomveld
1.3	*Schizachyrium sanguineum-Vangueria infausta*—struikveld
1.4	*Grewia flava-Acacia karroo*-boomveld
1.5	*Hyparrhenia hirta-Eragrostis plana*-grasveld

Grondvorm

Hu	–	Hutton
Gs	–	Glenrosa
Ms	–	Mispah
Cv	–	Clovelly
Gc	–	Glencoe
We	–	Westleigh
Rg	–	Rensburg

FIGUUR 3: 'n Terreinvormskets van die Ba-landtipe met die posisie van die onderskeie plantgemeenskappe.

Hierdie grasveldvariant word gekenmerk deur die totale afwesigheid van bome en struike. Die kruidstratum is goed ontwikkeld met 'n gemiddelde hoogte van 0,75 m en gemiddelde kroonbedekking van 68%. Die gemiddelde getal spesies per monsterperseel is 34. Prominente grasse wat in die variant aangetref word, is *Trachypogon spicatus, Loudetia simplex, Diheteropogon amplectens, Tristachya leucothrix, Bewsia biflora, Brachiaria serrata, Setaria flabellata* en *Elionurus muticus*. Die opvallende nie-grasagtige kruide is *Pearsonia cajanifolia, Pentanisia angustifolia, Becium obovatum, Acalypha angustata, Justicia anagaloides, Hermannia lancifolia* en *Lactuca serriola.*

1.1.2 Die Trachypogon spicatus-Protea caffra-variant.

Die *Trachypogon spicatus-Protea caffra*-variant kom teen glooiings voor en is dus meer beskut as die *Diheteropogon amplectens-Trachypogon spicatus*-variant. Groot, los rotsblokke word op die grondoppervlak aangetref (figure 2 en 3). *Cassia mimosoides, Elephanthorrhiza elephantina, Zornia glochidiata* en *Protea caffra* van spesiegroep 3 is die diagnostiese spesies in hierdie variant (tabel 1). Spesies van spesiegroepe 5, 7, 8 en 14 word ook in hierdie variant aangetref. Die gemiddelde getal spesies per monsterperseel is 48.

Die boomstratum word deur die prominente *Protea caffra* verteenwoordig. Die gemiddelde hoogte van die bome is 2,5 m en die gemiddelde kroonbedekking is 20%. Die struikstratum word deur die prominente *Diospyros lycioides* met 'n gemiddelde hoogte van 1,2 m en 'n gemiddelde kroonbedekking van 7,5% verteenwoordig.

Die kruidstratum het 'n gemiddelde hoogte van 0,7 m en 'n gemiddelde kroonbedekking van 40%. Prominente grasspesies soos *Trachypogon spicatus, Pogonarthria squarrosa, Tristachya leucothrix, Loudetia simplex, Trichoneura grandiglumis, Themeda triandra* en *Elionurus muticus* word in die variant aangetref. *Pentanisia angustifolia, Acalypha angustata, Gnid¹ⁿ capitata, Cyanotis speciosa, Hermannia lancifolia, Tephrosia longipes, Senecio venosus* en *Lactuca serriola* is opvallende nie-grasagtige kruide wat in die variant aangeteken is.

1.2 Die *Diospyros lycioides — Acacia caffra*-boomveld.

Die boomveld[17] word op die middelhange met 'n hoogte van 1 500 – 1 570 m bo seespieël in die studiegebied aangetref. Dit is laer as die *Trachypogon spicatus-Protea caffra*-variant geleë. Die goedgedreineerde, dieper (> 0,3 m) grond het geen dagsome nie (figuur 2). Die dominante grondtipe in die plantgemeenskap is die Hutton-, Clovelly- en Glencoegrondvorms. Die diagnostiese plantspesies (spesiegroep 4, tabel 1) van die *Diospyros lycioides-Acacia caffra*-boomveld is *Acacia caffra, Anthospermum hispidulum, Polygala hottentotta, Acacia robusta* en *Aloe transvaalensis*. Spesies van spesiegroepe 5, 7, 8, 10, 13 en 14 is ook in hierdie plantgemeenskap aangeteken (tabel 1). Die gemiddelde aantal spesies per monsterperseel, in die plantgemeenskap, is 35.

Die prominente bome is *Acacia caffra, A. robusta, A. karroo* en *Rhus pyroides*. Die boomstratum is goed ontwikkel. Die gemiddelde hoogte van die bome is 4,5 m en die gemiddelde kroonbedekking is 35%. Die struikstratum met 'n gemiddelde hoogte van 1,5 m en gemiddelde kroonbedekking van 15 % word deur *Rhus pyroides* en *Acacia karroo* in struikvorm verteenwoordig. Die twee struikagtige kruide, *Protasparagus suaveolens* en *P. laricinus*, word ook in die plantgemeenskap aangetref.

Die kruidstratum is swak ontwikkel, met onderskeidelik 'n gemiddelde hoogte en kroonbedekking van 0,5 m en 50 %. Grasspesies wat prominent in die plantgemeenskap is, is *Brachiaria serrata, Eragrostis racemosa, Aristida congesta, Rhynchelytrum repens, Trichoneura grandiglumis, Eustachys paspaloides, Elionurus muticus* en *Cynodon dactylon*. Prominente kruide is *Anthospermum hispidulum, Polygala hottentotta, Aloe transvaalensis, Cyanotis speciosa, Helichrysum nudifolium, Hermannia depressa, Helichrysum rugulosum, Teucrium trifidum, Lactuca serriola* en *Senecio venosus*.

Spesiegroep 5 toon die floristiese verwantskap tussen die *Loudetia simplex-Trachypogon spicatus*-grasveld en *Diospyros lycioides-Acacia caffra*-boomveld. In die ordening (figuur 4) word die verwantskap ook aangedui. Die verwantskap van die *Diospyros lycioides-Acacia caffra*-boomveld met die laerliggende plantgemeenskappe word met spesiegroep 13 aangedui.

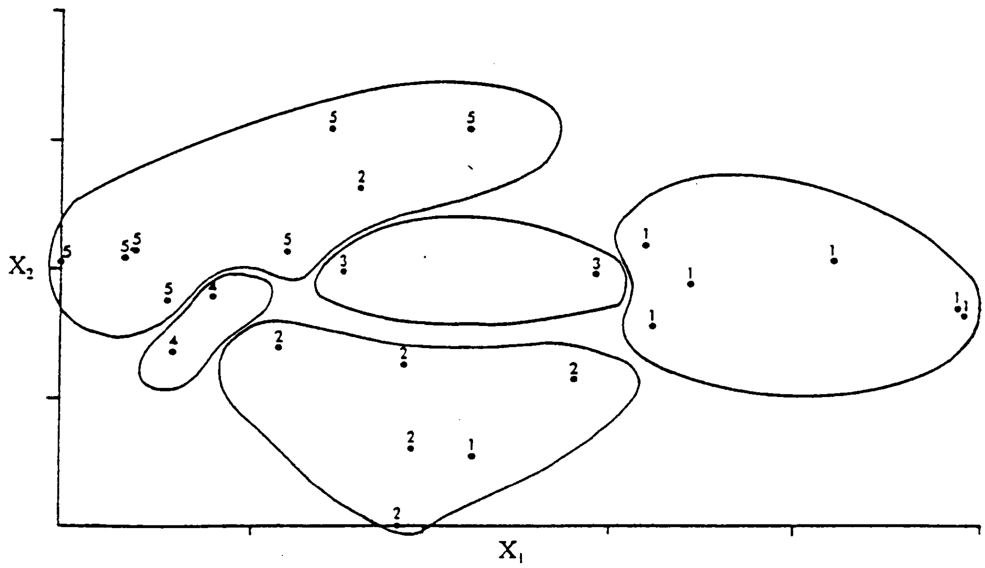
1.3 Die *Schizachyrium sanguineum-Vangueria infausta*-struikveld.

Die struikveld word op relatief hoogliggende kwartsietdagsome aangetref. Hoewel die struikveld relatief hoërliggend is, is dit laer geleë as die hoogliggende *Trachypogon spicatus-Loudetia simplex*-grasveld (figuur 3). Die grond is gewoonlik vlak (< 0,3 m) en die dominante grondtipe is die Mispah- en Glenrosagrondvorms (figuur 3). Die dreinering van die grond is goed. Spesiegroep 6 (tabel 1) sluit die diagnostiese spesies van die plantgemeenskap in, naamlik *Schizachyrium sanguineum, Vangueria infausta, Rhus magalismontana, Pellaea calomelanos* en *Zanthoxylum capense*. Die gemiddelde getal plantspesies per monsterperseel is 41.

Die boomstratum is swak ontwikkel met 'n gemiddelde hoogte van 4,5 m en 'n gemiddelde kroonbedekking van 10 %. Enkele bome van *Acacia karroo* verteenwoordig die boomstratum.

Die struikstratum is goed ontwikkel met prominente struike *Vangueria infausta, Zanthoxylum capense, Diospyros lycioides* en die dwergstruik *Rhus magalismontana*. Die twee struikagtige kruide *Protasparagus suaveolens* en *P. laricinus* word ook in hierdie plantgemeenskap aangetref. Die gemiddelde hoogte van die struike is 2,7 m en die gemiddelde kroonbedekking is 20 %.

Die kruidstratum se gemiddelde hoogte is 0,7 m en



1 – *Loudetia simplex-Trachypogon spicatus*-grasveld
2 – *Diospyros lycioides-Acacia caffra*-boomveld
3 – *Schizachyrium sanguineum-Vangueria infausta*-struikveld
4 – *Grewia flava-Acacia karroo*-boomveld
5 – *Hyparrhenia hirta-Eragrostis plana*-grasveld

FIGUUR 4: Die verspreiding van die onderskeie plantgemeenskappe langs die eerste en tweede asse van ordening, met geassosieerde habitatgradiënte teen die eerste as.

die gemiddelde kroonbedekking is 40%. Die prominente grasse wat in die gemeenskap aangeteken is, is *Schizachyrium sanguineum*, *Trichoneura grandiglumis*, *Aristida congesta*, *Rhynchelytrum repens*, *Loudetia simplex*, *Eustachys paspaloides* en *Cynodon dactylon*. Die nie-grasagtige kruide is *Pellaea calomelanos*, *Helichrysum nudifolium*, *Tephrosia longipes*, *Commelina africana*, *Dicoma anomala* en *Indigofera comosa*.

Spesies van spesiegroepe 7 en 8 dui op 'n floristiese verwantskap tussen die *Loudetia simplex-Trachypogon spicatus*-grasveld, *Diospyros lycioides-Acacia caffra*-boomveld en *Schizachyrium sanguineum-Vangueria infausta*-struikveld. In die ordening (figuur 4) is hierdie plantgemeenskappe hoofsaaklik aan die regterkant van die strooiingsdiagram geplaas. Hierdie verspreiding beklemtoon die verwantskappe met die hoogliggende plantgemeenskappe.

1.4 Die *Grewia flava-Acacia karroo*-boomveld.

Op die vloedvlaktes word die *Grewia flava-Acacia karroo*-boomveld aangetref. Die dominante grondtipe is die Westleigh-, Clovelly- en Glencoegrondvorms. Die diagnostiese spesies van die plantgemeenskap (spesiegroep 9, tabel 1) is *Grewia flava*, *Monsonia angustifolia*, *Hibiscus pusillus*, *Crabbea angustifolia* en *Tarchonanthus camphoratus*. Spesies van spesiegroepe 10, 12, 13 en 14 is ook in die plantgemeenskap aan geteken. Die gemiddelde getal plantspesies per monsterperseel is 35.

Die boomstratum is goed ontwikkeld met *Acacia karroo*, *Tarchonanthus camphoratus* en *Rhus pyroides* die prominente spesies. Die gemiddelde hoogte van die boomstratum is 5,5 m en die gemiddelde kroonbedekking is 35%. Die struikstratum met 'n gemiddelde hoogte van 1,9 m en 'n gemiddelde kroonbedekking van 20%, met die prominente struik *Grewia flava* asook die struikvorm van *Acacia karroo*, is goed ontwikkeld. Die dwergstruik *Ziziphus zeyheriana* is geneig om lokaal in die plantgemeenskap te verdig. Die twee struikagtige kruide, *Protasparagus suaveolens* en *P. laricinus*, is prominent in die plantgemeenskap.

Die kruidstratum is swak ontwikkeld met 'n gemiddelde hoogte van 0.55 m en 'n gemiddelde kroonbedekking van slegs 17%. Die prominente grasse is *Eustachys paspaloides*, *Eragrostis plana*, *Hyparrhenia hirta*, *Digitaria eriantha*, *Setaria sphacelata*, *Eragrostis curvula*, *Themeda triandra* en *Elionurus muticus*. Die prominente nie-grasagtige kruide is *Monsonia angustifolia*, *Hibiscus pusillus*, *Crabbea angustifolia*, *Scabiosa columbaria*, *Hermannia depressa*, *Sida dregei*, *Chamaesyce hirta* en *Teucrium trifidum*.

1.5 Die *Hyparrhenia hirta-Eragrostis plana*-grasveld.

Hierdie grasveld word op die relatief laerliggende, swakgedreineerde waterbane aangetref (figure 2 en 3). Die dominante grondvorm is Rensburg. Spesiegroep 11 (tabel 1) bevat die diagnostiese spesies van die plantgemeenskap, naamlik *Eragrostis plana* en *Hyparrhenia hirta*. Die plantegroei van die waterbane van die studiegebied is arm aan spesies. Die gemiddelde getal spesies is 22 per monsterperseel, terwyl die gemiddelde hoeveelheid spesies vir die ander plantgemeenskappe 39 per monsterperseel is. Spesies van spesiegroepe 12, 13 en 14 is ook in die plantgemeenskap aangeteken.

Die boom- en struikstratum is in hierdie grasveld afwesig. Die kruidstratum is goed ontwikkeld met 'n gemiddelde hoogte van 0.9 m en 'n gemiddelde kroonbedekking van 75%. Die prominente grasse is *Eragrostis plana*, *Hyparrhenia hirta*, *Digitaria eriantha*, *Setaria sphacelata*, *Eragrostis curvula*, *Themeda triandra* en *Cynodon dactylon*. Die opvallende nie-grasagtige kruide is *Scabiosa columbaria*, *Chamaesyce hirta*, *Hermannia depressa*, *Helichrysum rugulosum*, *Sida dregei* en *Lactuca serriola*. Die dwergstruik *Ziziphus zeyheriana* is ook hier geneig om lokaal voor te kom. Die waterbane is geskik vir beweiding, is meestal naby water en word dikwels oorbewei.

ORDENING

Die verspreiding van die relevès langs die eerste en tweede asse van die ordening word in figuur 4 aangedui. Hoewel geen duidelike diskontinuïteit in die verspreiding van die relevès waargeneem kan word nie, is die onderskeie plantgemeenskappe tog tot sekere streke in die strooiingsdiagram beperk. Die opeenvolging van die plantgemeenskappe langs die eerste as van die ordening (figuur 4) kan geassosieer word met gradiënte in topografiese posisies, gronddiepte, grondtekstuur, dreinering en klipperigheid van die grondoppervlak.

Die plantgemeenskappe wat na regs op die strooiingsdiagram geleë is, kom op hoogliggende, goedgedreineerde, vlak, sanderige grond voor. Daarenteen is die plantgemeenskappe wat na heel links op die diagram geleë is, geassosieer met 'n relatief laagliggende habitat met swakker gedreineerde, kleierige grond. Hierdie gradiënt in habitat is dus geassosieer met die gradiënt in plantegroei en is ook in ooreenstemming met die habitatinterpretasie wat in figuur 3 aangedui word.

GEVOLGTREKKING

Ten spyte van die relatiewe min natuurlike plantegroei wat op die Ba-landtipe aangetref word, is die plantgemeenskappe wat onderskei is, ekologies verantwoordbaar en vorm dit 'n basis vir plantegroeibestuurseenhede in die Mooirivieropvanggebied. Die studie beklemtoon die belang van geologie, topografie (topografiese posisie) en grondtipe vir die afbakening van plantgemeenskappe en derhalwe ook plantegroeibestuurseenhede vir boerdery of natuurbewaring. Die ondersoek lewer ook 'n bydrae tot die beoogde sintese wat 'n omvattende hiërargiese klassifikasie van die grasveldbioom ten doel het.

Erkenning

Die SNO word bedank vir finansiële steun om die projek te kon uitvoer.

Mev. D. Bezuidenhout, Dept. Plantkunde, Universiteit van Pretoria word bedank vir haar positiewe kommentaar op die manuskrip en ook die opstel van die figure.

LITERATUURVERWYSINGS

1. Mentis, M.T. & Huntley, B. (1982). A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog. Report*, 62 (CSIR, Pretoria).
2. Landtipe-opnamepersoneel. (1984). Landtipes van die kaarte 2626 Wes-Rand, 2726 Kroonstad. *Memoirs oor die Natuurlike Landbouhulpbronne van Suid-Afrika*, 4, 1–441.
3. Bezuidenhout, H. & Bredenkamp, G.J. (1990). A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom

– Ventersdorp – Randfontein area, South Africa, *Phytocoenologia*, 18(2/3), 387-403.
4. Bosch, O.J.H. & Janse van Rensburg, F.P. (1987). Ecological status of species on grazing gradients on shallow soils of the western grassland biome in South Africa, *J. Grassl. Soc. South. Afr.*, 4, 143-147.
5. Bezuidenhout, H. (1988). *'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal* (M.Sc.-verhandeling, PU vir CHO, Potchefstroom).
6. Edwards, D. (1972). Botanical survey and agriculture, *Proceedings of the Grassland Society of South Africa*, 7, 15-19.
7. Schulze, R.E. & McGee, O.S. (1978). Climate indices and classifications in relation to the biogeography of southern Africa. In *Biogeography and ecology of southern Africa*, Werger, M.J.A. ed. Vol. 1 (Junk, The Hague) p. 240.
8. Van Wyk, S. (1983). *'n Plantekologiese studie van die Abe Bailey-natuurreservaat* (M.Sc.-verhandeling, PU vir CHO, Potchefstroom).
9. Weerburo. (1988). *Klimaat van Suid-Afrika*, Staatsdrukker, Pretoria, WB 40, 1-475.
10. Bezuidenhout, H. & Bredenkamp, G.J. (1991). Plantegroeiklassifikasie van die A-landtipe van die Mooirivieropvanggebied, Transvaal, *S.A. Tydskr. Natuurwet. en Tegnol.*, 10, 4-11.
11. Louw, W.J. (1951). An ecological account of the vegetation of the Potchefstroom area, *Mem. Bot. Surv. S. Afr.*, 24, 1-105.
12. Acocks, J.P.H. (1975). Veld types of South Africa, *Mem. Bot. Surv. S. Afr.*, 40, 1-128.
13. Westhoff, V. & Van der Maarel, E. (1978). The Braun-Blanquet approach. In *Classification of plant communities*, Whittaker, R.H. ed. (Junk, The Hague) p. 399.
14. Mueller-Dombois, D. & Ellenberg, H. (1974). *Aims and methods of vegetation ecology* (Wiley, New York).
15. Hill, M.O. (1979). *TWINSPAN – a Fortran program for arranging multivariate data in an ordered two way table by the classification of individuals and attributes* (Cornell University, Ithaca, New York).
16. MacVicar, C.N., Loxton, R.F., Lambrechts, J.J.N., Le Roux, J., De Villiers, J.M., Verster, E., Merryweather, F.R., Van Rooyen, T.H. & Harmse H.J. Von M. (1977). *Grondklassifikasie, 'n binomiese sisteem vir Suid-Afrika* (Staatsdrukker, Pretoria).
17. Edwards, D. (1983). A broad-scale structural classification of vegetation for practical purposes, *Bothalia*, 14, 3 & 4, 705-812.
18. De Beer, A.S. (1988). *Plantspesievoorkeure van vleisbeeste in die Hoëveldstreek onder 'n stelsel van beheerde selektiewe beweiding* (M.Sc.(Agric)-verhandeling, Universiteit van Pretoria, Pretoria).
19. Gibbs Russell, G.E., Reid, C. Van Rooyen, J. & Smook, L. (1985). List of Species of Southern African Plants. Edition 2. Part 1, *Mem. Bot. Surv. S. Afr.*, 51, 1-152.
20. Gibbs Russell, G.E., Welman, W.G., Retief, E., Immelman, K.L., Germishuizen, G., Pienaar, B.J., Van Wyk, M., Nicholas, A., De Wet, C., Mogford, J.C. & Mulvena, J. (1987). List of Species of Southern African Plants. Edition 2. Part 2, *Mem. Bot. Surv. S. Afr.*, 56, 1-270.
21. Hill, M.O. (1979). *DECORANA – A Fortran program for detrended correspondence analysis and reciprocal averaging* (Cornell University, Ithaca, New York).
22. Barkman, J.J., Moravec, J. & Rauschert, S. (1986). Code of phytosociological nomenclature, 2nd edition, *Vegetatio*, 67, 145-195.
23. Scheepers, J.C. (1987). Grassland Biome Project: Proceedings of the workshop on classification and mapping, *Occasional Report*, 16, 1-31 (CSIR, Pretoria).
24. Kooij, M.S., Bredenkamp, G.J. & Theron, G.K. *(in press)*. A phytosociological survey of the north – western Orange Free State. 1. The physical environment, *Bothalia*.
25. Kooij, M.S., Bredenkamp, G.J. & Theron, G.K. *(in press)*. A phytosociological survey of the north – western Orange Free State. 2. The D land type, *Bothalia*.

CHAPTER 6

PHYTOSOCIOLOGICAL CLASSES OF THE WESTERN TRANSVAAL GRASSLAND, SOUTH AFRICA

Page

* To be *submitted* to: *South African Journal of Botany*

Phytosociological Classes of the western Transvaal grassland, South Africa.

H. Bezuidenhout*ᶠ, G.J. Bredenkamp and G.K. Theron

Department of Botany, University of Pretoria, Pretoria, 0002 Republic of South Africa

* To whom correspondence should be addressed at: Scientific Services, National Parks, P.O. Box 110040, Hadison Park, Kimberley, 8306 Republic of South Africa.

ᶠ Some of the data for this research were collected while this author was employed by the Department of Agricultural Development, Grassland Research Centre, Private Bag X05, Lynn East, 0039 Republic of South Africa.

Abstract

A detailed syntaxonomical and synecological account of five newly described phytosociological classes of the western Transvaal, South Africa is given. Using a new large data set classification technique a synoptic table was compiled from 1 025 relevés, representing 114 plant communities. An objective classification technique (TWINSPAN) was used complementary to the Braun-Blanquet technique. An ordination algorithm (DECORANA) was also applied to the synoptic data set. This indicates the floristic relationships among the classes while the vegetation gradient can be related to the habitat gradient.

Opsomming

'n Omvattende sintaksonomiese en sinekologiese beskrywing van vyf nuwe fitososiologiese klasse van die westelike Transvaal, Suid-Afrika, word gegee. Met behulp van 'n nuwe groot datastel klassifikasietegniek is 'n sinoptiese tabel saamgestel uit 1 025 relevés, wat 114 plantgemeenskappe verteenwoordig. 'n Objektiewe klassifikasietegniek (TWINSPAN) is ondersteunend tot die Braun-

Blanquet-tegniek gebruik. 'n Ordeningsalgoritme (DECORANA) is ook op die sinoptiese datastel toegepas. Die ordening toon floristiese verwantskappe tussen die klasse aan terwyl die plantegroeigradiënt met die habitatgradiënt verband hou.

Keywords: Braun-Blanquet technique, grassland, synoptic tables, synthesis, syntaxonomical classification.

Introduction

A formal syntaxonomical classification of the vegetation of the western Transvaal grassland has previously been avoided because too little knowledge about the western Transvaal grasslands was available (Bredenkamp & Theron 1978). Since Mentis and Huntley (1982) stated the necessity of research work in the Grassland Biome, a phytosociological research programme on the phytosociology and syntaxonomical synthesis of the Biome has been conducted (Bredenkamp *et al.* 1989; Bezuidenhout & Bredenkamp 1990; Kooij *et al.* 1990, Matthews 1991, Breytenbach *et al.* 1992, Myburgh *et al.* 1992, Bezuidenhout *et al.* 1993, Bloem *et al.* 1993, Eckhardt *et al.* 1993, Fuls *et al.* 1993, Smit *et al.* 1993). Relevant phytosociological data of the western Transvaal Grassland Biome have been collected by Morris (1973), Van Wyk & Bredenkamp (1986), Bezuidenhout *et al.* (1988), Bredenkamp & Bezuidenhout (1990), Bezuidenhout & Bredenkamp (1991a, 1991b), Bredenkamp *et al.* (*in prep.*), Bezuidenhout *et al.* (1993, *in press.*, *submitted*(a), *submitted*(b), *in prep.*(a), *in prep.*(b)). These data sets and resulting classifications provide the basis for a phytosociological and syntaxonomical synthesis of the western Transvaal grassland.

Study area

The study area represents the western part of the Highveld Agricultural Region, Transvaal and is bounded by latitudes 25° 45′ and 27° 15′ south and longitudes 24° 45′ and 27° 45′ east (Figure 1). The study area covers approximately 2.7 million hectares.

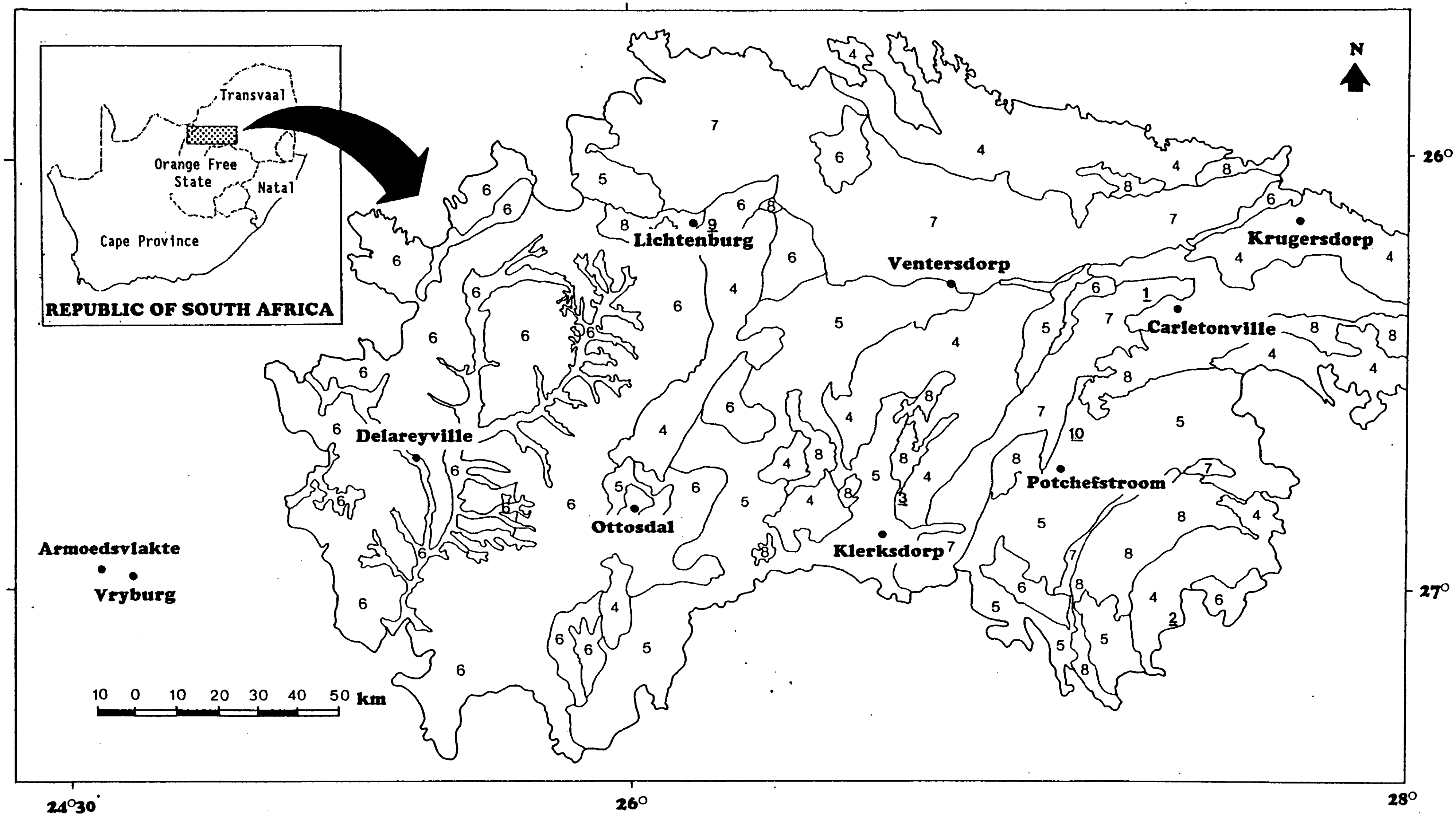


Figure 1: The location of the study area, showing the distribution of the different studies in the western Transvaal, South Africa ((1) Abe Bailey Nature Reserve, (2) Vredefort Dome, (3) Faan Meintjes Nature Reserve, (4) Ba land type, (5) Bc land type, (6) Bd and Ea land types, (7) Fa land type, (8) Fb land type, (9) Morris study area and (10) Boskop Dam Nature Reserve).

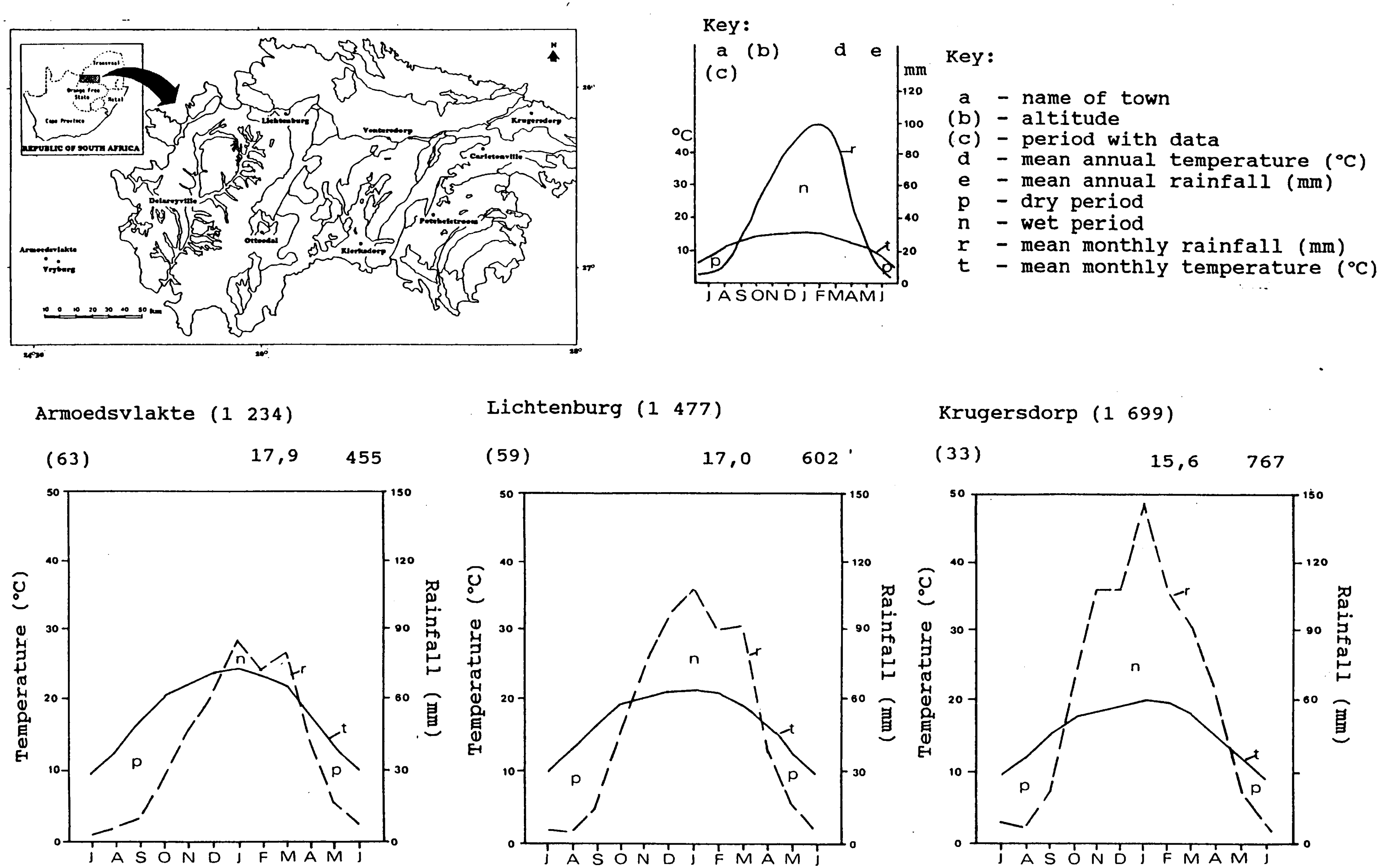


Figure 2: Climate diagrams for selected towns in the study area.

According to Acocks (1988) three veld types are represented in the study area. In the eastern parts Acocks' (1988) western variation of the Bankenveld (Veld type 61a) merges into the northern variation of the *Cymbopogon-Themeda* Veld (Veld type 48b), located in the central part of the study area. In the western parts the northern variation of the Dry *Cymbopogon-Themeda* Veld (Veld type 50a) merges north-westwards into the Sourish Mixed Bushveld (Veld type 19) and westwards into the Kalahari Thornveld Proper (Veld type 16a).

The rainfall is erratic, especially in the western part of the study area and increases in an easterly direction from 450 mm to 770 mm per year. The temperature decreases eastwards with an annual average of 17,9°C at Armoedsvlakte and 15,6°C at Krugersdorp (Weather Bureau 1986; Figure 2). The landscape varies from a flat to undulating plain, at an altitude of 1 200 m above sea-level, sometimes dissected by prominent ridges and hills with altitudes of up to 1 700 m above sea-level. In the western part pans occur occasionally.

The relatively heterogeneous geology is represented by the Witwatersrand and Ventersdorp Supergroups and the Transvaal Sequence with isolated occurrences of old Archaic granites and Karoo Sequence sediments (SACS 1980). Soils in the study area are heterogeneous and vary from sandy to clayey, due to great variation in parent rock material (Land Type Survey Staff 1984).

Methods

Eleven separate phytosociological studies had been carried out in the study area, comprising classifications of:

(i) The vegetation of the Abe Bailey Nature Reserve (Van Wyk & Bredenkamp 1986),

(ii) The Vredefort Dome north-west of Parys (Bezuidenhout *et al.* 1988),

(iii) The Faan Meintjes Nature Reserve (Bredenkamp & Bezuidenhout 1990),

(iv) The vegetation of the Bc Land Type (formal syntaxonomy)(Bezuidenhout & Bredenkamp 1991a),

(v) The vegetation of the Bd and Ea Land Types (formal syntaxonomy)(Bezuidenhout *et al.* 1993),

(vi) The vegetation of the Fa Land Type (formal syntaxonomy)(Bezuidenhout *et al. submitted*(a)),

(vii) The vegetation of the Ba Land Type (formal syntaxonomy)(Bezuidenhout *et al. submitted*(b)),

(viii) The vegetation of the Fb Land Type (formal syntaxonomy)(Bezuidenhout *et al. in press.*),

(ix) A Braun-Blanquet reclassification of Morris' (1973) Bankenveld data (Bezuidenhout *et al. in prep.*(a)),

(x) A Braun-Blanquet reclassification of Morris' (1973) *Cymbopogon-Themeda* grassland data (Bezuidenhout *et al. in prep.*(b)),

(xi) The Boskop Dam Nature Reserve (Bredenkamp *et al. in prep.*).

Each of these studies resulted in phytosociological tables and a vegetation classification, as well as descriptions of the plant communities identified. A total of 114 plant communities were identified. Using the new classification technique as described by Bredenkamp & Bezuidenhout (*in prep.*), synoptic tables were compiled for each of the phytosociological data sets and then re-entered into a synoptic data set. In each of the above-mentioned synoptic tables, non-diagnostic species with a constancy of less than 20 % were not included. This synoptic data set then consisted of eleven synoptic tables. An objective statistical classification technique, TWINSPAN (Hill 1979a) refined by Braun-Blanquet procedures was used for classifying the 114 synoptic relevés, representing 114 plant communities and a total of 493 species. The major groupings of related plant communities are considered to represent the vegetation (phytosociological) Classes within the area. A final synoptic table, representing the five Classes, gives the essential floristic detail (Table 1). The matrix of Table 1 shows the constancy values of each species within each Class and the following numerals were designated to five divisions:

1 : Up to 20 percent constancy
2 : > 20 - 40 percent constancy
3 : > 40 - 60 percent constancy
4 : > 60 - 80 percent constancy
5 : > 80 - 100 percent constancy (Mueller-Dombois & Ellenberg, 1974)

An ordination algorithm, DECORANA (Hill, 1979b) was also applied to the synoptic data set (Figure 4).

Taxon names conform to those of Arnold & De Wet (1993).

The new Classes are described and formally named in accordance to the Code of Phytosociological Nomenclature (Barkman *et al*. 1986). As it is not possible to allocate types for alliances or orders at this stage, the Class names are suggested names rather than final official names. Names of the vegetation units (plant communities and/or syntaxa of any rank) which were classified under these Classes are given in accordance with their original names.

Results

Five phytosociological Classes (Table 1) were recognized in the western Transvaal grasslands:

1) The *Diplachno fuscae - Stipagrostidetea uniplumis*, a grassland of the aeolian sandy north-western plains

2) The *Eragrostido racemosae - Trachypogonetea spicati*, a grassland of the shallow and rocky, relatively high-altitude regions

3) The *Rhoo leptodictyae - Acacietea caffrae*, a woodland of the rockier hills

4) The *Grewio flavae - Acacietea karroo*, a woodland of the footslopes and floodplains

5) The *Eragrostido planae - Hyparrhenietea hirtae* a grassland of the floodplains and dry watercourses.

All these Classes are clearly restricted to specific habitat conditions.

1. *Diplachno fuscae - Stipagrostidetea uniplumis* Class nov.

This Class occurs mainly on plains in the north-western parts of the study area where the influence of surface mining and cultivation had a significant impact on the vegetation (Morris 1973). According to Harmse (1967) most of the area has aeolian sand overlying the existing rock. The area consists mainly of an undulating plain which is accentuated by the absence of topographical features (Morris 1973). The largest part of the habitat is relatively dry, with soils of a low clay content and good internal drainage. Occasionally the habitat changes into a restricted drainage pattern where the clay content is higher, resulting in a wetter habitat. Inevitably, this leads to a mosaic distribution pattern of habitat and associated vegetation. The

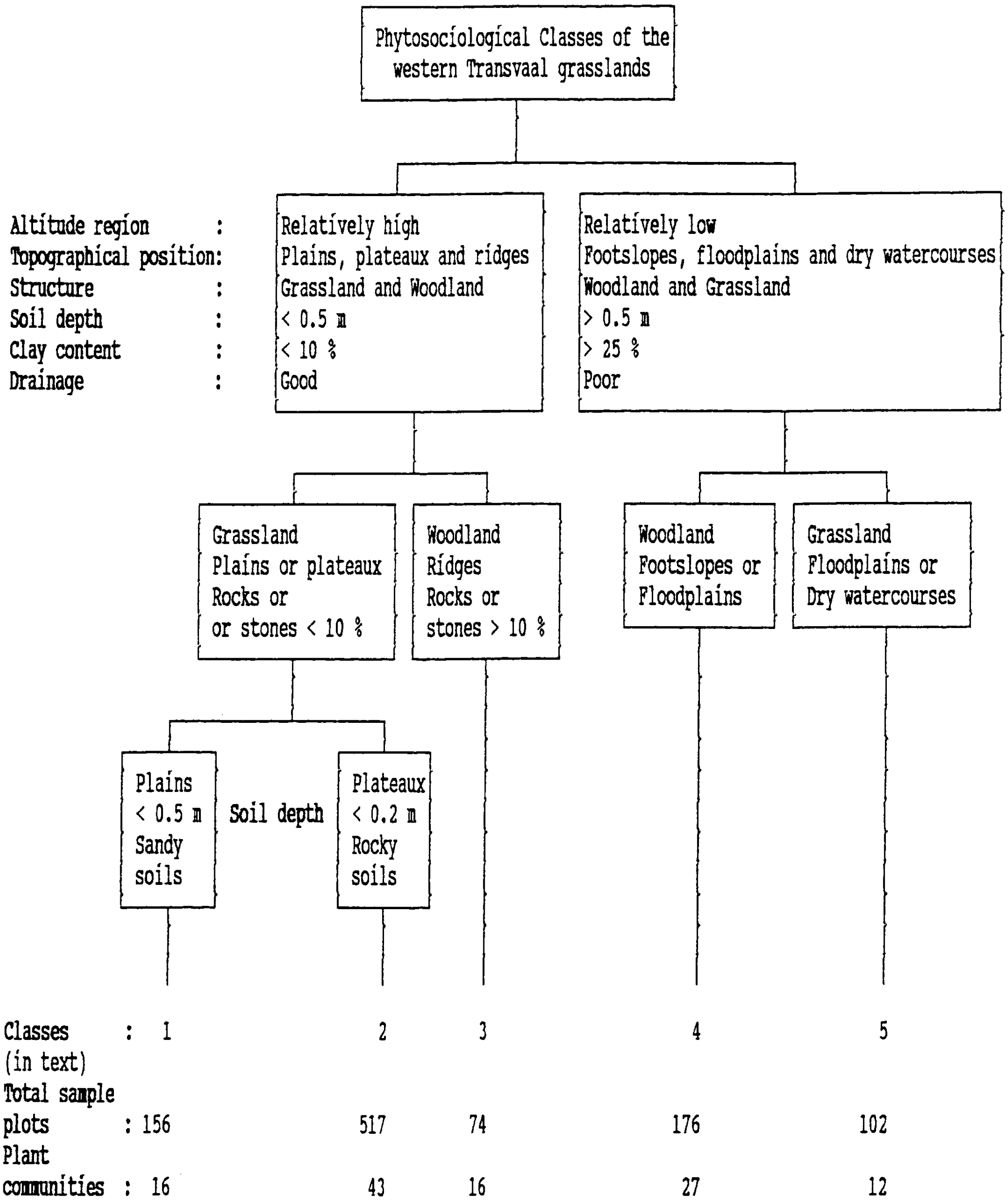


Figure 3: A dendrogram to illustrate the habitat relationships of the phytosociological Classes of the western Transvaal grasslands.

presence of the perennial grass *Diplachne fusca* which, according to Gibbs Russell *et al*. (1990) favours a wet habitat, but could also occur in other variations in grassland, confirms this mosaic. The *Diplachno fuscae - Stipagrostidetea uniplumis* is strongly associated with the *Cymbopogon - Themeda* Veld Type 48b and Dry *Cymbopogon - Themeda* Veld Type 50a of Acocks (1988).

Diagnostic species, with a constancy of higher than 40 %, are *Blepharis integrifolia*, *Diplachne fusca*, *Chamaesyce inaequilatera*, *Solanum supinum*, *Digitaria argyrograpta*, *Eragrostis stapfii*, *Hermannia tomentosa*, *Stipagrostis uniplumis*, *Nolletia ciliaris*, *Thesium magalismontanum*, *Dicoma macrocephala*, *Leucas capensis*, *Hibiscus microcarpus* and *Anthephora pubescens* (species group A; Table 1). Other diagnostic and companion species are listed in Table 1.

The ordination (Figure 4) indicates that this Grassland Class has a dry, sandy habitat. The soils of the *Diplachno fuscae - Stipagrostidetea uniplumis* (Class 1) also has better internal drainage than the *Eragrostido planae - Hyparrhenietea hirtae* (Class 5) (Figure 3).

A total of 156 sample plots representing 16 plant communities, all derived from Morris' (1973) data are classified under this Class. The plant communities include:

a) the three Variants of the *Stipagrostis uniplumis - Fingerhuthia africana* Grassland, the three Variants of the *Diplachne fusca - Cymbopogon excavatus* Grassland and the two communities, with four relevant Variants, under the *Elionurus muticus - Heteropogon contortus* Grassland described by Bezuidenhout *et al*. (*in prep*.(a))
b) the *Cymbopogon plurinodis - Eragrostis superba* Major Grassland with three communities and one Variant and the *Stipagrostis uniplumis - Anthephora pubescens* Variant of the *Anthephora pubescens - Schizachyrium sanguineum* Grassland described by Bezuidenhout *et al*. (*in prep*.(b)).

2. *Eragrostido racemosae - Trachypogonetea spicati* Class nov.

This Class is the predominating and extensive grassland of the western Transvaal. It occurs on the plateaux of rocky hills or ridges, but can also be found on shallow soils of the upland convex crests in the undulating landscape, or on relatively high altitude plains (Figure 3). The rocky soils are mostly derived from quartzite and shale (Witwatersrand Supergroup) or sometimes lava (Ventersdorp Supergroup). The clay content of these well-drained soils of this grassland varies, but is usually low. Diagnostic species (with a constancy higher than 40 %) are *Eragrostis racemosa*, *Trachypogon spicatus*, *Diheteropogon amplectens*, *Schizachyrium sanguineum*, *Andropogon schirensis*, *Trichoneura grandiglumis* and *Senecio coronatus* (species group B; Table 1). Other diagnostic and companion species are listed in Table 1. Floristically the *Eragrostido racemosae - Trachypogonetea spicati* (Class 2) shows affinity to the *Rhoo leptodictyae - Acacietea caffrae* (Class 3) (species groups B, D and J; Table 1). The vegetation of both Classes associate with rocky hills and ridges. The vegetation of Class 2 occurs on a more even topography to the rugged topography where the vegetation of Class 3 occurs (Figure 3). The vegetation of the *Eragrostido racemosae - Trachypogonetea spicati* (Class 2) is found in all the major land types and associates well with the western variation of the Bankenveld Veld Type (61a) (Acocks 1988).

The ordination (Figure 4) also shows an affinity between the *Eragrostido racemosae - Trachypogonetea spicati* (Class 2) and the *Diplachno fuscae - Stipagrostidetea uniplumis* (Class 3) but the two Classes are separated by a more sandy habitat (*Diplachno fuscae - Stipagrostidetea uniplumis*) and more rocky habitat (*Eragrostido racemosae - Trachypogonetea spicati*).

A total of 517 plots classified into 43 plant communities are present in this Class:

a) the two assocations of the *Schizachyrio sanguinei - Pogonarthrion squarrosae* and the three subassociations of the *Elionurio mutici - Cymbopogonetum plurinodis* (Bezuidenhout *et al.* *submitted*(b))

b) the three associations, one with two subassociations, described by Bezuidenhout & Bredenkamp (1991a) under the *Heteropogonion contorti*

c) the two associations of the *Hermannio depressae - Elionurion mutici* and the *Themeda triandra - Elionurus muticus* Grassland (Bezuidenhout *et al.* 1993)

d) the three associations of the *Trachypogono spicati - Diheteropogonion amplectentis* and the two subassociations of the *Cymbopogono plurinodis - Eragrostidetum gummifluae* described by Bezuidenhout *et al.* (*submitted*(a))

e) the two associations described by Bezuidenhout *et al.* (*in press*.) under the *Diheteropogono amplectentis - Schizachyrion sanguinei*

f) the *Brachiaria serrata - Triraphis andropogonoides* Grassland with three communities and the two Variants under the *Setaria flabellata - Cymbopogon plurinodis* Grassland (Bredenkamp & Bezuidenhout 1990)

g) the three Sub-communities, with the first two Sub-communities each classified into two Variants under the *Triraphis andropogonoides* Grassland Community, the *Hyparrhenia hirta-Verbena bonariensis* Variant under the *Hyparrhenia hirta* Wetland Community and the *Haemanthus hirsutus - Zinnia peruviana* Community described by Bredenkamp *et al.* (*in prep.*)

h) the two communities, one with three variants and the other with two variants under the *Justicia anagalloides - Elionurus muticus* Grassland (Van Wyk & Bredenkamp 1986)

i) the three Variants of the *Loudetia simplex - Schizachyrium sanguineum* Grassland and three Variants of the *Anthephora pubescens - Schizachyrium sanguineum* Grassland and the *Andropogon appendiculatus - Cymbopogon excavatus* Grassland as described by Bezuidenhout *et al.* (*in prep.*(b)).

3. *Rhoo leptodictyae - Acacietea caffrae* Class nov.

The vegetation of this Class is strongly associated with the rocky quartzite and conglomerate ridges of the Witwatersrand Supergroup and lava hills and quartzite ridges of the Ventersdorp Supergroup (Figure 3). The shallow (< 0,2 m) soils which are predominantly represented by the Mispah and Glenrosa forms (MacVicar *et al.* 1977) are well-drained. In the *Rhoo leptodictyae - Acacietea caffrae*, factors such as geology, aspect, percentage rock on the soil surface as well as microclimate play a major role in determining the specific plant communities (Bezuidenhout *et al.* 1988; Bredenkamp & Bezuidenhout 1990). Although this Class is strongly associated to the Fb land type, its occurrence is limited in the Ba and Bc land types. Certain species show an affinity to both the *Rhoo leptodictyae - Acacietea caffrae* (Class 3) and *Grewio flavae - Acacietea karroo* (Class 4) (species groups C, D and K; Table 1) as the vegetation of these two Classes sometimes tend to merge into each other at the footslopes of the ridges and hills. This Class also associates well with the Bankenveld Veld Type 61a of Acocks (1988).

In Table 1 (species group C) the following diagnostic species have a constancy value of more than 40 %: *Rhus leptodictya*, *Pavetta zeyheri*, *Acacia caffra*, *Ehretia rigida*, *Maytenus heterophylla*, *Ziziphus mucronata*, *Vangueria infausta*, *Tapiphyllum parvifolium*, *Dombeya rotundifolia*, *Loudetia simplex*, *Indigofera comosa*, *Phyllanthus parvulus*, *Leonotis ocymifolia*, *Rhynchosia venulosa*, *Rhus magalismontana*, *Pappea capensis*, *Combretum molle*, *Maytenus tenuispina*, *Setaria lindenbergiana*, *Zanthoxylum capense* and *Euclea crispa*. Other diagnostic and companion species are listed in Table 1.

In the ordination diagram (Figure 4) the communities of this Woodland Class are situated towards the right and top, indicating the moderately wet, well-drained habitat.

A total of 74 plots, representing 16 plant communities are classified under this Class. The plant communities are:

a) the six Savanna communities described by Bezuidenhout *et al.* (1988): *Nuxia congesta* - *Rhus magalismontana* Savanna, *Nuxia congesta* - *Combretum molle* Savanna, *Acacia caffra* - *Enneapogon scoparius* Savanna, *Diospyros lycioides* - *Sporobolus fimbriatus* Savanna, *Acacia caffra* - *Ziziphus mucronata* Savanna and *Acacia karroo* - *Ziziphus mucronata* Savanna
b) the two communities under the *Rhus magalismontana* - *Aristida vestita* Shrubland and the *Grewia flava* - *Acacia caffra* Woodland described by Bredenkamp & Bezuidenhout (1990)
c) the *Vanguerio infaustae* - *Acacietum caffrae* described by Bezuidenhout & Bredenkamp (1991a)
d) the two associations under the *Schizachyrio sanguinei* - *Vanguerion infaustae* (Bezuidenhout *et al. submitted*(b))
e) the *Rhoo rigidae* - *Acacietum caffrae*, *Dombeyo rotundifoliae* - *Acacietum caffrae* and the *Proteo caffrae* - *Acacietum caffrae* described by Bezuidenhout *et al.* (*in press.*)
f) the *Setaria lindenbergiana* - *Combretum molle* Community described by Bredenkamp *et al.* (*in prep.*).

4. *Grewio flavae* - *Acacietea karroo* Class nov.

The vegetation of this Class is a woodland which is mostly associated with moderately deep, often clayey alluvial or colluvial soils. This habitat is usually found at the footslopes of the quartzite ridges, chert ridges, lava hills and floodplains of the study area (Figure 3). Although the vegetation of this Class is relatively rare in the dolomite region, it occurs widely in the rest of the study area. The relatively high grazing capacity of the vegetation of this Class (Bosch 1985), leads to over-utilization and subsequent degradation of the vegetation. Some of the diagnostic species (species group D; Table 1), especially *Acacia karroo*, *Protasparagus laricinus* and *P. suaveolens* may also increase or encroach into disturbed woodland and grassland units (Friedel 1987). Diagnostic species (with a constancy of higher than 40 %) include *Grewia flava*, *Rhus pyroides*, *Teucrium trifidum*, *Diospyros lycioides*, *Celtis africana*, *Pavonia burchellii*, *Eragrostis obtusa*, *Protasparagus africana* and *Tragus berteronianus* (species group D; Table 1). Other diagnostic species and companion species are listed in Table 1.

In the scatter diagram (Figure 4) the communities of this Woodland Class are situated towards the centre and top, indicating the wet, poorly drained habitat.

This Class is represented by 176 plots, representing 27 plant communities. The plant communities are:

a) the three communities described by Van Wyk & Bredenkamp (1986) as the *Maytenus polyacantha* - *Celtis africana* Bush, the *Cymbopogon plurinodis* - *Tarchonanthus camphoratus* community and the *Eustachys paspaloides* - *Acacia karroo* Bush
b) the *Grewia flava* - *Acacia karroo* Woodland described by Bredenkamp & Bezuidenhout (1990)
c) the three associations described by Bezuidenhout *et al.* (*submitted*(b)) under the *Protasparago africani* - *Acacion karroo*
d) the two subassociations under the *Sporobolo africani* - *Acacietum karroo* and the *Elionurus muticus* - *Acacia karroo* community described by Bezuidenhout & Bredenkamp (1991a)
e) the two associations, one with two subassociations under the *Rhoo lanceae* - *Acacion karroo* and the two associations under the *Acacion eriolobae* described by Bezuidenhout *et al.* (1993)
f) the two associations and one community under the *Grewio flavae* - *Rhoion pyroidis* (Bezuidenhout *et al.* *submitted*(a))
g) the two subassociations described by Bezuidenhout *et al.* (*in press.*) under the *Acacietum karroo* - *caffrae*
h) the two Bush communities and one Sub-community under the *Rhus pyroides* Woodland Community and the *Senecio isatideus* - *Artemisia afra* Wetland Community described by Bredenkamp *et al.* (*in prep.*)
i) the *Cynodon dactylon* - *Acacia karroo* Woodland described by Bezuidenhout *et al.* (*in prep.*(a)).

In a syntaxonomic synthesis of the vegetation of the south-eastern Orange Free State, Du Preez & Bredenkamp (1991) identified a Class named the *Acacia karroo* riparian thicket. They mention that the *Acacia karroo* communities of the Bankenveld and Western Transvaal may possible included under this Class, but it presently seems as if the riparian *Acacia karroo* communities are quite different from the *Grewio flavae - Acacietea karroo*. Furthermore the communities with *Acacia karroo*, included in the phytosociological synthesis of Fuls (1993) are not presently considered as part of this Class.

It should however be emphasized that a comprehensive formal syntaxonomic review of all *Acacia karroo* communities in southern Africa is needed.

5. *Eragrostido planae - Hyparrhenietea hirtae* Class nov.

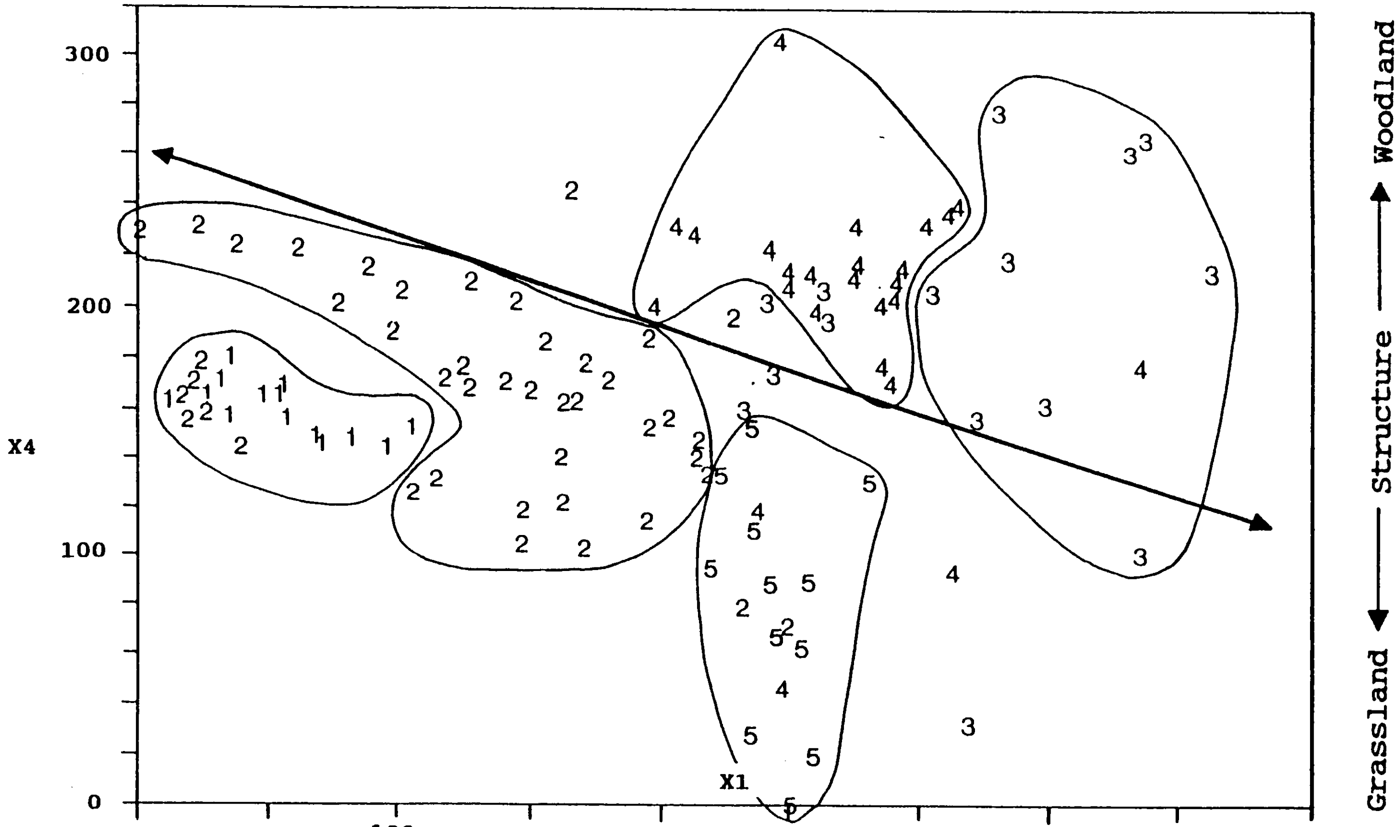
The vegetation of this Class is restricted to the poorly-drained floodplains and dry watercourses within the study area (Figure 3). The habitat is fairly unstable, due to seasonal flooding and drying which, together with the frequent overgrazing of the area, have caused the advanced state of degradation of the vegetation. The soils have a higher clay content than the soils of the upland areas. The vegetation of this Class occurs in all the land types and within all the Veld Types (Acocks 1988) in the study area.

The diagnostic species with a constancy value of 40 % or more are *Eragrostis plana*, *Hyparrhenia hirta*, *Berkheya radula*, *Conyza podocephala* and *Verbena bonariensis* (species group E; Table 1). Other diagnostic and companion species are listed in Table 1.

In the ordination diagram (Figure 4) the communities of this Grassland Class are situated towards the centre and bottom, indicating the wet, poorly drained habitat.

Sampling of this Class were done by 102 plots representing 12 plant communities. The plant communities of this Class are:

a) the *Conyza bonariensis - Cynodon dactylon* community (Van Wyk & Bredenkamp 1986)
b) the two subcommunities described by Bredenkamp & Bezuidenhout (1990) under the *Setaria sphacelata - Eragrostis plana* Wetland
c) the two Variants under the *Eragrostidetum planae* described by Bezuidenhout & Bredenkamp (1991a)



Moisture:	Dry	Wet	Moderately wet
Altitude:	Relative high	Low	Relative high
Clay content:	< 10 %	> 25 %	< 10 %
Soil depth:	0.1 - 0.5 m	> 0.5 m	< 0.2 m
Drainage:	Well-drained	Poor	Well-drained
Rockiness of surface:	< 10 %	None	> 10 %
Structure:	Grassland	Grassland / Woodland	Woodland

Figure 4: The ordination of the phytosociological Classes of western Transvaal grassland, South Africa ((1) <u>Diplachno fuscae - Stipagrostidetea uniplumis</u>, (2) <u>Eragrostido racemosae - Trachypogonetea spicati</u>, (3) <u>Rhoo leptodictyae - Acacietea caffrae</u>, (4) <u>Grewio flavae - Acacietea karroo</u>, (5) <u>Eragrostido planae - Hyparrhenietea hirtae</u>).

d) the two subassociations under the *Falckio oblongae - Eragrostidetum planae* (Bezuidenhout *et al. submitted*(b))
e) the *Cirsio vulgaris - Eragrostidetum planae* and the *Diplachno fuscae - Echinochloetum holubii* described by Bezuidenhout *et al.* (1993)
f) the *Paspalo dilatati - Hyparrhenietum hirtae* (Bezuidenhout *et al. submitted*(a))
g) the *Hyparrhenio hirtae - Eragrostidetum planae* described by Bezuidenhout *et al.* (*in press.*)
h) the *Hyparrhenia hirta - Eragrostis plana* Variant (Bredenkamp *et al. in prep.*).

This area is much drier, and floristically different from the *Themeda triandra - Eragrostis plana* moist grasslands, a Class described by Du Preez & Bredenkamp (1991) from the eastern Orange Free State, and also differs from the *Aristida junciformis - Eragrostis plana* Grassland of the undulating plains in the northern Orange Free State (Fuls 1993).

Ordination

In the scatter diagram the distribution of the Classes along the first and second axes (Figure 4) of the ordination is given. Although no distinct discontinuity among the different Classes could be made, the Classes are restricted to specific spatial areas in the diagram. A clear gradient is illustrated on the first axis showing variance in moisture, drainage, altitude, clay content and percentage rocks/stones on the soil surface. The Woodland Class on the right of the scatter diagram associated with high altitudes, well-drained, moderately wet soils, with a low clay content of the soil. The two Grassland Classes on the left of the diagram are associated with high altitude, well-drained drier soils with a low clay content, while the two Classes in the centre are associated with low altitude, poorly drained wetter soils with a relatively high clay content.

Conclusion and Discussion

This is the first comprehensive synecological account of the phytosociological Classes of the western Transvaal grassland. The vegetation of western Transvaal can be divided into two structural units, woodland and grassland. Five Classes have been identified, all of which are strongly related to a specific habitat. A total of 1 025 plots have been used to classify the vegetation of the study area. Species from species group F (Table 1) are the common species of this study area. The other species (species groups G - O; Table 1) indicates minor floristic relationships among the different Classes. The main contributing abiotic factors which influence the distribution of the Classes are available moisture, topographical position in relation to altitude, soil depth, drainage, percentage stones or rocks on the soil surface and to a lesser extent percentage clay content (Figure 3 & 4).

Although the Classes are easily correlated with the habitat, a vegetation map with all the Classes can not be drawn on a 1:250 000 scale which had been used in this survey, because the vegetation Classes are distributed in a mosaic pattern and some Classes are not limited to certain areas. Because the vegetation of the different Classes sometimes occur only locally, it complicates the compilation of a vegetation map on this scale. According to the Land Type Survey Staff (1984) more than 80 % of the study area is ploughed. This makes the compilation of a vegetation map even more difficult. A more detailed description of the vegetation of the western Transvaal grassland is given by Bezuidenhout & Bredenkamp (1991a), Bezuidenhout *et al*. (1993, *in press*., *submitted*(a), *submitted*(b). These respective classifications can be used in management and conservation planning. It cannot be emphasised enough that the vegetation units that occur in the western Transvaal grasslands, with the exception of the *Grewio flavae - Acacietea karroo* (Class 4), which relate to a certain extent to Du Preez & Bredenkamp (1991), is unique and cannot be found elsewhere in South Africa.

Regarding possible synonymy of the different plant communities within a Class, all original relevés representing a specific Class should be combined in a single phytosociological table in order to establish the floristic relationship and hierarchy among the communities. From these analyses a hierarchical syntaxonomy including synonyms may be compiled. This account creates the essential basis for such detailed syntaxonomic investigation.

Acknowledgement

Mrs. D. Bezuidenhout is thanked for assistance in the preparation of the manuscript. Mrs J. Schaap assisted with drawing Figure 1.

References

ACOCKS, J.P.H. 1988. Veld types of South Africa. 3rd edn. *Mem. bot. Surv. S. Afr.* 57: 1 - 146.

ARNOLD, T.H. & DE WET, B.C. 1993. Plants of southern Africa: names and distribution. *Mem. bot. Surv. S. Afr.* 62: 1 - 825.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of Phytosiological Nomenclature 2nd edn. *Vegetatio* 67: 145-195.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 7: 4 - 9.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* 18: 387 - 403.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991a. The vegetation of the Bc land type in the western Transvaal Grassland, South Africa. *Phytocoenologia* 19: 497 - 518.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991b. Plantegroeiklassifikasie van die A-landtipe van die Mooirivieropvanggebied, Transvaal. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 10: 4 - 11.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. 1993. The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa. *S. Afr. J. Bot.* 59: 319 - 331.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON G.K. *in press*. Syntaxonomy of the vegetation of the Fb land type in the western Transvaal Grassland, South Africa. *S. Afr. J. Bot.*

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted*(a). The vegetation of the western Transvaal dolomitic and chert grassland, South Africa. (*S. Afr. J. Bot.*)

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted*(b). The vegetation syntaxa of the Ba land type in the western Transvaal Grassland, South Africa. (*S. Afr. J. Bot.*)

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep.*(a). A Braun-Blanquet reclassification of the *Cymbopogon-Themeda* grassland in the Lichtenburg area, south-western Transvaal.

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep.*(b). A Braun-Blanquet reclassification of the Bankenveld grassland in the Lichtenburg area, south-western Transvaal.

BLOEM, K.J., THERON, G.K. & VAN ROOYEN, N. 1993. Grassland communities of the Verlorenvalei Nature Reserve in the North-eastern Sandy Highveld, Transvaal. *S. Afr. J. Bot.* 59: 273 - 280.

BOSCH, O.J.H. 1985. Die weiveld van die Faan Meintjes-natuurreservaat: 'n Ekologiese ondersoek. Stadsraad Klerksdorp en Total S.A. Klerksdorp.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. 1990. The vegetation of the Faan Meintjes Nature Reserve, Transvaal. *S. Afr. J. Bot.* 56: 54 - 64.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. *in prep.* A proposed procedure for the analysis of large data sets in the classification of South African Grasslands.

BREDENKAMP, G.J., BEZUIDENHOUT, H., NAUDE, C., JOUBERT, H. *in prep.* The vegetation of the Boskop Dam Nature Reserve, Potchefstroom.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the plains of the Potchefstroom-Parys-Fochville area. *S. Afr. J. Bot.* 55: 199 - 206.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve. 1. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 - 329.

BREYTENBACH, P.J.J., MYBURGH, W.J., THERON, G.K. & BREDENKAMP, G.J. 1992. The phytosociology of the Villiers - Grootvlei area, South Africa. 1. Physical environment and the plant communities of the Bb Land Type. *S. Afr. J. Bot.* 58: 239 - 249.

DU PREEZ, P.J. & BREDENKAMP, G.J. 1991. Vegetation Classes of the southern and eastern Orange Free State (Republic of South Africa) and the Highlands of Lesotho. *Navors. nas. Mus., Bloemfontein.* 7: 478 - 526.

ECKHARDT, H.C., VAN ROOYEN, N., BREDENKAMP, G.J. & THERON, G.K. 1993. An overview of the vegetation of the Vrede-Memel-Warden area, north-eastern Orange Free State. *S. Afr. J. Bot.* 59: 391 - 400.

FRIEDEL, M.H. 1987. A preliminary investigation of the woody plant increase in the western Transvaal and implications for veld assessment. *J. Grassl. Soc. South. Afr.* 4: 25 - 30.

FULS, E.R. 1993. Vegetation ecology of the northern Orange Free State. Ph.D dissertation, University of Pretoria, Pretoria.

FULS, E.R., BREDENKAMP, G.J. & VAN ROOYEN, N. 1993. The grassland communities of the midslopes in the northern Orange Free State, South Africa. *S. Afr. J. Bot.* 59: 478 - 484.

GIBBS RUSSELL, G.E., WATSON, L., KOEKEMOER, M.,SMOOK, L.,BARKER, N.P., ANDERSON,H.M. & DALLWITZ, M.J. 1990. Grasses of southern Africa. *Mem. bot. Surv. S. Afr.* 58: 1 - 437.

HARMSE, H.J. VON M. 1967. Soil genesis in the Highveld Region, South Africa. D.Sc. dissertation, University of Utrecht.

HILL, M.O. 1979a. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

HILL, M.O. 1979b. DECORANA - A Fortran program for detrended correspondence analysis and reciprocal averaging. Cornell University, New York.

KOOIJ, M.S., BREDENKAMP, G.J. & THERON, G.K. 1990. Classification of the vegetation of the B land type in the north-western Orange Free State. *S. Afr. J. Bot.* 56: 309 - 318.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. agric. nat. resour. S. Afr.* 4: 1 - 441.

MACVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H. & VON M. HARMSE, H.J. 1977. Soil classification - A binomial system for South Africa. Dept. Agricultural-technical services, Pretoria.

MATTHEWS, W.S. 1991. Phytosociology of the north-eastern Mountain sourveld. M.Sc. thesis, University of Pretoria, Pretoria.

MENTIS, M.T. & HUNTLEY, B.T. 1982. A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog.* 62: 1 - 29.

MORRIS, J.W. 1973. Automatic classification and ecological profiles of South-western Transvaal Highveld Grassland. D.Sc. dissertation, University of Natal, Durban.

MORRIS, J.W. 1976. Automatic classification of the highveld grassland of Lichtenburg, south-western Transvaal. *Bothalia* 12: 267 - 292.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York.

MYBURGH, W.J., BREYTENBACH, P.J.J., THERON, G.K. & BREDENKAMP, G.J. 1992. Die fitososiologie van die Bankenveld in die Grootvlei-omgewing, Suid-Transvaal. *Bothalia* 22: 245 - 254.

SACS. 1980. South African Committee for Stratigraphy. Stratigraphy of South Africa. Part 1 (comp. L.E. Kent). Lithostratigraphy of Republic of South Africa, South West Africa/Namibia, and the Republics of Botswana, Transkei and Venda. Dept. Mineral and Energy Affairs, Pretoria.

SMIT, C.M., BREDENKAMP, G.J. & VAN ROOYEN, N. 1993. Plant communities of the Ad land type in the Newcastle - Memel - Chelmsford Dam area. *S. Afr. J. Bot.* 59: 116 - 122.

VAN WYK, S. & BREDENKAMP, G.J. 1986. 'n Braun-Blanquet-klassifikasie van die plantegroei van die Abe Bailey-Natuurreservaat. *S. Afr. J. Bot.* 52: 321 - 331.

WEATHER BUREAU. 1986. Climate of South Africa - Climate statistics up to 1984. Weather Bureau Report No. 40. Government Printer, Pretoria.

Table 1: A synoptic table of synrelevés of the vegetation Classes of the western Transvaal grasslands, South Africa.

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12
Species group A Diagnostic species of *Diplachno fuscae - Stipagrostidetea uniplumis*					
Blepharis integrifolia	5	1		1	
Diplachne fusca	4	1			1
Chamaesyce inaequilatera	4	1			
Solanum supinum	4	1		1	
Digitaria argyrograpta	3	1		1	
Eragrostis stapfii	3	1			
Hermannia tomentosa	3	1		1	
Stipagrostis uniplumis	3	1		1	
Nolletia ciliaris	3	1			
Thesium magalismontanum	3	1			
Dicoma macrocephala	3	1			
Leucas capensis	3	1			
Hibiscus microcarpus	3	1			
Anthephora pubescens	3	1			
Blepharis squarrosa	2	1			
Ursinia nana	2	1	1		
Raphionacme burkei	2	1		1	
Ophrestia oblongifolia	2	1			
Helichrysum caespititium	2	1			
Eragrostis trichophora	2	1			
Cyperus margaritaceus	2	1		1	
Selago welwitschii	2	1		1	
Nidorella hottentotica	2	1			
Oropetium capense	2	1		1	
Indigofera daleoides	2	1			
Plexipus pinnatifidus	2	1			
Menodora africana	2	1			
Hermannia geniculata	2				
Barleria pretoriensis	2				
Fingerhuthia africana	2				
Helichrysum zeyheri	2				
Lightfootia fasciculata	1				
Rhynchosia totta	1				
Euphorbia pseudotuberosa	1				
Helichrysum cerastioides	1				
Convolvulus ocellatus	1				
Wahlenbergia undulata	1				
Raphionacme velutina	1				
Limeum viscosum	1				

Species group B
Diagnostic species of *Eragrostido racemosae - Trachypogonetea spicati*

Eragrostis racemosa	1	5	1	1	1
Trachypogon spicatus	1	4	2	1	
Diheteropogon amplectens	1	4	2	1	
Schizachyrium sanguineum	1	3	2		
Andropogon schirensis		3	2	1	
Trichoneura grandiglumis		3	2	1	
Senecio coronatus	1	3		1	
Bewsia biflora		2			
Hermannia lancifolia		2	1	1	1
Digitaria tricholaenoides		2			
Cucumis hirsutus		2		1	
Chamaecrista mimosoides		2	1	1	
Polygala hottentotta		2	1	1	
Ipomoea obscura		2	1	1	
Oxygonum dregeana	1	2	1	1	
Chaetacanthus costatus	1	2		1	1
Sporobolus pectinatus		1	1		
Polygala rehmannii		1			
Blepharis transvaalensis		1			
Urelytrum agropyroides		1			
Cyperus zollingeri		1			
Walafrida saxatilis		1			
Scilla nervosa		1			
Fimbristylis hispidula		1			
Helichrysum chionosphaerum		1			
Tristachya rehmannii		1			
Lotononis calycina		1			
Senecio othonniflorus		1			
Clerodendrum triphyllum		1			
Abildgaardia hygrophila		1			
Pachystigma pygmaeum		1			
Delosperma herbeum		1			
Senecio erubescens		1			
Melinis nerviglumis		1			
Polygala uncinata		1			
Zaluzianskya elongata		1			
Sporobolus conrathii		1			
Polygala amatymbica		1			
Gnidia burchellii		1			
Chamaecrista comosa		1			
Indigofera setiflora		1			
Bulbostylis oritrephes		1			
Anthericum cooperi		1			
Tristachya leucothrix		1			
Alloteropsis semialata		1			
Pearsonia cajanifolia		1			
Parinari capensis		1			
Ipomoea ommaneyi		1			
Graderia scabra		1			
Digitaria monodactyla		1			

Species group B (continued)
Diagnostic species of *Eragrostido racemosae - Trachypogonetea spicati*

Helichrysum miconiifolium		1			
Indigofera sanguinea		1			
Chaetacanthus burchellii		1			
Pentanisia angustifolia		1			
Monocymbium ceresiiforme		1			
Helichrysum indicum		1			
Gisekia pharnacioides		1			
Indigofera hedyantha		1			
Boophane disticha		1			
Hypoxis multiceps		1			
Sporobolus stapfianus		1			
Deverra burchellii		1			
Helichrysum coriaceum		1			
Tephrosia lupinifolia		1			
Hypoxis argentea		1			

Species group C
Diagnostic species of *Rhoo leptodictyae - Acacietea caffrae*

Rhus leptodictya			5	1	
Pavetta zeyheri			5		
Acacia caffra			4	2	
Ehretia rigida			4	3	
Maytenus heterophylla	1		4	3	
Ziziphus mucronata			4	3	
Vangueria infausta			4	1	
Tapiphyllum parvifolium		1	4		
Dombeya rotundifolia			4		
Loudetia simplex		1	3	1	
Indigofera comosa		2	3		
Phyllanthus parvulus			3		
Leonotis ocymifolia			3		
Rhynchosia venulosa		1	3	1	
Rhus magalismontana		1	3	1	
Pappea capensis			3		
Combretum molle			3		
Maytenus tenuispina			3		
Setaria lindenbergiana			3		
Zanthoxylum capense			3	1	
Euclea crispa			3	1	
Vernonia galpinii		1	2		
Becium angustifolium			2		
Cheilanthus hirta		1	2	1	
Grewia occidentalis			2	1	
Euclea undulata			2		
Acacia robusta			2	1	
Brachylaena rotundata			2		
Kyphocarpa angustifolia		1	2	1	
Olea europaea			2	1	
Sporobolus fimbriatus		1	2	1	1

Species group C (continued)
Diagnostic species of *Rhoo leptodictyae* - *Acacietea caffrae*

Hibiscus engleri			2		
Pellaea calomelanos			2	1	
Mundulea sericea			2	1	
Lepidium bonariense			2	1	
Tephrosia burchellii		1	2	1	
Ruellia patula			2		
Asclepias decipiens			2		
Nuxia congesta			2		
Melhania prostrata			2		
Selaginella dregei			1		
Protea caffra			1		
Helichrysum kraussii			1		
Rhoicissus tridentata			1		
Enneapogon scoparius			1		
Barleria obtusa			1		
Phyllanthus incurvus			1		
Cussonia paniculata			1		
Dalechampia kirkii			1		
Evolvulus alsinoides			1		
Berchemia zeyheri			1		
Enneapogon pretoriensis			1		
Plumbago auriculata			1		
Cassine aethiopica			1		
Diospyros whyteana			1		
Rhus lucida			1		
Scolopia zeyheri			1		
Sphenostylis angustifolia			1		
Cotyledon barbeyi			1		
Carissa bispinosa			1		
Aristida canescens			1		
Oldenlandia herbacea			1		
Phylica paniculata			1		
Aristida vestita			1		
Pachycarpus schinzianus			1		
Indigofera spicata			1		
Cryptolepis oblongifolia			1		
Sutera campanulata			1		

Species group D
Diagnostic species of *Grewio flavae* - *Acacietea karroo*

Grewia flava		1	3	5	
Protasparagus laricinus		1	2	5	
Protasparagus suaveolens		1	3	5	
Acacia karroo		1	2	4	1
Rhus pyroides		1	2	4	
Teucrium trifidum		1	3	4	1
Diospyros lycioides		1	3	4	
Celtis africana		1	2	3	

Species group D (continued)
Diagnostic species of *Grewio flavae - Acacietea karroo*

Pavonia burchellii			2	3	
Eragrostis obtusa		1		3	1
Protasparagus africana			1	3	
Tragus berteronianus	1	1	1	3	
Rhus lancea				2	
Eragrostis capensis		1	1	2	1
Clematis brachiata	1	1	1	2	
Talinum caffrum		1		2	
Hibiscus calyphyllus				1	
Heteromorpha arborescens				1	
Solanum nigrum				1	
Setaria verticillata				1	
Scadoxus puniceus				1	
Priva meyeri				1	
Plectranthus madagascariensis				1	
Ledebouria luteola				1	
Kedrostis africana				1	
Ehrharta erecta				1	
Dipcadi viride				1	
Ceterach cordatum				1	
Bidens pilosa				1	
Anomatheca grandiflora				1	
Achyranthes aspera				1	
Gerbera piloselloides				1	
Hyperthelia dissoluta				1	
Salvia stenophylla				1	
Bulbine capitata				1	
Bonatea speciosa				1	
Urochloa mosambicensis				1	
Lepidium africanum				1	
Jatropha zeyheri				1	
Cheilanthes viridis				1	
Panicum maximum				1	
Boscia albitrunca				1	
Delosperma mahonii				1	
Acacia erioloba				1	
Acacia hebeclada				1	
Pseudognaphalium oligandrum				1	
Pygmaeothamnus zeyheri				1	
Chloris virgata				1	
Rhus ciliata				1	
Eragrostis rigidior				1	
Aloe transvaalensis				1	
Schmidtia pappophoroides				1	
Crotalaria lotoides				1	
Terminalia sericea				1	
Ozoroa paniculosa				1	
Grewia flavescens				1	
Dichrostachys cinerea				1	

Species group D (continued)
Diagnostic species of *Grewio flavae - Acacietea karroo*

Dicerocaryum eriocarpum				1	
Acacia mellifera				1	
Eragrostis biflora				1	
Cyperus longus				1	
Portulaca oleracea				1	
Artemisia afra				1	
Senecio isatideus				1	

Species group E
Diagnostic species of *Eragrostido planae - Hyparrhenietea hirtae*

Eragrostis plana		1		1	5
Hyparrhenia hirta		1	1	1	3
Berkheya radula		1		1	3
Conyza podocephala		1	1	1	3
Verbena bonariensis		1	1		3
Falckia oblonga					2
Paspalum dilatatum					2
Cirsium vulgare					2
Eragrostis chloromelas		1		1	2
Chamaesyce hirta		1	1	1	2
Chloris pycnothrix					1
Asclepias fruticosa					1
Salvia runcinata					1
Echinochloa holubii					1
Gnaphalium filagopsis					1
Schoenoplectus muricinux					1
Cyperus esculentus					1
Oenothera tetraptera					1
Amaranthus hybridus					1
Plantago lanceolata					1
Oenothera indecora					1
Oenothera rosea					1
Haplocarpha scaposa					1
Setaria incrassata					1
Andropogon eucomus					1

Species group F
Common species of the western Transvaal grassland

Eragrostis curvula	5	5	5	5	5
Themeda triandra	5	5	4	5	4
Aristida congesta	5	5	4	5	4
Elionurus muticus	5	5	4	3	3
Cymbopogon plurinodis	5	4	2	4	3
Heteropogon contortus	5	5	4	2	2
Cynodon dactylon	3	3	2	5	5
Vernonia oligocephala	5	4	1	3	3
Aristida diffusa	4	4	2	1	1

Species group F (continued)
Common species of the western Transvaal grassland

Cymbopogon excavatus	3	4	2	1	3
Setaria flabellata	5	3	2	3	2
Hermannia depressa	3	3	1	3	3
Commelina africana	3	2	5	1	1
Eragrostis superba	4	2	1	3	1
Corchorus asplenifolius	4	3	1	2	2
Eragrostis gummiflua	3	2	2	2	2
Triraphis andropogonoides	5	4	2	3	1
Justicia anagalloides	5	4	2	2	1
Felicia muricata	2	2	2	4	3
Melinis repens	1	3	5	2	1
Crabbea angustifolia	5	3	1	2	1
Pogonarthria squarrosa	4	3	1	2	1
Turbina oblongata	4	2	2	1	1
Panicum coloratum	1	1	1	2	3
Helichrysum nudifolium	1	3	1	1	2
Hibiscus pusillus	1	1	1	3	2
Sporobolus africanus	3	1	1	3	1
Barleria macrostegia	5	4	1	3	1
Sutera atropurpurea	1	1	1	1	1
Eragrostis lehmanniana	4	2		3	1
Scabiosa columbaria	2	1		1	3
Geigeria burkei	2	2		2	2
Anthospermum rigidum	5	2		1	1
Setaria nigrirostris	1	1	1		1

Species group G

Eustachys paspaloides	5	3	3	3	
Brachiaria serrata	5	5	3	1	
Senecio venosus	2	4	1	1	
Elephantorrhiza elephantina	2	4	1	1	
Lippia scaberrima	2	3	2	4	
Ziziphus zeyheriana	2	3	2	4	
Blepharis angusta	1	2	1	2	
Dicoma anomala	3	4	1	1	
Commelina benghalensis	1	1	1	1	
Plexipus hederaceus	2	3	1	1	
Raphionacme hirsuta	3	2		2	
Gazania krebsiana	4	2		1	
Berkheya onopordifolia	1	1		1	
Salvia radula	1	1		1	
Mariscus capensis	1	1		1	

Species group H

Sida dregei		2	2	4	1
Hibiscus trionum		2	2	1	3
Gomphrena celosioides		1	2	2	2
Dicoma zeyheri		2	2	1	1
Walafrida densiflora		2	1	2	4
Stoebe vulgaris		2	1	1	2

Species group H (continued)					
Mariscus indecorus		2	2	1	1
Anthospermum hispidulum		3	3	2	3
Helichrysum rugulosum		2	1	1	3
Crabbea acaulis		2	2	2	3
Setaria sphacelata		2	2	3	4
Solanum incanum		2	1	2	1
Digitaria eriantha		4	3	5	5
Monsonia angustifolia		1	1	2	3
Acalypha angustata		4	2	1	1
Becium obovatum		2	2	1	1
Guilleminea densa		1	1	1	1
Aristida stipitata		1	1	1	1
Lightfootia denticulata		3		2	1
Ledebouria marginata		2		2	1
Salvia disermas		1		1	1
Stachys spathulata		1		1	1
Tylosema esculentum		1		1	1
Bulbine narcissifolia		1		1	1
Nidorella resedifolia		1		1	1
Pentzia globosa		1		1	1
Senecio affinis		1		1	1
Schkuhria pinnata		1		3	3
Lactuca serriola		3		2	4
Tephrosia semiglabra		1	1		1
Species group I					
Kohautia amatymbica	2	2			
Chamaecrista biensis	3	2			
Sida chrysantha	1	1			
Crassula lanceolata	1	1			
Zornia milneana	1	1			
Thesium transvaalense	1	1			
Species group J					
Bulbostylis burchellii	2	3	3		
Tephrosia longipes		2	2		
Acrotome hispida		1	1		
Plexipus adenostachyus		1	1		
Crabbea hirsuta		1	1		
Eriosema burkei		1	1		
Panicum natalensis		1	1		
Leucas glabrata		1	1		
Anthericum galpinii		1	1		
Indigofera filipes		1	1		
Pearsonia sessilifolia		1	1		
Thesium utile		1	1		
Triumfetta sonderi		1	1		
Eleusine coracana		1	1		
Pavetta gardeniifolia		1	1		

Species group K

Tarchonanthus camphoratus			1	1	
Rhus rigida			1	1	
Osyris lanceolata			1	1	
Lantana rugosa			1	1	
Maytenus polyacantha			1	1	
Ipomoea crassipes			1	1	
Tribilus terrestris			1	1	

Species group L

Kyllinga alba		1		1	
Ipomoea bathycolpos		1		1	
Antizoma angustifolia		1		1	
Hypoxis rooperi		1		1	
Ledebouria ovatifolia		1		1	
Albuca setosa		1		1	
Euphorbia clavaroides		1		1	
Hypoxis rigidula		1		1	
Helichrysum callicomum		1		1	
Rhynchosia adenodes		1		1	
Urginea sanguinea		1		1	
Indigofera hilaris		1		1	
Osteospermum muricatum		1		1	

Species group M

Solanum capense		2	3	1	
Pollichia campestris		2	2	3	
Gnidia capitata		2	2	2	
Cyanotis speciosa		3	1	2	
Rhynchosia nervosa		2	2	1	
Solanum panduriforme		1	2	2	
Zornia glochidiata		1	1	1	
Lotononis foliosa		1	1	1	
Tephrosia elongata		1	1	1	
Dianthus mooiensis		1	1	1	
Cleome rubella		1	1	1	
Sporobolus discosporus		1	1	1	
Aloe davyana		1	1	1	
Zinnia peruviana		1	1	1	
Haemanthus humilis		1	1	1	
Microchloa caffra		1	1	1	

Species group N

Tagetes minuta				1	1
Portulaca quadrifida				1	1
Convolvulus sagittatus				1	1
Chenopodium album				1	1
Arctotis venusta				1	1
Cynodon hirsutus				1	1
Aristida bipartita				1	1
Cyperus esculentus				1	1

Species group O

Bidens bipinnata			1	1	1
Merremia tridentata			1		1
Salvia runcinata			1		1
Urochloa panicoides			1		1

Species group Q

Andropogon appendiculatus		1			1
Kohautia cynanchica		1			1
Hermannia coccocarpa		1			1

CHAPTER 7

GENERAL DISCUSSION AND CONCLUDING REMARKS

PAGE

7.1 General

In this dissertation conclusions for specific contributions are given at the end of each of the different manuscripts or articles. It includes the conservation status as well as the agricultural importance of that particular area. However, certain points deserve a more detailed discussion and will be addressed in the following paragraphs.

When passing through the western Transvaal grassland, its physiognomic appearance is similar to all the other grasslands in the Grassland Biome. However, this study proved that the vegetation of the study area is unique and could therefore be syntaxonomically assessed, as was done in the description of the vegetation of the different land types. Apart from the *Grewio flavae - Acacietea karroo* (Class 4) in chapter 6 that may have certain similarities to the *Acacietea karroo* described by Du Preez & Bredenkamp (1991) in the south-eastern Orange Free State, the rest of the Classes are unique in the vegetation of southern Africa. The plant communities identified in the phytosociological synthesis of the northern Orange Free State vegetation (Fuls 1993) are not presently considered to have any similarities to the vegetation Classes of the western Transvaal grassland.

Although the recognised vegetation units or syntaxa and associated habitats can be distinguished in the veld, a map which includes all the vegetation units or even major vegetation units is difficult to compile on a 1 : 250 000 scale. These units are mostly distributed in a mosaic pattern and are often not restricted to certain areas. There are also vast areas that have been ploughed, and only 2.7 % of the land is not suitable for cultivation (Land Type Survey Staff 1984). This complicates the compilation of a phyto-physiographic delimitation of the vegetation units in the western Transvaal grassland. In the general discussion on the sampling strategies, an account is given on how the land types fit into the delimitation of the study area.

It was established that some floristic relationships do exist among the different Veld Types (Acocks 1988) from the study area, but the Kalahari Thornveld (Veld Type 16) can clearly be distinguished from the Dry *Cymbopogon* - *Themeda* Veld (Veld Type 50) in the western parts of the study area (Bezuidenhout *et al.* 1993). A relatively good floristic relationship is indicated among Acocks' (1988) different Veld Types and the vegetation units classified and described by Bezuidenhout & Bredenkamp (1991a, b, c), Bezuidenhout *et al.* (1993, *in press.*, *submitted*(a), *submitted*(b), *in prep.*(a) and *in prep.*(b)), Bredenkamp *et al.* (1989) and Bredenkamp & Bezuidenhout (1990). Thus, on a 1 : 1 500 000 scale, Acocks' (1988) Veld Types is relatively accurate in the western Transvaal grasslands, but the scale is to small to be of value in decision making when it comes to important issues such as management and conservation planning. The above-mentioned more detailed classifications should be used as a basis.

Siegfried (1989) identified the Grassland Biome as one of the most critically threatened southern African ecosystems, with only 2 % being conserved. The present conservation status of the western Transvaal grassland is very poor (0.33 %) with only small areas officially conserved namely: (i) the Baberspan Nature Reserve (3 086 hectares), (ii) Abe Bailey Nature Reserve (1 888 hectares), (iii) Boskop Dam Nature Reserve (3 160 hectares) (Greyling & Huntley 1984) and the Faan Meintjes Nature Reserve (930 hectares) (Bredenkamp & Bezuidenhout 1990). The poor conservation record within the western Transvaal grassland, combined with the high exploitation thereof, emphasise the urgent need for ecologically sound conservation planning in the region. The identification and allocation of conservation areas must be done on a scientific basis. The result of this vegetation classification of the different land types does provide an ecological basis for the identification and establishment of conservation areas in the western Transvaal grassland.

However, the large impact of disturbance in the study area by means of utilization, has left the western Transvaal grasslands with a mosaic pattern of vegetation. In the study area part of the Fa land type (dolomitic and chert grassland - Bezuidenhout *et al. submitted.*(a)), Fb land type (Bezuidenhout *et al. in press.*) and the Vredefort Dome (Du Preez 1987 and Bezuidenhout *et al.* 1988) deserve to be conserved. Both of these land types occur on mostly shallow, rocky soils where the only disturbance is over-grazing. Any available land, in all land types should be conserved. The Gatsrand area north-east of Potchefstroom (Fb land type - Bezuidenhout *et al.* *in press*.) and the dolomitic and chert Woodland between Potchefstroom and Klerksdorp (Bezuidenhout *et al.* *submitted*(a)) are areas that have the potential to be conserved. With two of the four Nature Reserves, the Abe Bailey - and the Boskop Dam Nature Reserves situated in the dolomitic and chert grassland, this grassland is relatively well conserved. The Vredefort Dome is unfortunately devided among many owners and it will be difficult to consolidate a big enough area to be conserved as an ecosystem. It is presently believed that in order to conserve the biodiversity of the western Transvaal grasslands, an area larger than 10 000 hectares is required. The present conservation areas could also be enlarged and proper management planning is of vital importance.

The relatively low and erratic rainfall of the western parts doesn't favour agronomy, although many farmers have ploughed and planted maize and/or other crops in good rainfall years (Morris 1976, Bezuidenhout & Bredenkamp 1991a). These areas are better suited for cattle and, to a lesser extent, sheep farming (Department of Agriculture and Water Supply 1987, Bezuidenhout *et al.* 1993).

7.2 Methodological aspects

i) Sampling strategies

In this study most of the attention was vested in dominant vegetation communities which were adequately sampled to enable identification and characterisation of the different vegetation units. The stratified sampling strategy used for this study ensured that a representative sample of the variation was obtained while the random element ensured that the sampling was statistically acceptable (Werger 1973). Such a strategy is of particular importance where the number of samples is strictly limited (because of extensive cultivation), as was the case in this study.

Thus, the random stratified sampling strategy used was both efficient and sufficient. It was efficient in covering the variation adequately and sufficient in that a limited number of samples provided acceptable results. Quadrat size of 16 m² (grassland) and 100 m² (woodland & shrubland) appeared to be sufficiently large as were also found by Bredenkamp & Theron (1980), Kooij (1990), Du Preez (1991) and Smit (1992). Habitat data recorded was also adequate for this type of broad scale, regional study.

Stratification by land types was a relatively new idea for a phytosociological study in 1985 when this study commenced. The study of the Mooi River Catchment area, proved the method to be successful (Bezuidenhout 1988). In later studies of the Grassland Biome, it was also used fairly successfully (Kooij 1990, Breytenbach 1991, Smit 1992, Coetzee 1993 and Eckhardt *et al. in press*). Bezuidenhout (1988) found that certain vegetation units are restricted to certain land types and topographical positions (terrain types). In order to use this classification and description of the vegetation of the western Transvaal grassland properly, the following procedures should be followed.

a) Identification of the land type.
b) Identification of the topographical position.

A comprehensive description of the vegetation type which is expected to be found in a specific topographical position in a land type is available (Bezuidenhout & Bredenkamp 1991a, Bezuidenhout *et al*. 1993, *in press*., *submitted*(a), *submitted*(b)). Some of the topographical positions which may be confusing in the veld, are the midslopes (3) with the bottomlands flats (4), and the midslopes (3) with the plateaux (1). But by using the diagnostic species and other prominent species of these vegetation units, this problem can easily be solved.

It is important to note that Eckhardt (1993) and Fuls (1993) mentioned that the plant communities occurring in the north and north-eastern Orange Free State are not necessarily restricted to certain land types and terrain units. However, Eckhardt *et al*. (1993) used the Ea land type successfully to assess the veld condition and grazing capacity in the grassland of the north-eastern Orange Free State. Kooij (1990) in the north-western Orange Free State also used land types and terrain forms successfully for the stratification of the study area. One of the reasons for the Eckhardt (1993) and Fuls (1993) studies not fitting the land types stratification model is probably the higher rainfall which seems to override other abiotic factors.

ii) Classification

The combination of procedures followed namely a numerical classification technique (TWINSPAN)(Hill 1979a) as a first approximation of the vegetation units, followed by the refinement by Braun-Blanquet procedures, proved to be highly successful. Amongst others, these procedures were successfully used by Kooij (1990), Breytenbach (1991), Du Preez (1991), Matthews 1991, Smit (1992), Coetzee (1993), Eckhardt (1993) and Fuls (1993).

It is clear that wheel point data cannot be treated together with total floristic data in a single classification, as relevés containing only part of the total floristic composition may be classified in totally separate classes. However wheel point data may be used for classification of vegetation and may be reconciliated with basic Braun-Blanquet classifications. Classes obtained from classifications based on wheel point data may often represents higher vegetation units in a hierarchical classification system (Bredenkamp *et al*. 1991).

The new classification method to be applied on very large phytosociological data sets, in the synthesis of the results of many different studies, in order to derive a hierachical syntaxonomy, proved to be successful. This method was also successfully used by other researchers in the Grassland Biome (Du Preez 1991 and Fuls 1993).

No formal syntaxonomy was applied to the classifications of the Mooi River Catchment Area, smaller Nature Reserves and the reclassification of the Lichtenburg area. This is in accordance with the opinion of Mueller-Dombois & Ellenberg (1974), stating that it is useful to maintain an unsystematic status for communities in all cases where the emphasis is on intensive local studies. To accommodate numerous detailed vegetation units in the formal nomenclatoral system has led to inflation of the rank of association (Pignatti 1968 and Coetzee 1983).

A hierarchical, formal classification of the five land types as well as a synecological and syntaxonomical synthesis of the grassland communities in the entire western Transvaal were conducted in accordance to the Code of Phytosociological Nomenclature (Barkman *et al.* 1986).

This is the first comprehensive synecological and syntaxonomical account of the grassland and associated vegetation in the western Transvaal Grassland Biome. It should be emphasised that regarding possible synonymy of the different plant communities within a class, all original relevés representing a specific class should be combined in a single phytosociological table in order to establish the floristic relationships amongst the different communities. From these analyses a hierarchical syntaxonomy including synonyms may be compiled. This account creates the essential basis for such detailed syntaxonomic investigation.

iii) Ordination

The results of the ordinations (DECORANA)(Hill 1979b) indicate the floristic relationships amongst the vegetation units and emphasise the relation between the habitat gradients and vegetation units. It was possible to relate the vegetation units to certain environmental variables and often clear gradients could be recognised. This could be ascribed to the relatively low to intermediate rainfall of the study area where the importance of terrain and soil types, soil depth, clay content, drainage and rockiness of the soil surface is emphasized. Higher rainfall to the eastern parts of the Grassland Biome causes the influence of these environmental factors to be less prominent (Eckhardt 1993 and Fuls 1993).

7.3 Concluding remarks

The objectives for this study were successfully achieved namely:

(a) To identify, describe, and determine the location of the grassland and other vegetation types within the western Transvaal Grassland Biome, and

(b) to create a synecological and syntaxonomical synthesis of the vegetation of the western Transvaal grassland.

The classification, descriptions and ecological interpretations of the vegetation and associated habitats of the different land types should form a basis for all vegetation-related management and conservation planning in the region. The described vegetation units can easily be recognised in the veld and should be regarded as scientifically based ecological and management units. It should be used by conservationist as well as agriculturalist for optimal land use planning. It is also possible that the farmer at farm level scale could use these results. Other detailled studies on vegetation dynamics and plant-soil interactions, can now be initiated within the recognised vegetation units.

Typical of the vegetation of the western Transvaal grasslands, two structural units, namely woodland and grassland, could easily be identified. A third structural unit, shrubland, could also be identified in some of the land types. The main contributing abiotic factors which influence the distribution of the vegetation, apart from land types (uniformity in respect to terrain form, soil pattern and climate), are available moisture, topographical position in relation to altitude, soil depth, drainage, percentage stones or rocks on the soil surface and to a lesser extent clay content.

7.4 References

ACOCKS, J.P.H. 1988. Veld Types of South Africa. 3rd edn. *Mem. bot. Surv. S. Afr.* 57: 1 - 146.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of Phytosociological Nomenclature. 2nd edn. *Vegetatio* 67: 145 - 195.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991a. The vegetation of the Bc land type in the western Transvaal Grassland, South Africa. *Phytocoenologia* 19: 497 - 518.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991b. Plantegroeiklassifikasie van die A-landtipe van die Mooirivieropvanggebied, Transvaal. *S. Afr. Tydskr. Natuurwet. & Tegnol*. 10: 4 - 11.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991c. Die plantgemeenskappe van die Ba-landtipe van die Mooirivieropvanggebied, Transvaal. *S. Afr. Tydskr. Natuurwet. & Tegnol*. 10: 85 - 92.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydskr. Natuurwet. & Tegnol*. 7: 4 - 9.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. 1993. The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa. *S. Afr. J. Bot.* 59: 319 - 331.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *in press*. Syntaxonomy of the vegetation of the Fb land type in the western Transvaal Grassland, South Africa. (*S. Afr. J. Bot.*).

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted*(a). The vegetation syntaxa of the Ba land type in the western Transvaal Grassland, South Africa. (*S. Afr. J. Bot.*).

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted*(b). The vegetation of the western Transvaal dolomitic and chert grassland, South Africa. (*S. Afr. J. Bot.*).

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep*(a). A Braun-Blanquet reclassification of the *Cymbopogon-Themeda* Grassland in the Lichtenburg area, south-western Transvaal.

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep*(b). A Braun-Blanquet reclassification of the Bankenveld Grassland in the Lichtenburg area, south-western Transvaal.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. 1990. The vegetation of the Faan Meintjes Nature Reserve, Transvaal. *S. Afr. J. Bot.* 56: 54 - 64.

BREDENKAMP, G.J., BEZUIDENHOUT, H., BOSCH, O.J.H. & JANSE VAN RENSBURG, F.P. 1991. A comparison of vegetation classification from wheel point and total floristic data sets from a South African grassland. *Bot. Bull. Academia Sinica* 32: 187 - 195.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom-Fochville-Parys area. *S. Afr. J. Bot.* 55: 199 - 206.

BREDENKAMP, G.J. & THERON, G.K. 1980. A synecological account of the Suikerbosrand Nature Reserve II. The phytosociology of the Ventersdorp geological system. *Bothalia* 13: 199 - 216.

BREYTENBACH, P.J.J. 1991. Die fitososiologie van die Villiers-Grootvlei-omgewing. M.Sc. thesis, University of Pretoria, Pretoria.

COETZEE, B.J. 1983. Phytosociology, vegetation structure and landscapes of the Central District, Kruger National Park. *Dissertationes Botanicae* 69: 1 - 456.

COETZEE, J.P. 1993. Phytosociology of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area. M.Sc. thesis, University of Pretoria, Pretoria.

DEPARTMENT OF AGRICULTURE AND WATER SUPPLY. 1987. Landbou-ontwikkelingsprogram: Hoëveldstreek 1986. Directorate Agricultural Information, Government Printer, Pretoria.

DU PREEZ, P.J. 1987. Ekologie van die boomgemeenskappe van die Vredefortdistrik, Oranje-Vrystaat. M.Sc. thesis, University of the Orange Free State, Bloemfontein.

DU PREEZ, P.J. 1991. A syntaxonomical and synecological study of the vegetation of the southern and eastern Orange Free State and related areas with special reference to Korannaberg. D.Sc. dissertation. University of the Orange Free State, Bloemfontein.

DU PREEZ, P.J. & BREDENKAMP, G.J. 1991. Vegetation classes of the southern and eastern Orange Free State (Republic of South Africa) and the highlands of Lesotho. Navors. *Nas. Mus., Bloemfontein* 7: 477 - 525.

ECKHARDT, H.C. 1993. A synecological study of the vegetation of the north-eastern Orange Free State. M.Sc. thesis. University of Pretoria, Pretoria.

ECKHARDT, H.C., VAN ROOYEN, N. & BREDENKAMP, G.J. 1993. The application of Braun-Blanquet data in the assessment of veld condition and grazing capacity in grassland. *Afr J Range For Sci* 10: 41 - 46.

ECKHARDT, H.C., VAN ROOYEN, N. & BREDENKAMP, G.J. *in press*. The vegetation of the north-eastern Orange Free State, South Africa: the physical environment of the total study area and plant communities of the Ea land type. (*Bothalia*).

FULS, E.R. 1993. Vegetation ecology of the northern Orange Free State. Ph.D. dissertation, University of Pretoria, Pretoria.

GREYLING, T. & HUNTLEY, B.J. 1984. Directory of southern African conservation areas. *S. Afr. Nat. Sci. Prog. Rep*. 98: 1 - 311.

HILL, M.O. 1979a. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

HILL, M.O. 1979b. DECORANA - A Fortran program for detrended correspondence analysis and reciprocal averaging. Cornell University, New York.

KOOIJ, M.S. 1990. A phytosociological study of the north-western Orange Free State. M.Sc. thesis, University of Pretoria, Pretoria.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. agric. nat. Resour. S. Afr.* 4: 1 - 441.

MATTHEWS, W.S. 1991. Phytosociology of the north-eastern Mountain sourveld. M.Sc. thesis, University of Pretoria, Pretoria.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

MORRIS, J.W. 1976. Automatic classification of the highveld grassland of Lichtenburg, south-western Transvaal. *Bothalia* 12: 267 - 292.

PIGNATTI, S. 1968. Die Inflation der höheren pflanzensoziologischen Einheiten. *In* R. Tüxen (ed.) Pflanzensoziologische Systematik. Junk, The Hague.

SIEGFRIED, W.R. 1989. Preservation of species in southern African nature reserves. *In* B.J. Huntley (ed.) Biotic diversity in southern Africa: Concepts and conservation. Oxford University Press, Cape Town.

SMIT, C.M. 1992. Phytosociology of the Newcastle-Memel-Chelmsford Dam area. M.Sc. thesis, University of Pretoria, Pretoria.

WERGER, M.J.A. 1973. Phytosociology of the Upper Orange River Valley, South Africa. Ph.D. dissertation, University of Nijmegen, Nijmegen.

Summary

SYNTAXONOMY AND SYNECOLOGY OF WESTERN TRANSVAAL GRASSLANDS

by

Hugo Bezuidenhout

Promoter: Prof Dr G.J. Bredenkamp
Co-promoter: Prof Dr G.K. Theron

in the
Department of Botany
University of Pretoria

for the degree
PHILOSOPHIAE DOCTOR (BOTANY)

A large part of the Grassland Biome is situated in the Highveld Region where industrial, mining as well as agricultural activities are very prominent. Due to this threat and a lack of vegetation data, especially phytosociological data, a phytosociological research program was encouraged by the Foundation of Vegetation Classification and Mapping Working Group under the auspices of the Grassland Biome Project. One of the major aims of the Grassland Biome Program is the compilation of a comprehensive synecological and syntaxonomical synthesis of the Grassland Biome in southern Africa. Gaps in the knowledge of the vegetation were identified and a variety of projects were initiated. Amongst others, this study in the western Transvaal grassland had been launched.

Relatively little is known about the vegetation of this area and consequently the primary aim of this study was to identify, classify, describe and determine the location of the grassland plant communities and other vegetation types within the western Transvaal grassland. Although not the primary aim, the compilation of a comprehensive syntaxonomical and synecological

synthesis of the vegetation in the study area is equally important, as it fits in with the total syntaxonomical study of the Grassland Biome. The results will provide valuable insight into the plantecology of the vegetation of the western Transvaal grassland and should be used as a point of reference for future management, conservation and research purposes.

The western Transvaal grassland occurs in the north-western corner of the Grassland Biome. The study area covers approximately 2.7 million hectares and is bounded by latitudes 25° 45′ and 27° 15′ south and longitudes 24° 45′ and 28° 00′ east. The gently undulating landscape is sometimes interrupted by ridges and hills and could be divided into four major land types. The relatively heterogeneous geology are represented by the isolated Archaic granite, Witwatersrand Supergroup, Ventersdorp Supergroup, Transvaal Sequence, small outcrops of the Karoo Sequence and recent deposits. Soils are also heterogeneous and vary from sandy, clayey to rocky, due to the variation in parent material. The study area is classified as a warm, temperate to semi-dry climate in a summer rainfall region. Marked climatic contrasts between summer and winter are common in the area with extremes like droughts, flooding, hail, rare snow and frosts regularly occurring. The rainfall is unpredictable and varies from an average of 450 mm per year in the west to 770 mm per year in the east.

The Braun-Blanquet procedures as well as other multivariate analysis techniques were used to successfully attain the objectives of this study. Two newly described concepts have helped to better the standard procedures. The TWINSPAN classification is an extremely good first approximation to create a basic classification, which when refined by the application of Braun-Blanquet procedures results more quickly into ecologically, interpretable vegetation units. An ordination algorithm (DECORANA) was used to indicate the floristic relationships amongst the vegetation units and make the classification more interpretable. In the past the effective classification of large data sets was a problem but by using the new procedure for the analysis of large phytosociological data sets it has resulted in a successfully synecological and syntaxonomical synthesis of the western Transvaal grasslands. The first stratification of the study area was based on land types whereafter terrain types were used. These procedures helps to attain an easy classification and ecologically interpretable vegetation description of the vegetation units, for the layman as well as the scientist.

No attempt was made to formally fix names for the vegetation units of the smaller, local, detailed studies. The vegetation of two of the four Nature Reserves in the study area were identified, classified and ecologically interpreted. These results can be used as baseline information for management planning in the Reserves. The data of the Lichtenburg area was reclassified and used in the compilation of the synthesis of the western Transvaal grassland. The vegetation of the five major land types were synecologically and syntaxonomically classified and two orders, 13 alliances, 37 associations, 12 sub-associations, five communities without syntaxonomical rank and two variants were identified and newly described. In a detailed syntaxonomical and synecological account of the western Transvaal grassland, compiled from 1 025 relevés, representing 114 plant communities, five newly described phytosociological Classes are presented.

The vegetation units of the western Transvaal grasslands are unique to the region and could therefore be classified syntaxonomically. The present conservation status of the western Transvaal grassland is very poor and an urgent need for ecologically sound conservation planning in the region is a necessity. The synecological and syntaxonomical synthesis provide the essential basis for detailed syntaxonomic investigation in the Grassland Biome.

Opsomming

SINTAKSONOMIE EN SINEKOLOGIE VAN WES-TRANSVAALSE GRASVELDE

deur

Hugo Bezuidenhout

Promotor: Prof Dr G.J. Bredenkamp
Mede-promotor: Prof Dr G.K. Theron

in die
Departement Plantkunde
Universiteit van Pretoria

vir die graad
PHILOSOPHIAE DOCTOR (PLANTKUNDE)

'n Groot gedeelte van die Grasveldbioom is in die Hoëveldstreek geleë. Industriële-, mynbou- sowel as landbou-aktiwiteite is hier die hartklop van Suid-Afrika. Weens dié bedreiging sowel as die tekort aan bestaande plantegroeidata, veral fitososiologiese data, is 'n Navorsingsprogram deur die Plantegroei Klassifikasie en Kartering Werkgroep as deel van die Grasveldbioomprojek begin. Een van die hoof doelwitte van die projek is om 'n omvattende sinekologiese en sintaksonomiese sintese van die Grasveldbioom van suidelike Afrika saam te stel. Leemtes is in die kennis van verskeie gebiede se plantekologie geïdentifiseer en gevolglik is projekte in die onderskeie gebiede geïnisieer. Een van die projekte is in die Wes-Transvaalse grasveld aangepak.

Met die aanvang van die projek was daar relatief min inligting oor die plantegroei van die gebied bekend. Die hoofdoel van die studie was dus om die grasveld en ander plantegroei-eenhede van die Wes-Transvaal te identifiseer, klassifiseer, beskryf en hul verspreiding te bepaal. 'n Sekondêre ewe belangrike doel was om 'n

samevattende sinekologiese en sintaksonomiese sintese, met inagneming van die breë samevattende Grasveldbioomprojek, van die Wes-Transvaalse plantegroei saam te stel. Uit bogenoemde doelstellings sal waardevolle kennis oor die plantegroei van die gebied verkry word, wat as verwysingsraamwerk vir bestuurs-, bewarings- en navorsingsdoeleindes gebruik kan word.

Die Wes-Transvaalse grasveld is in die noord-westelike hoek van die Grasveldbioom geleë. Die gebied, wat 'n totale oppervlakte van 2.7 miljoen hektaar beslaan, lê tussen die lengtegrade 25° 45′ en 27° 15′ suid en die breedtegrade 24° 45′ en 28° 00′ oos. Die liggolwende landskap, wat soms deur heuwels en rante onderbreek word, word deur geïsoleerde Argaïese graniet, Ventersdorp Supergroep, Witwatersrand Supergroep, Transvaalse Opeenvolging, 'n klein gedeelte van die Karoo Opeenvolging asook meer resente afsettings onderlê. Weens die groot variasie in moedermateriaal, is die gronde van die studiegebied heterogeen en wissel dit van kleierig, sanderig tot klipperig. Vier hoof landtipes word in die gebied onderskei. Die studiegebied word as 'n warm, gematigde tot semi-droë klimaat in 'n somerreënvalstreek beskryf. Klimaatskontraste tussen somer en winter is algemeen en uiterstes soos droogtes, vloede, hael, ryp en soms selfs sneeu word in die gebied aangetref. Die reënval is onvoorspelbaar en varieer van die weste (450 mm per jaar) tot in die ooste (770 mm per jaar).

Die Braun-Blanquet-prosedures sowel as ander tegnieke onder andere meerveranderlike analises is gebruik om betekenisvolle resultate te verkry. Die studie het ook twee nuwe toevoegings tot die bestaande prosedures bygedra. Een van die gevolgtrekkings was dat die TWINSPAN klassifikasie 'n goeie eerste klassifikasie is maar dat die resultaat daarvan verder deur die Braun-Blanquet- prosedures verfyn moet word. Dit lei tot 'n vinniger klassifikasie van die data. 'n Ordeningsalgoritme DECORANA wat die floristiese verwantskappe tussen die plantegroei-eenhede aandui, is gebruik om die klassifikasies meer interpreteerbaar te maak. Die verwerking van groot datastelle was in die verlede 'n probleem en 'n prosedure vir die hantering van groot datastelle word voorgestel. Hierdie prosedure is gebruik om 'n suksesvolle sinekologiese en sintaksonomiese sintese van die Wes-Transvaalse grasveld te maak. Die studiegebied is deur middel van landtipes gestratifiseer, wat daarna weer in topografiese posisies ingedeel is. Hierdie prosedure het gehelp om 'n eenvoudige en ekologies interpreteerbare beskrywing van die plantegroei-eenhede daar te stel, wat deur die leek sowel as die wetenskaplike gebruik kan word.

Wanneer dit 'n lokale, intensiewe studie van 'n relatiewe klein lokaliteit was, is daar geen formele naamgewing toegepas nie. Plantegroei van twee van die vier Natuurreservate in die studiegebied is ook as deel van hierdie studie geïdentifiseer, geklassifiseer en ekologies geïnterpreteer. Hierdie studies kan as basis vir bestuursplanne vir die onderskeie Natuurreservate dien. Die Lichtenburg-omgewing se plantegroei is geherklassifiseer en bruikbare resultate, wat by die sinekologiese en sintaksonomiese sintese van die Wes-Transvaalse grasveld gebruik is, is verkry. Die plantegroei van vyf hoof landtipes (Bc, Bd en Ea, Fb, Fa, Ba) is sinekologies en sintaksonomies geklassifiseer volgens die internasionale kode. In die sinekologiese en sintaksonomiese klassifikasie van die onderskeie landtipes is twee nuwe ordes, 13 nuwe alliansies, 37 nuwe assosiasies, 12 nuwe sub-assosiasies, vyf nuwe gemeenskappe sonder rang en twee nuwe variante geïdentifiseer en beskryf. In die sintese van die Wes-Transvaalse grasveld, bestaande uit 1 025 relevés, wat 114 plantgemeenskappe verteenwoordig, is vyf nuwe klasse geïdentifiseer en beskryf.

Dit blyk dat die plantegroei-eenhede van die Wes-Transvaalse grasveld uniek is tot die streek en daarom is dit sintaksonomies ontleed. Die huidige bewaringstatus van die Wes-Transvaalse plantegroei is baie swak en daadwerklike ekologies gefundeerde bewaringsbeplanning is noodsaaklik. Die sinekologiese en sintaksonomiese sintese van die studiegebied lewer 'n bydrae tot die uiteindelike doel om 'n omvattende sintaksonomiese en sinekologiese beskrywing van die totale Grasveldbioomprojek in Suid-Afrika te maak.

Acknowledgements

I wish to express my deepest gratitude towards our Heavenly Father Whose Providence gave me such wonderful people to assist me as well as His Grace which supported me to finish this study.

Without the assistance and co-operation of the following people and organizations/institutions this study would not have been possible. I would like to offer my sincerest thanks and deepest gratitude for their help and contributions.

Prof G.J. Bredenkamp - it was a privilege to have Prof Bredenkamp as a Promoter. His active dedication to his subject was an inspiration to me and his positive attitude and practical advice as well as speedy feedback, even on holiday, is deeply appreciate.

Prof G.K. Theron - it was a privilege to have Prof Theron as a Co-promoter. His thoroughness, encouragement and speedy feedback, even on holiday, is deeply appreciated.

Dr's A. Hall-Martin and P. Novellie (National Parks Board) for support to finish this study.

Dr J.C. Scheepers for encouragement.

Miranda Deutschländer, Hester Steyn and Petri Coetzee for their friendly assistance.

Nooientjie Schaap and Annette Loubser for assistance with some of the figures and tables.

The Foundation for Research Development, Council for Scientific and Industrial Research is thanked for financial support.

The Department of Agricultural Development for giving permission to use some data which were collected while under their employment.

Family and friends for their encouragement and moral support.

My wife Thea Bezuidenhout, whom apart from encouragement and moral support also assisted with the drawing of nearly all the figures and tables as well as for fruitful discussions and valuable comments on the whole thesis.

My parents Koos and Litch Bezuidenhout for never stopping to encourage and support me as well as funding my undergraduate studies.

Curriculum Vitae

Hugo Bezuidenhout was born on 26 January 1960 in Potchefstroom, Western Transvaal. He matriculated in 1978 at the Gimnasium High School, Potchefstroom.

In 1982 he obtained a B.Sc. degree at the Potchefstroom University for Christian Higher Education (P.U. for C.H.E) with Plant - and Soil Sciences as major subjects. While doing his two year military service, where he worked as a soil scientist, he received a Diploma in Terrain Evaluation from the same University at the end of 1984.

From 1985 until the end of 1987, he was employed as a Research Assistant at the Department of Botany (P.U for C.H.E.). During that period he received the following degrees from the aforementioned University: in 1986 the B.Sc. honours degree (*cum laude*) and in the beginning of 1988 the M.Sc. degree for his thesis entitled: "A Plantsociological study of the Mooi River catchment area, Transvaal".

In the beginning of 1988 he accepted a post as Assistant Agricultural Researcher offered by the Department of Agricultural Development, Research Centre for Pastures Science, Roodeplaat (Pretoria) and was promoted to Agricultural Researcher in the beginning of 1990. At the end of 1990 he was appointed as Senior Scientist at the National Parks Board's Scientific Services, Southern Parks in Kimberley, where he is still employed.

He is also used as referee for several phytosociological manuscripts for two journals as well as external examiner for the University of Pretoria. At present he is a full member of the South African Association of Botanists as well as a full member of the Grassland Society of Southern Africa.

Since 1988 he has published 11 scientific articles and three semi-scientific articles in international as well as national journals. He has also presented or contributed to several unpublished papers as well as posters at various national and international congresses.

In 1989 he married Dorothea Janse van Rensburg and one son, Kobus, was born from this marriage.

REFERENCES

ACOCKS, J.P.H. 1953. Veld Types of South Africa. 1st edn. *Mem. bot. Surv. S. Afr.* 28: 1 - 192.

ACOCKS, J.P.H. 1975. Veld Types of South Africa. 2nd edn. *Mem. bot. Surv. S. Afr.* 40: 1 - 128.

ACOCKS, J.P.H. 1988. Veld Types of South Africa. 3rd edn. *Mem. bot. Surv. S. Afr.* 57: 1 - 146.

ANON. 1987. Agriculture in South Africa. 2nd edn. Chris van Rensburg, Johannesburg.

ARNOLD, T.H. & DE WET, B.C. 1993. Plants of southern Africa: names and distribution. *Mem. bot. Surv. S. Afr.* 62: 1 - 825.

BAILEY, N.T.F. 1974. Statistical Methods in Biology. Lion Library, London.

BARKER, C.H. 1985. 'n Geomorfologiese studie van die Mooirivieropvanggebied. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of Phytosociological Nomenclature. 2nd edn. *Vegetatio* 67: 145 - 195.

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanical Garden. *S. Afr. J. Bot.* 54: 525 - 533.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H. *in prep.* The vegetation of the Vaalbos National Park, north-eastern Cape.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* 18: 387 - 403.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991. Plantegroeiklassifikasie van die A-landtipe van die Mooirivieropvanggebied, Transvaal. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 10: 4 - 11.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991. Die plantgemeenskappe van die Ba-landtipe in die Mooirivieropvanggebied, Transvaal. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 10: 85 - 92.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991. The vegetation of the Bc land type in the western Transvaal Grassland, South Africa. *Phytocoenologia* 19: 497 - 518.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel noordwes van Parys. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 7: 4 - 9.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. 1993. The vegetation of the Bd and Ea land types in the grassland of the western Transvaal, South Africa. *S. Afr. J. Bot.* 59: 319 - 331.

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *in press.* Syntaxonomy of the vegetation of the Fb land type in the western Transvaal Grassland, South Africa. *S. Afr. J. Bot.*

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted.* The vegetation syntaxa of the Ba land type in the western Transvaal Grassland, South Africa. (*S. Afr. J. Bot.*)

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *submitted.* The vegetation of the western Transvaal dolomitic and chert grassland, South Africa. (*S. Afr. J. Bot.*)

BEZUIDENHOUT, H., BREDENKAMP, G.J. & THERON, G.K. *in prep.* Phytosociological Classes of the western Transvaal grassland, South Africa.

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep*. A Braun-Blanquet reclassification of the Bankenveld Grassland in the Lichtenburg area, south-western Transvaal.

BEZUIDENHOUT, H., BREDENKAMP, G.J., THERON, G.K. & MORRIS, J.W. *in prep*. A Braun-Blanquet reclassification of the *Cymbopogon-Themeda* Grassland in the Lichtenburg area, south-western Transvaal.

BLOEM, K.J. 1988. 'n Plantsosiologiese studie van die Verlorenvaleinatuurreservaat, Transvaal. M.Sc. thesis, University of Pretoria, Pretoria.

BLOEM, K.J., THERON, G.K. & VAN ROOYEN, N. 1993. Grassland communities of the Verlorenvalei Nature Reserve in the North-eastern Sandy Highveld, Transvaal. *S. Afr. J. Bot*. 59: 273 - 280.

BOSCH, O.J.H. 1985. Die weiveld van die Faan Meintjes-natuurreservaat: 'n Ekologiese ondersoek. Klerksdorp Record, Klerksdorp.

BOSCH, O.J.H. 1989. Degradation of the semi-arid grasslands of southern Africa. *J. Arid. Environ*. 16: 165 - 175.

BOSCH, O.J.H. & JANSE VAN RENSBURG, F.P. 1987. Ecological status of species on grazing gradients on shallow soils of the western grassland biome in South Africa. *J. Grassl. Soc. South. Afr*. 4: 143 - 147.

BOSCH, O.J.H., JANSE VAN RENSBURG, F.P. & TRUTER, S. DU T. 1987. Identification and selection of benchmark sites on litholitic soils of the western grassland biome of South Africa. *J. Grassl. Soc. South. Afr*. 4: 59 - 62.

BRAUN-BLANQUET, J. 1932. Plant sociology. Transl. by Fuller, G.D. & Conard, H.S. McGraw-Hill, New York.

BRAUN-BLANQUET, J. 1964. Pflanzensociologie. 3rd edn. Springer, Vienna.

BREDENKAMP, G.J. 1975. A plant sociological study of the Suikerbosrand Nature Reserve. M.Sc. thesis, University of Pretoria, Pretoria.

BREDENKAMP, G.J. 1982. A plant ecological study of the Manyeleti Game Reserve. D.Sc. dissertation, University of Pretoria, Pretoria.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. 1990. The vegetation of the Faan Meintjes Nature Reserve, Transvaal. *S. Afr. J. Bot.* 56: 54 - 64.

BREDENKAMP, G.J. & BEZUIDENHOUT, H. *in prep.* A proposed procedure for the analysis of large data sets in the classification of South African Grasslands.

BREDENKAMP, G.J., BEZUIDENHOUT, H., BOSCH, O.J.H. & JANSE VAN RENSBURG, F.P. 1991. A comparison of vegetation classification from wheel point and total floristic data sets from a South African grassland. *Bot. Bull. Academia Sinica* 32: 187 - 195.

BREDENKAMP, G.J., BEZUIDENHOUT, H., NAUDE, C., JOUBERT, H. *in prep.* The vegetation of the Boskop Dam Nature Reserve, Potchefstroom.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom - Fochville - Parys area. *S. Afr. J. Bot.* 55: 199 - 206.

BREDENKAMP, G.J. & LAMBRECHTS, A.V.W. 1979. A check list of the floristic plants and ferns of the Suikerbosrand Nature Reserve. *Jl S. Afr. Bot.* 45: 25 - 47.

BREDENKAMP, G.J. & THERON, G.K. 1976. Vegetation units for management of the grasslands of the Suikerbosrand Nature Reserve. *S. Afr. J. Wild. Res.* 6: 113 - 122.

BREDENKAMP, G.J. & THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve I. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513 - 329.

BREDENKAMP, G.J. & THERON, G.K. 1980. A synecological account of the Suikerbosrand Nature Reserve II. The phytosociology of the Ventersdorp geological system. *Bothalia* 13: 199 - 216.

BREYTENBACH, P.J.J. 1991. Die fitososiologie van die Villiers-Grootvlei-omgewing. M.Sc. thesis, University of Pretoria, Pretoria.

BREYTENBACH, P.J.J., MYBURGH, W.J., THERON, G.K. & BREDENKAMP, G.J. 1992. The phytosociology of the Villiers - Grootvlei area, South Africa. 1. Physical environment and the plant communities of the Bb Land Type. *S. Afr. J. Bot.* 58: 239 - 249.

COETZEE, B.J. 1972. 'n Plantsosiologiese studie van die Jack Scott-natuurreservaat. M.Sc. thesis, University of Pretoria, Pretoria.

COETZEE, B.J. 1974. A phytosociological classification of the vegetation of the Jack Scott Nature Reserve. *Bothalia* 11: 329 - 347.

COETZEE, B.J. 1975. A phytosociological classification of the Rustenburg Nature Reserve. *Bothalia* 11: 561 - 580.

COETZEE, B.J. 1983. Phytosociology, vegetation structure and landscapes of the Central District, Kruger National Park. *Dissertationes Botanicae* 69: 1 - 456.

COETZEE, B.J. & WERGER, M.J.A. 1975. An association-analysis and the classification of plant communities. *Vegetatio* 30: 201 - 206.

COETZEE, C.B. (Red.) 1976. Delfstowwe van die Republiek van Suid-Afrika. 5 edition Handbook 7. Department of Mineral and Energy Affairs. Government Printer, Pretoria.

COETZEE, J.P. 1993. Phytosociology of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area. M.Sc. thesis, University of Pretoria, Pretoria.

DANCKWERTS, J. 1982. Veld condition assessment in the eastern Cape region. *Dohne Agric.* 5: 9 - 14.

DAUBENMIRE, R. 1968. Plant Communities. A textbook of plantsynecology. Harper & Row, New York.

DEALL, G.B., SCHEEPERS, J.C. & SCHUTZ, C.J. 1989. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 1. Physical environment. *Bothalia* 19: 53 - 67.

DE BEER, A.S. 1988. Plantspesievoorkeure van vleisbeeste in die Hoëveldstreek onder 'n stelsel van beheerde selektiewe beweiding. M.Sc.(Agric.) thesis, University of Pretoria, Pretoria.

DEPARTMENT OF AGRICULTURE AND WATER SUPPLY. 1987. Landbou-ontwikkelingsprogram: Hoëveldstreek 1986. Directorate Agricultural Information, Government Printer, Pretoria.

DE WAAL, A. 1988. Tick Tick Tick .... *Publico* 8: 4 - 5.

DU PREEZ, P.J. 1987. Ekologie van die boomgemeenskappe van die Vredefortdistrik, Oranje-Vrystaat. M.Sc. thesis, University of the Orange Free State, Bloemfontein.

DU PREEZ, P.J. 1991. A syntaxonomical and synecological study of the vegetation of the southern and eastern Orange Free State and related areas with special reference to Korannaberg. D.Sc. dissertation. University of the Orange Free State, Bloemfontein.

DU PREEZ, P.J. & BREDENKAMP G.J. 1991. Vegetation classes of the southern and eastern Orange Free State (Republic of South Africa) and the highlands of Lesotho. *Navors. Nas. Mus., Bloemfontein* 7: 477 - 525.

DU PREEZ, P.J. & SCHEEPERS, J.C. 1993. 'n Herklassifisering van die grasveld in die Bethlehem-omgewing. *Bull. Grassland Soc. Sth. Afr.* 4: 37.

DU TOIT, A.C. 1954. The geology of South Africa. Oliver & Boyd, Edinburgh.

ECKHARDT, H.C. 1993. A synecological study of the vegetation of the north-eastern Orange Free State. M.Sc. thesis. University of Pretoria, Pretoria.

ECKHARDT, H.C., VAN ROOYEN, N. & BREDENKAMP, G.J. 1993. The application of Braun-Blanquet data in the assessment of veld condition and grazing capacity in grassland. *Afr J Range For Sci* 10: 41 - 46.

ECKHARDT, H.C., VAN ROOYEN, N. & BREDENKAMP, G.J. 1993. The phytosociology of thicket and woodland vegetation of the north-eastern Orange Free State. *S. Afr. J. Bot*. 59: 401 - 409.

ECKHARDT, H.C., VAN ROOYEN, N. & BREDENKAMP, G.J. *in press*. The vegetation of the north-eastern Orange Free State, South Africa: the physical environment of the total study area and plant communities of the Ea land type. *Bothalia*

ECKHARDT, H.C., VAN ROOYEN, N., BREDENKAMP, G.J. & THERON G.K. 1993. An overview of the vegetation of the Vrede-Memel-Warden area, north-eastern Orange Free State. *S. Afr. J. Bot*. 59: 391 - 400.

EDWARDS, D. 1972. Botanical survey and agriculture. *Proc. Grassl. Soc. sth. Afr*. 7: 15 - 19.

EDWARDS, D. 1979. The role of plant ecology in the development of South Africa. *Bothalia* 12: 748 - 751.

EDWARDS, D. 1983. A broad-scale structural classification of vegetation for practical purposes. *Bothalia* 14: 705 - 812.

ELSENBROEK, J.H. 1988. Die petrologie en struktuur van die alkaligraniet in die Vredefortkoepel noordwes van Parys. M.Sc. thesis, University of Potchefstroom for Christian Higher Education, Potchefstroom.

FISHER, R.A. & YATES, F. 1963. Statistical tables for biological, agricultural and medicine research. Longmans, London.

FOTH, H.D., WITHEE, L.V., JACOBS, H.S. & THIEN, S.J. 1978. Laboratory manual for introductory: SOIL SCIENCE. 4th edn. WM.C.Brown Company Publishers, Dubuque.

FOURIE, J.H., DE WET, N.J. & PAGE, J.J. 1987. Veldtoestand en neiging in Kalahari-Duineveld onder 'n ekstensiewe veeboerderystelsel. *J. Grassl. Soc. South. Afr.* 4: 48 - 54.

FRIEDEL, M.H. 1987. A preliminary investigation of the woody plant increase in the western Transvaal and implications for veld assessment. *J. Grassl. Soc. South. Afr.* 4: 25 - 30.

FULS, E.R. 1993. Vegetation ecology of the northern Orange Free State. Ph.D. dissertation, University of Pretoria, Pretoria.

FULS, E.R., BREDENKAMP, G.J. & VAN ROOYEN, N. 1993. The grassland communities of the midslopes in the northern Orange Free State, South Africa. *S. Afr. J. Bot.* 59: 478 - 484.

FULS, E.R., BREDENKAMP, G.J. & VAN ROOYEN, N. 1993. The grassland communities of the footslopes in the northern Orange Free State, South Africa. *S. Afr. J. Bot.* 59: 485 - 490.

FULS, E.R., BREDENKAMP, G.J., VAN ROOYEN, N. & THERON, G.K. 1993. The physical environment and major plant communities of the Heilbron-Lindley-Warden-Villiers area, northern Orange Free State. *S. Afr. J. Bot.* 59: 345 - 359.

GAUCH, H.G. 1979. COMPCLUS - A Fortran program for rapid initial clustering of large data sets. Cornell University, Ithaca, New York.

GAUCH, H.G. 1982. Multivariate analysis in community ecology. Cambridge University Press, New York.

GEOLOGICAL SURVEY. 1986. Geological map, 1:250 000, 2626 West Rand. Government Printer, Pretoria.

GIBBS RUSSELL, G.E. 1984. List of species of southern African plants. *Mem. bot. Surv. S. Afr.* 48: 1 - 144.

GIBBS RUSSELL, G.E., REID, C., VAN ROOY, J. & SMOOK, L. 1985. List of species of southern African plants. 2nd edn. Part 1. *Mem. bot. Surv. S. Afr.* 51: 1 - 152.

GIBBS RUSSELL, G.E., WATSON, L., KOEKEMOER, M.,SMOOK, L.,BARKER, N.P., ANDERSON,H.M. & DALLWITZ, M.J. 1990. Grasses of southern Africa. *Mem. bot. Surv. S. Afr.* 58: 1 - 437.

GIBBS RUSSELL, G.E., WELMAN, W.G., RETIEF, E., IMMELMAN, K.L., GERMISHUIZEN, G., PIENAAR, B.J., VAN WYK, M. & NICHOLAS, A. 1987. List of species of southern African plants. 2nd edn. Part 2. *Mem. bot. Surv. S. Afr.* 56: 1 - 270.

GREYLING, T. & HUNTLEY, B.J. 1984. Directory of southern African conservation areas. *S. Afr. Nat. Sci. Prog. Rep.* 98: 1 - 311.

GUBB, A.A. 1989. An evaluation of Landsat MSS data for ecological land classification. M.Sc. thesis, University of Cape Town, Cape Town.

HARMSE, H.J. VON M. 1967. Soil genesis in the Highveld Region, South Africa. D.Sc. dissertation, University of Utrecht, Utrecht.

HENDERSON, M., FOURIE, D.M.C., WELLS, M.J., HENDERSON, L. 1987. Declared weeds and alien invader plants in South Africa. Department of Agriculture and Water Supply. Government Printer, Pretoria.

HILL, M.O. 1979. DECORANA - A Fortran program for detrended correspondence analysis and reciprocal averaging. Cornell University, New York.

HILL, M.O. 1979. TWINSPAN - A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, New York.

HUNTLEY, B., HUNTLEY, J.P. & BIRKS, H.J.B. 1981. PHYTOPAK - A suite of computer programs designed for the handling and analysis of phytosociological data. *Vegetatio* 45: 85 - 95.

JENSéN, S. & VAN DER MAAREL, E. 1980. Numerical approaches to lake classification with special reference to macrophyte communities. *Vegetatio* 42: 117 - 128.

KOOIJ, M.S. 1990. A phytosociological study of the north-western Orange Free State. M.Sc. thesis, University of Pretoria, Pretoria.

KOOIJ, M.S., BREDENKAMP, G.J. & THERON, G.K. 1990. The vegetation of the north-western Orange Free State, South Africa. 1. Physical environment. *Bothalia* 20: 233 - 240.

KOOIJ, M.S., BREDENKAMP, G.J. & THERON, G.K. 1990. The vegetation of the north-western Orange Free State, South Africa. 2. The D land types. *Bothalia* 20: 241 - 248.

KOOIJ, M.S., BREDENKAMP, G.J. & THERON, G.K. 1990. Classification of the vegetation of the B land type in the north-western Orange Free State. *S. Afr. J. Bot.* 56: 309 - 318.

KOOIJ, M.S., SCHEEPERS, J.C., BREDENKAMP, G.J. & THERON, G.K. 1991. The vegetation of the Kroonstad area, Orange Free State I: Vlei and bottomland communities. *S. Afr. J. Bot.* 57: 213 - 219.

KOOIJ, M.S., SCHEEPERS, J.C., BREDENKAMP, G.J. & THERON, G.K. 1992. The vegetation of the Kroonstad area: A description of the grassland communities. *S. Afr. J. Bot.* 58: 155 - 164.

KRUGER, J.A. 1971. 'n Ekologiese ondersoek van die plantegroei van die plaas Somerville 53 en omgewing, met besonderse aandag aan die bodemkundige aspek. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

KRUGER, G.P. 1983. Terrain morphological map of southern Africa. Soil and Irrigation Research Institute, Dept. Agriculture, Pretoria.

LAMBERT, J.M. & WILLIAMS, W.T. 1962. Multivariate methods in plant ecology. IV. Nodal analysis. *J. Ecol.* 50: 775 - 802.

LAND TYPE SERIES. 1979. 2526 Rustenburg. Prepared by the Soil and Irrigation Research Institute, Pretoria. 1:250 000. Government Printer, Pretoria.

LAND TYPE SERIES. 1979. 2626 Wes-Rand. Prepared by the Soil and Irrigation Research Institute, Pretoria. 1:250 000. Government Printer, Pretoria.

LAND TYPE SURVEY STAFF. 1984. Land types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. agric. nat. Resour. S. Afr.* 4: 1 - 441.

LOUPPEN, M.J.W. & VAN DER MAAREL, E. 1979. CLUSCLA - A computer program for the clustering of large phytosociological data sets. *Vegetatio* 40: 107 - 114.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Mem. bot. Surv. S. Afr.* 24: 1 - 105.

MABBUTT, J.A. 1968. Review of concepts of land classification. *In* G.A. Stewart (ed.), Land evaluation. Macmillan, Melbourne.

MACVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H. & HARMSE, H.J. VON M. 1977. Soil classification - A binomial system for South Africa. Department of Agriculture and Technical Services, Pretoria.

MATTHEWS, W.S. 1991. Phytosociology of the north-eastern Mountain sourveld. M.Sc. thesis, University of Pretoria, Pretoria.

MENTIS, M.T. & HUNTLEY, B.T. 1982. A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog. Rep.* 62: 1 - 29.

MOLENGRAAFF, G.A.F. 1904. Geology of the Transvaal. Essen & Perkins, Johannesburg.

MORRIS, J.W. 1973. Automatic classification and ecological profiles of south-western Transvaal Highveld grassland. Ph.D. dissertation, University of Natal, Durban.

MORRIS, J.W. 1976. Automatic classification of the highveld grassland of Lichtenburg, south-western Transvaal. *Bothalia* 12: 267 - 292.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

MYBURGH, W.J. 1990. 'n Plantsosiologiese studie van die Bankenveld en die vleigebiede in die Grootvlei-distrik, Suid-Transvaal. B.Sc. (Hons.), University of Pretoria, Pretoria.

MYBURGH, W.J. 1993. Die fitososiologie van die suurgrasveld in die Suidoos-Transvaalse Hoëveld. M.Sc. thesis, University of Pretoria, Pretoria.

MYBURGH, W.J., BREYTENBACH, P.J.J, THERON, G.K. & BREDENKAMP, G.J. 1992. Die fitososiologie van die Bankenveld in die Grootvlei-omgewing, Suid-Transvaal. *Bothalia* 22: 245 - 254.

NAKOR. 1979. National plan for nature conservation. Department Environmental Planning, Pretoria.

NEL, L.T. 1935. The geology of the Klerksdorp-Ventersdorp area. Geological Survey, Government Printer, Pretoria.

ORLóCI, L. & STANEK, W. 1979. Vegetation survey of the Alaska highway, Yukon territory: Types and gradients. *Vegetatio* 41: 1 - 56.

PIGNATTI, S. 1968. Die Inflation der höheren pflanzensoziologischen Einheiten. *In* R. Tüxen (ed.), Pflanzensoziologische systematik. Junk, The Hague.

ROUX, P.W. & OPPERMAN, D.P.J. 1982. Gronderosie in die Karoobioom. CSP, CSIR, Pretoria.

ROUX, P.W. & VORSTER, M. 1983. Vegetation change in the Karoo. *Proc. Grassl. Soc. sth. Afr.* 18: 25 - 29.

RUTHERFORD, M.C. & WESTFALL, R.H. 1986. Biomes of Southern Africa - an objective categorization. *Mem. bot. Surv. S. Afr.* 54: 1 - 97.

SACS. 1980. Stratigraphy of South Africa. Part 1 (comp. L.E. Kent). Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia, and the Republics of Botswana, Transkei and Venda. Dept. Mineral and Energy Affairs, Pretoria.

SCHEEPERS, J.C. 1975. The plant ecology of the Kroonstad and Bethlehem areas of the Highveld agricultural region. D.Sc. dissertation, University of Pretoria, Pretoria.

SCHEEPERS, J.C. 1983. Progress with vegetation studies in South Africa. *Bothalia* 14: 683 - 690.

SCHEEPERS, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on the classification and mapping. *S. Afr. Ecosys. Prog. Occ. Rep. Series* 16: 1 - 31.

SCHULZE, R.E. & MCGEE, O.S. 1978. Climate indices and classifications in relation to the biogeography of southern Africa. *In* M.J.A. Werger. (ed.), Biogeography and ecology of southern Africa. Junk, The Hague.

SCOGINGS, P.F. & THERON, G.K. 1990. An application of multivariate analysis techniques to dry-weight-rank data from a Bankenveld nature reserve. *S. Afr. J. Bot.* 56: 648 - 653.

SIEGFRIED, W.R. 1989. Preservation of species in southern African nature reserves. *In* B.J. Huntley (ed.), Biotic diversity in southern Africa: Concepts and conservation. Oxford University Press, Cape Town.

SMIT, C.M. 1992. Phytosociology of the Newcastle-Memel-Chelmsford Dam area. M.Sc. thesis, University of Pretoria, Pretoria.

SMIT, C.M., BREDENKAMP, G.J. & VAN ROOYEN, N. 1993. Plant communities of the Ad land type in the Newcastle - Memel - Chelmsford Dam area. *S. Afr. J. Bot.* 59: 116 - 122.

STRAHLER, A.N. 1975. Physical geography. Fourth edition. John Wiley and Sons, Inc., New York.

THERON, G.K. 1973. 'n Ekologiese studie van die plantegroei van die Loskopdam-natuurreservaat deel 1 en 2. D.Sc. dissertation, University of Pretoria, Pretoria.

TIDMARSH, C.E.M. & HAVENGA, C.M. 1955. The wheel point method of survey and measurement of semi-open grasslands and Karoo vegetation in South Africa. *Mem. bot. Surv. S. Afr.* 29: 1 - 14.

TRUSWELL, J.F. 1977. Geological Evolution of South Africa. Purnell, Cape Town.

TURNER, B.J. 1989. A phytosociological study of the south-eastern Transvaal Highveld grasslands. M.Sc. thesis, University of Pretoria, Pretoria.

TüXEN, R. 1970. Pflanzensoziologie als synthetische Wissenschaft. *Meded. Bot. Tuinen Belmonte Arboretum Landbouwhogischool Wageningen* 12: 141 - 159.

VAN DER MAAREL, E. 1982. On the manipulation and editing of phytosociological and ecological data. *Vegetatio* 50: 71 -76.

VAN DER MAAREL, E., ESPEJEL, I. & MORENO-CASASOLA, P. 1987. Two-step vegetation analysis based on very large data sets. *Vegetatio* 68: 139 - 143.

VAN DER MAAREL, E., JANSEN, J.G.M. & LOUPPEN, J.M.W. 1978. TABORD - A program for structuring phytosociological tables. *Vegetatio* 38: 143 - 156.

VAN DER MEULEN, F. 1979. Plant sociology of the western Transvaal Bushveld, South Africa: A syntaxonomic and synecological study. *Dissertationes Botanicae* 49: 1 - 192.

VAN OUDTSHOORN, F.P. 1991. Gids tot grasse van Suid-Afrika. Briza, Pretoria.

VAN ROOYEN, N. 1984. 'n Fenologiese studie van die plantegroei van die Roodeplaatdam-natuurreservaat. D.Sc. dissertation, University of Pretoria, Pretoria.

VAN ROOYEN, N., THERON, G.K. & GROBBELAAR, N. 1981. A floristic description and structural analysis of the plant communities of the Punda Milia-Pafuri-Wambiya area in the Kruger National Park, Republic of South Africa. 1. The hygrophilous communities. *Jl S. Afr. Bot.* 47: 213 - 246.

VAN WYK, A.E., & MALAN, S.J. 1988. Veldgids tot die veldblomme van die Witwatersrand- & Pretoria-gebied. Struik, Cape Town.

VAN WYK, S. 1983. 'n Plantekologiese studie van die Abe Bialey-natuurreservaat. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

VAN WYK, S. & BREDENKAMP, G.J. 1986. 'n Braun-Blanquet-klassifikasie van die plantegroei van die Abe Bailey-Natuurreservaat. *S. Afr. J. Bot.* 52: 321 - 331.

VILJOEN, J.N.J. 1987. 'n Pedologiese ondersoek van grond geassosieer met gesteentes van die Supergroep Ventersdorp in die Wes-Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

VON BACKSTRÖM, J.W., SCHUMANN, F.W., LE ROUX, H.D., KENT, L.E. & DU TOIT, A.L. 1953. The geology of the area around Lichtenburg. *Explanation sheet 54 (Lichtenburg)*. Geological survey, Pretoria.

WEATHER BUREAU 1960. Climate of South Africa. Part 6, Surface winds. *Weather Bureau Report* 26 : 1 - 206.

WEATHER BUREAU 1965. Climate of South Africa. Part 8, General survey. *Weather Bureau Report* 28 : 1 - 330.

WEATHER BUREAU. 1986. Climate of South Africa. Climate statistics up to 1984. *Weather Bureau Report* 40: 1 - 474.

WERGER, M.J.A. 1973. Phytosociology of the Upper Orange River Valley, South Africa. Ph.D. dissertation, University of Nijmegen, Nijmegen.

WERGER, M.J.A. 1974. On concepts and techniques applied in the Zurich-Montpellier methods of vegetation survey. *Bothalia* 11: 309 - 323.

WERGER, M.J.A. & EDWARDS, D. 1976. Progress with vegetation studies in southern Africa. *Boissiera* 24: 625 - 632.

WERGER, M.J.W., KRUGER, F.J. & TAYLOR, H.C. 1972. A phytosociological study of the Cape fynbos and other vegetation at Jonkershoek, Stellenbosch. *Bothalia* 10: 599 - 614.

WESTHOFF, V. & VAN DER MAAREL, E. 1978. The Braun-Blanquet approach. *In* R.H. Whittaker (ed.), Classification of Plant Communities. W. Junk, London.

WILLIAMS, W.T. & LAMBERT, J.M. 1959. Multivariate methods in plant ecology. I Association-analysis in plant communities. *J. Ecol.* 47: 83 - 101.

WILLIAMS, W.T. & LAMBERT, J.M. 1961. Multivariate methods in plant ecology. III. Inverse association-analysis. *J. Ecol.* 49: 717 - 729.