The grasslands and wetlands of the Sekhukhuneland Centre of Plant Endemism, South Africa

S.J. SIEBERT*†, A.E. VAN WYK*, G.J. BREDENKAMP* and F. DU PLESSIS*

ABSTRACT

A hierarchical classification, description, and ecological and floristic interpretations are presented on the vegetation types of the grasslands and wetlands of the Sekhukhuneland Centre of Plant Endemism. Relevés were compiled in 74 stratified random plots. A TWINSPAN classification, refined by Braun-Blanquet procedures, revealed eight associations, 11 subassociations and four variants. Many new syntaxa are described and ecologically interpreted. For each syntaxon, the species richness, endemism and conservation status was determined. The floristic and habitat information, proposed classification, general description and vegetation key are provided to aid future identification of conservation areas, land use planning and further research. An ordination (DECORANA), based on floristic data, confirmed the relationships that exist between plant communities and associated habitats and environmental gradients. Much of the plant community diversity and distribution can be ascribed to a heterogeneous environment, predominantly determined by soil moisture.

INTRODUCTION

Several phytosociological studies have been conducted on vegetation types along the northeastern escarpment of the Northern Province and Mpumalanga (Bloem 1988; Deall *et al.* 1989; Matthews *et al.* 1992a, b; Burgoyne *et al.* 2000). However, the vegetation of some areas still remains to be investigated and described, both on reconnaissance level and in more detail. The undulating norite hills in the Roossenekal-Tonteldoos region is an area with very limited information on the vegetation. It is located in the southern portion of the Sekhukhuneland Centre of Plant Endemism (SCPE) (Van Wyk & Van Wyk 1997; Van Wyk & Smith 2001), and comprises the Roossenekal Subcentre of Endemism (Siebert 1998). The Roossenekal Subcentre is known for its many plant endemics, the distributions of which correlate with the diversity in geological substrate in the region (Siebert 1998; Siebert *et al.* 2001).

Various grassland and wetland vegetation types that show a floristic affinity and relationships with the Roossenekal Subcentre (Siebert 1998), have previously been described from the adjacent Steenkampsberg (Bloem 1988; Burgoyne 1995), Witbank Nature Reserve (Smit *et al.* 1997), and the Great Dyke of Zimbabwe (Werger *et al.* 1978). Acocks (1988) mapped the vegetation of the Roossenekal Subcentre as two veld types, namely North-eastern Sandy Highveld (57) and Bankenveld (61). A broad-scale classification of the same region's vegetation was given by Low & Rebelo (1996), who recognize three vegetation types, namely Mixed Bushveld (18), Moist Sandy Highveld Grassland (38) and North-eastern Mountain Grassland (43). These veld/vegetation types are closely associated with seasonal fires (Edwards 1984).

Only Acocks (1988) accurately mapped the high-altitude outcrops of norite (Leolo Mountains) in the northern region of the SCPE as grassland, namely North-eastern Sandy Highveld (57). Geologically and floristically the Leolo Mountains is similar to the Roossenekal Subcentre, and is treated as part of the study area covered in this paper (Siebert 1998). However, the vegetation classification of the entire Sekhukhuneland Centre needs further attention, as comparatively little is known about its plant communities, floristic diversity and the relationship between distribution patterns of plants and the clayey soils derived from the ultramafic norite.

This paper forms part of a comprehensive vegetation and floristic survey of the Sekhukhuneland area. It is envisaged that the identification, classification and description of the various vegetation units (syntaxa) will contribute to the knowledge of the plant diversity and biological intricacies of the region. This paper provides ecological and floristic data of the region's grasslands and wetlands, and the associated habitats, by characterizing and interpreting the vegetation units. Classification is basic to the formulation of a management policy and for proper land use planning. An assessment of the plant species richness, endemism and Red Data List taxa in the plant communities of the study area is supplied as baseline data to apply in future conservation actions in the region and application in ecosystem management. An adequate database of natural features and other land uses is essential for effective land use management and implementation (Kent & Ballard 1988; Bedward *et al.* 1992; Rhoads & Thompson 1992).

In a broad overview of the vegetation types of the SCPE, Siebert *et al.* (2002) recognized six major vegetation units. The vegetation units described in this paper cover the *Themeda triandra–Senecio microglossus* Cool Moist Grassland and the *Fuirena pubescens–Schoenoplectus corymbosus* Wetland Vegetation, the two major vegetation types of the relatively moist Roossenekal Subcentre. A vegetation key is presented to aid with the identification of the proposed syntaxa in the study area.

* Department of Botany, University of Pretoria, 0002 Pretoria.
† Present address: SABONET, c/o National Botanical Institute, Private Bag X101, 0001 Pretoria.

STUDY AREA

The study area is situated in northern Mpumalanga between latitude 25° 00' and 25° 20' S and longitude 29° 50' and 30° 05' E (southern part of the SCPE) and southern Northern Province between latitude 24° 30' and 24° 50' S and longitude 30° 00' and 30° 05' E (Leolo Mountains) (Figure 1). The area covers ± 1 500 km² and comprises a homogeneous geology (Visser *et al.* 1989), with a heterogeneous physiography (Land Type Survey Staff 1987). The Sekhukhuneland Centre is more or less restricted to the Rustenburg Layered Suite of the Bushveld Complex (Siebert *et al.* 2001). The area dealt with in this paper lies on the Upper and Main Zones of the Rustenburg Layered Suite and is mainly underlain by concentric belts of norite, and to a lesser degree outcrops of ferrogabbro (Visser *et al.* 1989). This norite stratum extends north-south and rises to form the Leolo Mountains (1 700 m asl). The lower reaches of the mountainous areas are characterized by many small outcrops of magnetite.

The Roossenekal Subcentre is defined as the grassland areas in and adjacent to the sixteenth degree grid 2529 BB and also includes the outlier Leolo Mountains in the Northern Province. Thirty-four of the Sekhukhuneland endemics/near-endemic plant species which are largely restricted to these areas were recorded during the study (Siebert 1998). The area forms an ecotone between the Mixed Bushveld (18) and the North-eastern Sandy Highveld (57) Veld Types (Acocks 1988), but it is probably more representative of Bankenveld (61), than any of the aforementioned veld types. The valleys have a subtropical climate with little or no frost in winter, whereas in the mountains, conditions become more temperate with increasing altitude. In this region of undulating rocky hills, the vegetation is characterized by scattered woodlands in sheltered habitats of footslopes and in valleys, and grassland with bush clumps covering the exposed plateaus, hill slopes and valleys. The difference in altitude between the two most extreme locations is ± 500 m (1 700 m asl on the Leolo Mountains to 1 200 m asl where the Klip River cuts through the hills near Roossenekal).

The study area lies in the summer rainfall region, with an average annual precipitation of about 700 mm (South African Weather Bureau 1998). Local rainfall patterns
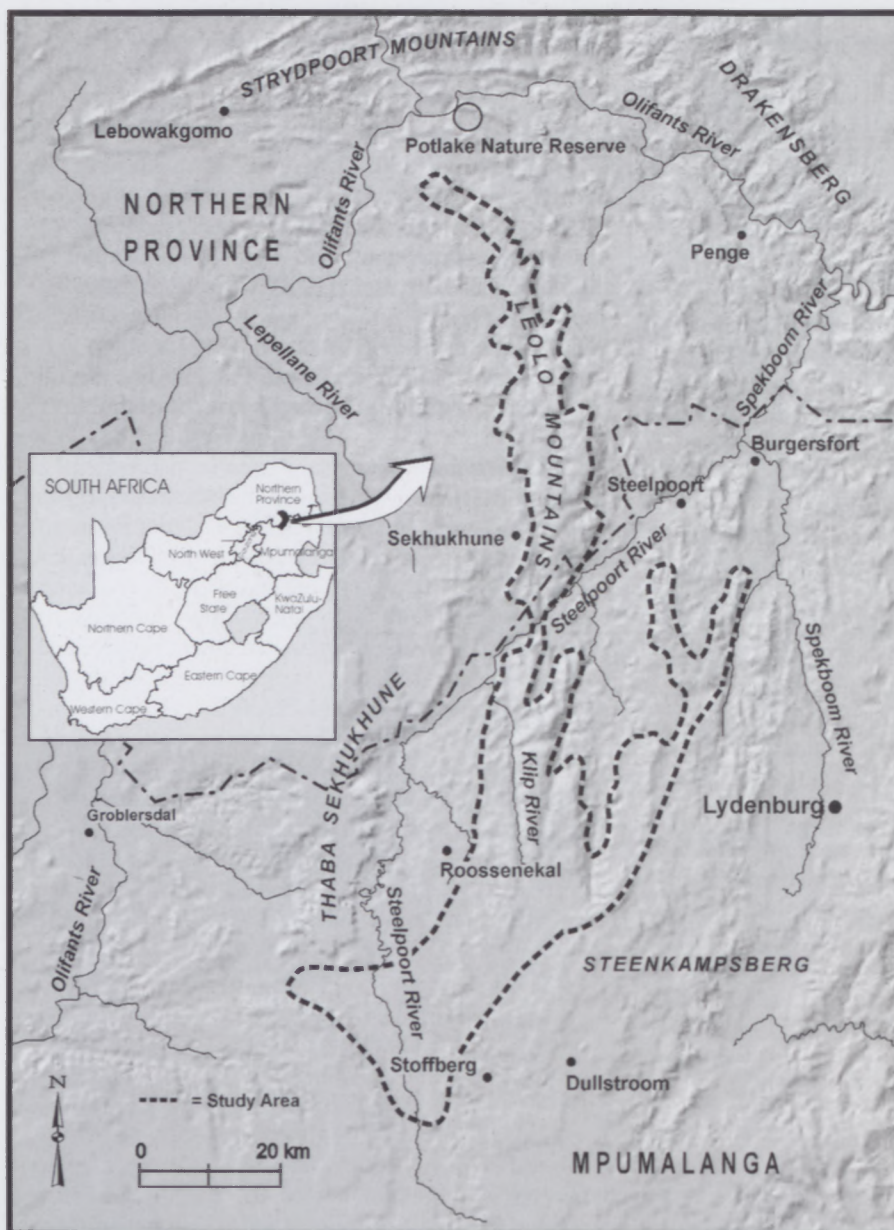

FIGURE 1.—Location of the grasslands of the study area in the Northern Province and Mpumalanga, South Africa.
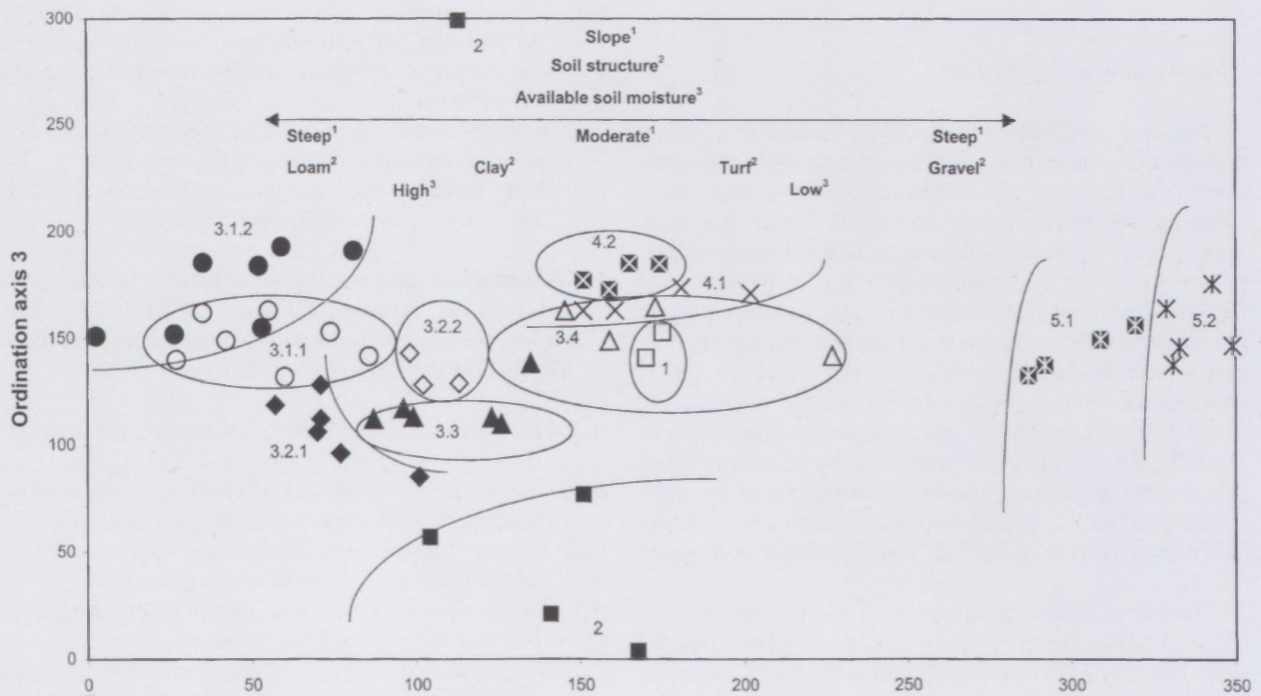
FIGURE 2.—Relative positions of all the relevés along the second and third axis of the ordination of the grassland vegetation of the Sekhukhuneland Centre of Plant Endemism. Numbers correspond with those of syntaxa in Table 1a and in the text.

are strongly influenced by the area's topography and altitude (Siebert 1998), varying from 721 mm in the east, to 607 mm per annum in the west; 710 mm in the south, to 702 mm in the north (Erasmus 1985). Daily average temperature ranges from a minimum of 2.8°C in winter to a maximum of 25.9°C in summer, with an average annual temperature of 16.2°C (South African Weather Bureau 1998). Temperatures vary at different localities within the area, also correlating strongly with physiographic regions, being higher in low-lying valleys and lower on high-lying plateaus (Buckle 1996). However, minimum temperatures of below freezing point are rare, even in the high-lying areas.

METHODS

A first approximation of a vegetation classification, based on the total floristic data set of 415 stratified random sample plots was obtained by the application of the Two-Way Indicator Species Analysis (TWINSPAN) (Hill 1979a). The first step of an objective multivariate classification identified six major vegetation types for the Sekhukhuneland Centre (Siebert et al. 2002). These results were then used to subdivide the data set into five phytosociological tables. One of these tables, representing two major vegetation types, namely grasslands and wetlands, was again subjected to TWINSPAN. Using Braun-Blanquet procedures in the MEGATAB computer program (Hennekens 1996a), we further refined the resultant classification.

Floristic and habitat data of the grasslands and wetlands were derived from 74 relevés. Stratification was based on terrain type, aspect and vegetation structure. To standardize the plot size and to counter the bias of different scale (Jonsson & Moen 1998), plots sampled in the grassland were fixed at 100 m². Within each sample plot, all species were recorded and a cover-abundance value was assigned

to each species according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). Plant species names conform to those of Retief & Herman (1997), and the practice followed in the H.G.W.J. Schweickerdt Herbarium (PRU), University of Pretoria. Terminology to describe vegetation structure follows Edwards (1983). Environmental data recorded for each sample plot include terrain type (Land Type Survey Staff 1987), aspect, slope, geology (Visser et al. 1989), soil type (MacVicar et al. 1991) and rockiness of soil surface. Longitude and latitude readings were also recorded for each sample plot using a GPS. All relevé data are stored in the TURBOVEG database (Hennekens 1996b), managed by the Department of Botany, University of Pretoria (Mucina et al. 2000). Syntaxa names are given in accordance with the Code of Phytosociological Nomenclature (Weber et al. 2000).

The ordination algorithm Detrended Correspondence Analysis (DECORANA) (Hill 1979b) (Figure 2) was applied to confirm gradients in vegetation and the relationship between these plant communities and the physical environment.

To facilitate the identification of areas of high conservation potential, the alpha diversities of the different plant communities were calculated. The alpha diversity (plant species richness) is defined as the number of species per unit area within a homogeneous community or the total number of species per community (Whittaker 1977). A 100 m² sample plot was taken as the unit area within a homogeneous community.

The geographical distribution of all the taxa was verified at the National Herbarium (PRE), Pretoria, to identify any taxa endemic/near-endemic to the region (Siebert 1998). All taxa were also checked against the Red Data List of southern African plants (Hilton-Taylor 1996) to determine their conservation status.

RESULTS

Classification of vegetation

The analysis resulted in the identification of 17 plant communities, ordered as eight associations, 11 subassociations and four variants (Table 1a, b). These units were subsequently hierarchically classified. Since the study area covered by these communities lies in the climatically uniform moist and cool southern region of the SCPE (Siebert 1998), no major macroclimatic variation plays a role in local differentiation of the plant communities. The major plant communities relate to soil character, rockiness and terrain type, with aspect and slope also playing minor roles. Communities were not always distinctive in the field. This might be attributed to the homogeneity of grassland physiognomy and the heterogeneity of the environmental factors, which resulted in a complex mosaic distribution pattern of habitats and associated vegetation.

The hierarchical classification of the vegetation reinforces the correlation between habitat and plant communities (Figures 2, 3). The distribution of the SCPE endemic/near-endemic and Red Data List plant taxa among various plant communities is listed in Table 2. A summary of selected floristic and habitat attributes for each plant community is supplied in Table 3.

The *Themeda triandra–Senecio microglossus* Cool Moist Grassland (Siebert *et al.* 2002) is interpreted as belonging to the proposed *Tristachya leucothrix–Trachypogon spicatus* Class (Du Preez & Bredenkamp 1991). The *Fuirena pubescens–Schoenoplectus corymbosus* Wetlands (Siebert *et al.* 2002) is interpreted as part of the *Miscanthus junceus–Schoenoplectus corymbosus* Community (Bloem 1988), proposed here as an alliance. The grassland and wetland plant communities of the Roossenekal Subcentre are classified as follows:

I. *Tristachya leucothrix–Trachypogon spicatus* Class of moist mountain slopes and plateaus (Du Preez & Bredenkamp 1991) [= *Themeda triandra–Senecio microglossus* Cool Moist Grassland (Siebert *et al.* 2002)]

1. *Helichryso splendidi–Tristachyetum leucothricis* Association
2. *Zantedeschio pentlandi–Aloetum castaneae* Association
3. *Brachiario serratae–Melhanietum randii* Association
3.1. *Brachiario serratae–Melhanietum randii helichrysetosum rugulosi* Subassociation
3.1.1. *Digitaria eriantha* Variant
3.1.2. *Alloteropsis semialata* Variant
3.2. *Brachiario serratae–Melhanietum randii argyrolobietosum transvaalense* Subassociation
3.2.1. *Koeleria capensis* Variant
3.2.2. *Berkheya seminivea* Variant
3.3. *Brachiario serratae–Melhanietum randii gnidietosum capitatae* Subassociation
3.4. *Brachiario serratae–Melhanietum randii setarietosum nigrirostis* Subassociation
4. *Elionuro mutici–Trachypogonetum spicati* Association
4.1. *Elionuro mutici–Trachypogonetum spicati bewsietosum biflorae* Subassociation

4.2. *Elionuro mutici–Trachypogonetum spicati acacietosum tortilis* Subassociation
5. *Jamesbrittenio macranthae–Loudetietum simplicis* Association
5.1. *Jamesbrittenio macranthae–Loudetietum simplicis combretetosum hereroense* Subassociation
5.2. *Jamesbrittenio macranthae–Loudetietum simplicis eucleetosum linearis* Subassociation

II. *Miscanthus junceus–Schoenoplectus corymbosus* Alliance of streams (Bloem 1988) [= *Fuirena pubescens–Schoenoplectus corymbosus* Wetland Vegetation (Siebert *et al.* 2002)]

6. *Fuireno pubescentis–Schoenetum nigricantis* Association
6.1. *Fuireno pubescentis–Schoenetum nigricantis triraphietosum andropogonoidis* Subassociation
6.2. *Fuireno pubescentis–Schoenetum nigricantis pycnostachetosum reticulatae* Subassociation
6.3. *Fuireno pubescentis–Schoenetum nigricantis bulbostylietosum hispidulae* Subassociation
7. *Andropogono eucomusae–Fimbristyletum ferrugineae* Association

III. Drakensberg escarpment wetlands (Hilliard & Burtt 1987)

8. *Limosello maioris–Ranunculetum meyeri* Association

Description of plant communities

The *Themeda triandra–Senecio microglossus* Cool Moist Grassland and scattered *Fuirena pubescens–Schoenoplectus corymbosus* Wetland Vegetation are predominantly restricted to the valleys, slopes and plateaus of undulating norite hills (Siebert *et al.* 2002). Surface rocks are common and abundant in many of the communities, with soil clay percentages varying from 25% to more than 50%. The vegetation can be classified into herbland and grassland (Edwards 1983). An important feature of the region is the fact that the mountain and hill ranges have a north-south orientation; therefore the grassland communities are mostly restricted to eastern and western aspects, crests and valleys. Grasslands have been a long-standing component of the Afromontane vegetation mosaic (Meadows & Linder 1989; Matthews *et al.* 1993), and are therefore seen as primary vegetation. Plant communities of the grasslands and wetlands recognized in the SCPE are classified as follows:

I. *Tristachya leucothrix–Trachypogon spicatus* Class (Du Preez & Bredenkamp 1991)

1. *Helichryso splendidi–Tristachyetum leucothricis* ass. nova hoc loco

Nomenclatural type: relevé 408 (holotypus).

Environmental data: a medium altitude grassland, forms a transition from low to high altitude (1 700 m asl). It lies in a rather moist region (> 600 mm/annum), mostly restricted to the summit of the Leolo Mountains on norite. The habitat is a gentle undulating plateau (1–5°) with a general east-west aspect (Table 3). The dominant

TABLE 1a.—Phytosociological table of grasslands of Sekhukhuneland Centre of Plant Endemism

Relevé

Association
Sub-association
Variant

Species group A
Earyops brevipapposus
Helichrysum splendidum
Lotononis foliosa
Vernonia myriantha
Xerophyta viscosa
Hirpicium bechuanense
Manulea parviflora
Buddleja saligna
Jamesbrittenia silenoides
Androcymbium melanthioides
Geranium wakkerstroomianum

Species group B
Cymbopogon excavatus
Zantedeschia pentlandii
Crassula sarcocaulis
Canthium suberosum
Thesium barkei
Halleria lucida
Boophone disticha
Apodytes dimidiata
Aloe pretoriensis
Olinia emarginata
Aristida junciformis

Species group C
Vernonia oligocephala
Melhania randii
Clerodendrum triphyllum
Rhynchosia sordida
Dicoma zeyheri
Gnidia capitata
Callilepis leptophylla
Phyllanthus parvulus
Dierama mossii
Hypoxis hemerocallidea

Species group D
Berkheya densifolia
Cyanotis speciosa
Digitaria eriantha
Agapanthus inapertus
Euphorbia clavarioides
Indigofera hedyantha
Tephrosia longipes
Monsonia attenuata

Species group E
Schistostephium heptalobum
Alloteropsis semialata
Helichrysum nudifolium
Rhynchosia hirta
Clutia pulchella
Albuca setosa
Felicia muricata
Kalanchoe rotundifolia
Berkheya onopordifolia

TABLE 1a.—Phytosociological table of grasslands of Sekhukhuneland Centre of Plant Endemism (cont.)

Relevé

Association
Sub-association
Variant

Species group E (cont.)
Sporobolus pectinatus
Helichrysum albilanatum

Species group F
Helichrysum rugulosum
Pimpinella caffra
Senecio coronatus
Tephrosia elongata
Tristachya biseriata
Acalypha angustata
Panicum natalense
Leonotis ocymifolia

Species group G
Berkheya seminivea
Droniopsis atropurpurea
Helichrysum cephaloideum
Pachycarpus transvaalensis
Thesium magalismontanum
Helichrysum pilosellum
Pearsonia obovata

Species group H
Eulalia villosa
Ipomoea obscura
Crabbea hirsuta
Koeleria capensis

Species group I
Eragrostis chloromelas
Thunbergia atriplicifolia
Haplocarpha scaposa
Helichrysum setosum
Schistostephium crataegifolium

Species group J
Vernonia natalensis
Rhus discolor
Argyrolobium transvaalense
Vernonia galpinii
Becium obovatum
Convolvulus sagittatus
Barleria ovata
Gerbera ambigua
Ipomoea crassipes

Species group K
Aloe castanea
Kedrostis foetidissima
Eragrostis racemosa
Ledebouria revoluta
Cyphostemma sp. A (AW 1389)
Alepidea setifera
Tetraselago wilmsii
Pellaea calomelanos

TABLE 1a.—Phytosociological table of grasslands of Sekhukhuneland Centre of Plant Endemism (cont.)

Relevé

Association
Sub-association
Variant

Species group L
Setaria nigrirostris
Pegoletia lanceolata
Scleria dieterlenii
Bulbostylis contexta
Lotononis macrosepala
Mentha longifolia
Mariscus dregeanus
Lotononis adpressa

Species group M
Pentanisia prunelloides
Senecio latifolius
Polygala uncinata
Tephrosia purpurea
Acalypha punctata
Eragrostis pseudosclerantha
Scilla natalensis
Andropogon schirensis

Species group N
Brachiaria eruciformis
Indigofera evansiana
Rhus rogersii
Kohautia caespitosa
Striga elegans
Rhamnus prinoides
Setaria incrassata

Species group O
Bewsia biflora
Pearsonia grandifolia
Senecio erubescens
Rhynchosia albissima
Helichrysum harveyanum
Senecio venosus
Senecio inornatus
Helichrysum oreophilum
Argyrolobium amplexicaule
Conyza podocephala
Rhus tumulicola var. meeuseana

Species group P
Panicum maximum
Acacia tortilis
Dichrostachys cinerea
Digitaria sanguinalis
Jasminum quinatum
Kyphocarpa angustifolia
Chrysanthemoides monilifera
Sporobolus fimbriatus
Indigastrum burkeanum
Panicum deustum

Species group Q
Pollichia campestris
Senecio scitus

TABLE 1a.—Phytosociological table of grasslands of Sekhukhuneland Centre of Plant Endemism (cont.)

Relevé

Association
Sub-association
Variant

Species group Q (cont.)
Rhoicissus sp. (SS 48)
Sorghum bicolor
Asparagus suaveolens
Senecio lygodes

Species group R
Setaria sphacelata
Thesium gracilentum
Sphenostylis angustifolia
Sebaea grandis
Rhynchosia spectabilis
Elephantorrhiza elephantina
Trachypogon spicatus
Cephalaria zeyheriana
Gnidia variabilis

Species group S
Jamesbrittenia macrantha
Rhynchosia komatiensis
Helichrysum aureonitens
Melinis repens
Aristida adscensionis
Polygala hottentotta
Lotononis wilmsii
Elephantorrhiza praetermissa

Species group T
Combretum hereroense
Hemizygia petrensis
Chamaecrista comosa
Lotononis calycina
Phyllanthus incurvus
Ledebouria marginata
Triumfetta sonderii
Aneilema longirrhizum

Species group U
Seddera capensis
Andropogon chinensis
Polygala sp. (SS 449)
Indigofera tristoides
Euclea linearis
Jamesbrittenia burkeana
Phyllanthus glaucophyllus
Ipomoea bathycolpos

Species group V
Melhania prostrata
Thesium multiramulosum
Aristida congesta

Species group W
Pearsonia aristata
Dicoma anomala
Indigofera egens
Polygala amarymbica

TABLE 1a.—Phytosociological table of grasslands of Sekhukhuneland Centre of Plant Endemism (cont.)

Relevé

Association
Sub-association
Variant

Species group W (cont.)
Abildgaardia ovata
Loudetia simplex
Anthospermum rigidum
Hermannia antonii
Helichrysum gerberifolium

Species group X
Tristachya leucothrix
Protea caffra
Eragrostis nindensis
Commelina africana
Cyanotis pachyrrhiza
Themeda triandra
Euclea crispa
Brachiaria serrata
Gnidia caffra
Diheteropogon amplectens
Rhoicissus tridentata
Hypoxis rigidula
Vitex obovata subsp. wilmsii
Raphionacme galpinii
Rhus wilmsii
Acacia caffra
Aloe greathradii
Athrixia elata
Ruellia patula
Striga bilabiata
Rhynchosia totta
Tristachya rehmannii
Indigofera hilaris
Eragrostis superba
Berkheya insignis
Elionurus muticus

Species group shared with Table 1b
Species group Y
Eragrostis capensis
Eragrostis curvula
Hyparrhenia hirta
Senecio microglossus
Aristida bipartita
Heteropogon contortus
Cymbopogon validus
Hyparrhenia filipendula
Scabiosa columbaria
Lippia rehmannii
Acacia karroo
Eucomis autumnalis
Chlorophytum facciculatum

TABLE 1b.—Phytosociological table of wetlands of Sekhukhuneland Centre of Plant Endemism

Relevé

	6.1	6.2	6.3	7	8
(relevé no., top)	3 . .	1 . .	2 1 1 1 2	. . . .	4 4
(relevé no., mid)	1 7 2	2 2 0	3 3 6 7 .	4 8 9 8	1 1
(relevé no., bot)	5 1 3	2 2 3	2 4 6 6 5	1 1 2 1	0 5
Association	6	6	6	7	8
Sub-association	1	2	3		

Species group AA

Species	6.1	6.2	6.3	7	8
Schoenus nigricans	A A 1	+ 3 A	. 1 1 A R	. . . .	. .
Chironia purpurascens	+ . +	. + +	+ + + + .	. . . .	. .
Hypoxis argentea	R R .	. . R	R R R . .	. . . .	. .
Hyparrhenia tamba	. + .	R 1 .	R 1 . 1 .	+ . . .	R .
Equisetum ramosissimum	. . +	+ . .	R . . + R	. . . .	. .

Species group AB

Species	6.1	6.2	6.3	7	8
Triraphis andropogonoides	A 1 A	. . .	. . . . .	. . . .	. .
Juncus punctorius	A 1 .	R . .	. . . . .	. . . .	. .
Dittrichia graveolens	+ 1 +	R . .	. . . . .	. R . .	. .
Nuxia gracilis	+ + 1	. . .	. . . R .	. . . .	. .
Adiantum capillus-veneris	R . +	+ . .	. . . . .	. . . .	. .
Coleochloa setifera	. R 1	1 . .	. . . . .	. . . .	. .

Species group AC

Species	6.1	6.2	6.3	7	8
Cyperus sexangularis	1 + .	1 + .	. . . . .	. . . .	. .
Kyllinga erecta	+ . +	R + +	. . . . .	. . . .	. .
Berula erecta	. + R	+ + R	+	. . . .	. .

Species group AD

Species	6.1	6.2	6.3	7	8
Bulbostylis hispidula	. . .	. . .	A 1 + . .	. . . .	. .
Alepidea amatymbica	. . .	. . .	+ + R . .	. . . .	. .
Bothriochloa insculpta	. . .	. . .	+ + . + .	. . . .	. .
Microchloa caffra	. . .	. . .	+ . . R .	. . . .	. .

Species group AE

Species	6.1	6.2	6.3	7	8
Pycnostachys reticulata	. . .	1 1 1	. + R . .	. . . .	. .
Mariscus congestus	. . .	1 + +	+ + A . .	. . . .	. .
Leonotis leonurus	. . .	+ . R	+ . . + .	. . . .	. .
Lippia javanica	. . .	R + .	R + R + .	R . . .	. .
Senecio gerrardii	. . .	. 1 1	1 . . + .	. . . .	. .
Monopsis decipiens	. . .	. + R	. R + . .	. . . .	. .
Pteris buchananii	. . .	. + .	R . + . .	. . . .	. .

Species group AF

Species	6.1	6.2	6.3	7	8
Polygonum meisnerianum	. . .	. . .	. . . . .	1 . R .	. .
Mariscus sumatrensis	. . .	. . .	. . . . .	+ + . .	. .
Conyza bonariensis	. . .	. . .	. . . . .	+ . + .	. .
Cyperus marginatus	. . .	. . .	. . . . .	+ . . +	. .
Flaveria bidentis	. . .	. . .	. . . . .	R . R .	. .
Mariscus rehmannianus	. . .	. . .	. . . . .	. 1 1 R	. .
Salix mucronata	. . .	. . .	. . . . .	. + + 1	. .
Eragrostis gummiflua	. . .	. . .	. . . . .	. R 1 +	. .

Species group AG

Species	6.1	6.2	6.3	7	8
Phragmites australis	. . .	1 1 3	. . . . .	A 3 1 3	. .
Fimbristylis ferruginea	R . .	+ + .	. R . . .	+ 1 + .	. .
Helichrysum cooperi	. . .	. + R	+	. R . R	. .
Cyperus sphaerospermus	. . .	R . +	. . . . .	1 + . +	. .
Gomphocarpus fruticosus	. . .	R . 1	. . . . .	+ . R .	. .
Senecio gregatus	. . .	R + .	. . . . .	. + R .	. .

Species group AH

Species	6.1	6.2	6.3	7	8
Ischaemum fasciculatum	. . .	. R .	+ + R . .	R + . .	. .
Kyllinga alba	. . .	. . .	R . + + .	R + + R	. .
Hemarthria altissima	. . .	. . .	. + . R .	+ . . +	. .

Species group AI

Species	6.1	6.2	6.3	7	8
Andropogon eucomus	1 . 1	+ . 1	+ 1 + + 1	1 R + 1	. .
Fuirena pubescens	A 1 +	+ + 1	3 B A A 1	. + R 1	. .
Artemisia afra	1 + +	. . +	+ + + + +	. + 1 .	. .
Cliffortia nitidula	1 1 .	+ . R	. 1 + R 1	R + . +	. .
Verbena brasiliensis	+ R .	+ . +	+ R . . .	1 + . .	. .
Miscanthus junceus	+ . .	+ A A	. R 1 1 1	1 + . 1	. .
Pulicaria scabra	+ . .	R . .	R . + + .	R + . +	. .
Imperata cylindrica	. + +	+ . +	. + . + .	+ + + +	. .
Rhus leptodictya	. R +	. R .	. R + . .	R + + R	. .
Plantago lanceolata	. R R	. + .	R + + . +	+ . . R	. .
Verbena bonariensis	. . +	+ + R	. . R R +	R . . .	. .
Typha capensis	. . R	+ R 1	. 1 . + .	R 1 . .	. .

Species group AJ

Species	6.1	6.2	6.3	7	8
Ranunculus meyeri	. . .	. . .	. . . . .	. . . .	1 1
Anagallis huttonii	. . .	. . .	. . . . .	. . . .	+ +
Limosella maior	. . .	. . .	. . . . .	. . . .	+ +
Ranunculus multifidus	. . .	. . .	. . . . .	. . . .	+ +
Sporobolus centrifugus	. . .	. . .	. . . . .	. . . .	+ +

Species group AK

Species	6.1	6.2	6.3	7	8
Schoenoplectus corymbosus	+ A +	+ 1 B	A R + . .	+ R 1 +	+ +
Gomphostigma virgatum	+ + .	+ . R	. R . + .	. 1 . +	R .

Species group shared with Table 1a

Species group Y

Species	6.1	6.2	6.3	7	8
Eragrostis capensis	. . .	R . .	. + . . .	. + . .	R .
Eragrostis curvula	R . R	. R .	R	R . . .	. .
Hyparrhenia hirta	. . R	. R .	. . . . .	. + 1 .	. .
Senecio microglossus	1 + +	. + .	+ . + . +	R . . +	R .
Aristida bipartita	+ + 1	R . R	. . R . .	R . R R	. .
Heteropogon contortus	R R R	. . .	. R . . .	+ . . R	. R
Cymbopogon validus	1 B +	+ A 1	1 1 . . 1	+ + + +	. .
Hyparrhenia filipendula	R R .	1 + +	+ 1 + + 1	+ . . .	R R
Scabiosa columbaria	+ . .	. . .	+ + R . .	. + . .	. .
Lippia rehmannii	. R +	. R +	. + . . .	+ + + .	. R
Acacia karroo	R + .	+ . .	. + . . .	+ . R .	. .
Eucomis autumnalis	. R .	. R .	. R R . .	R . R .	. R
Chlorophytum fasciculatum	+ + R	. . .	. . . . .	. . . .	. R

soil type is the Mayo Form, a melanic A-horizon over a lithocutanic B-horizon. Rock size is 300–500 mm in diameter and rock cover 15–20%.

Diagnostic and dominant/prominent taxa: in the SCPE this association is characterized by species group A (Table 1a). *Euryops brevipapposus*, *Helichrysum splendidum* and *Vernonia myriantha* are the most prominent diagnostic species of this syntaxon. Other diagnostic species include the shrub *Buddleja saligna* and the herbaceous *Lotononis foliosa* and *Xerophyta viscosa*. There are no diagnostic grasses, but dominant species include *Eragrostis capensis*, *E. curvula* and *Tristachya leucothrix*. A prominent forb is *Pentanisia prunelloides*, while the shrub *Protea caffra* (endemic form) is conspicuously present.

Floristic diversity: this grassland community is unique for the SCPE and only a slight floristic affinity exists with other grassland types of the SCPE in species groups M and X (Table 1a). The average number of species per relevé is 30, and the total number of species recorded for the association is 40 (two relevés) (Table 3). Three plant taxa of conservation significance occur in this association (Table 2), namely the endemic form of *Protea caffra*, the endemic *Zantedeschia jucunda* that is classified as Indeterminate in the Red Data List (also restricted to the association) and *Jamesbrittenia silenoides*, a taxon assessed as Vulnerable in KwaZulu-Natal.

2. Zantedeschio pentlandi–Aloetum castaneae ass. nova hoc loco

Nomenclatural type: relevé 100 (holotypus)

Environmental data: a short herbland on rocky flats, areas where bedrock is exposed at ground level. The plant community is associated with rock outcrops of norite, a rock type mined extensively as dimension stone in the region. It is situated on gentle slopes (0–5°) and with a very high surface rock cover of 50–70% (Table 3). Solid exposed rock sheets can cover areas of 25 m^2. The dominant soil type is the Mispah Form, indicating very shallow soils over hard rocks, often restricted to crevices. The habitat is situated on the midslopes, scarps and crests of undulating hills.

Diagnostic and dominant/prominent taxa: characteristic species are represented by species group B (Table 1a). Diagnostic trees/shrubs of the association include *Apodytes dimidiata*, *Canthium suberosum*, *Halleria luci-*

TABLE 2.—Endemic/near-endemic and Red Data List plant taxa of grasslands and wetlands associated with Sekhukhuneland Centre of Plant Endemism

Taxon	Family	1	2	3.1.1	3.1.2	3.2.1	3.2.2	3.3	3.4	4.1	4.2	5.1	5.2	6.1	6.2	6.3	7	8
Acacia karroo [form] (*P4*)	FABA	.	.	.	.	.	.	$+	.	$l	$l	.	.	$+	.	$r	$r	.
Aloe castanea	ASPH	.	#l	#+	#r	#r	.	#+	.	.	.	.	.	.	.	.	.	.
Aneilema longirrhizum	COMM	.	.	.	.	.	.	.	.	.	.	#+	.	.	.	.	.	.
Argyrolobium wilmsii	FABA	.	.	.	#r	#r	#r	.	.	.	.	.	.	.	.	.	.	.
Asclepias sp. (*S27*)	ASCL	.	$r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Berkheya densifolia	ASTE	.	.	#r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B. insignis [form] (*S257*)	ASTE	.	.	$+	$+	$+	$+	$+	$l	$l	$l	$+	$+	.	.	.	.	.
Callilepis leptophylla	ASTE	.	.	N+	N+	N+	N+	N+	N+	.	.	.	.	.	.	.	.	.
Cyphostemma sp. (*W13389*)	VITA	.	$r	$r	$r	$r	.	$r	.	.	.	.	.	.	.	.	.	.
Disa rhodantha	ORCH	.	.	.	.	.	.	.	.	.	.	.	.	.	Kr	Kr	.	.
Elephantorrhiza praetermissa	FABA	.	K$r	.	.	.	.	.	.	.	.	K$r	K$r	.	.	.	.	.
Euclea linearis [form] (*S937*)	EBEN	.	.	.	.	.	.	.	.	.	.	.	#+	.	.	.	.	.
Eucomis autumnalis subsp. *clavata*	LILI	.	.	Nr	Nr	.	Nr	.	.	.	.	.	.	Nr	Nr	Nr	Nr	Nr
E. montana	LILI	.	Rr	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gnidia caffra [form] (*W12975*)	TILI	.	.	$+	$r	$r	$+	$+	$+	$+	$+	$+	$+	.	.	.	.	.
Helichrysum albilanutum	ASTE	.	.	.	#l	.	.	.	.	.	.	.	.	.	.	.	.	.
H. uninervium	ASTE	.	.	.	.	.	.	.	.	.	.	#l	#l	.	.	.	.	.
Hermannia antonii	STER	.	.	.	#r	.	.	#+	#l	.	.	#r	#r	.	.	.	.	.
Ipomoea bathycolpos var. *sinuatodentata*	CONV	.	.	.	.	.	.	.	.	.	.	.	$r	.	.	.	.	.
Jamesbrittenia macrantha	SCHR	.	.	.	.	.	.	.	.	.	.	K$l	K$l	.	.	.	.	.
J. silenoides	SCHR	Nr	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Jasminum quinatum	OLEA	.	#r	.	.	.	.	.	.	.	#+	.	.	.	.	.	.	.
Melhania randii	STER	.	.	K#l	K#l	K#l	K#l	K#l	K#l	.	.	.	.	.	.	.	.	.
Nuxia gracilis	LOGA	.	.	.	.	.	.	.	.	.	.	.	.	K#l	.	K#+	.	.
Pegolettia lanceolata	ASTE	.	.	.	.	#r	.	#+	#r	.	.	.	.	.	.	.	.	.
Polygala sp. (*S449*)	POLY	.	.	.	.	.	.	.	.	.	.	.	$l	.	.	.	.	.
Protea caffra [form] (*S1382*)	PROT	$+	.	$l	$+	$r	$+	.	$l	.	.	$l	$l	.	.	.	.	.
Rhoicissus sp. (*S48*)	VITA	.	.	$+	$+	$l	.	$l	$l	$r	.	.	.	.	.	.	.	.
Rhus keetii	ANAC	.	.	.	.	.	.	.	.	.	.	#r	.	.	.	.	.	.
R. rogersii	ANAC	.	.	.	.	.	.	.	.	Nr	Nr	.	.	.	.	.	.	.
R. tumulicola var. *meeuseana*	ANAC	.	.	.	.	.	.	.	.	#r	.	.	.	.	.	.	.	.
R. wilmsii	ANAC	.	K#+	K#+	K#+	K#r	K#r	K#r	K#r	.	.	K#l	K#l	.	.	.	.	.
Rhynchosia nitens	FABA	.	Kr	.	.	.	.	Kr	.	.	.	.	.	.	.	.	.	.
Schizoglossum sp. (*S628*)	ASCL	.	$r	$r	.	.	$r	.	.	.	.	.	.	.	.	.	.	.
Scilla natalensis	LILI	.	Nr	Nr	N+	Nr	Nr	N+	N+	.	.	.	.	.	.	.	.	.
Thesium gracilentum	SANT	.	.	K+	K+	Kr	Kr	Kr	K+	K+	K+	.	.	.	.	.	.	.
T. multiramulosum	SANT	.	.	.	.	.	.	.	.	.	#+	#+	#+	.	.	.	.	.
Triaspis glaucophylla	MALP	.	#+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tristachya biseriata	POAC	.	Kr	K+	K+	.	.	.	.	.	.	.	.	.	.	.	.	.
Tulbaghia sp. (*S1304*)	LILI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	$r	.
Vitex obovata subsp. *wilmsii*	VERB	.	#+	#+	#+	#+	#+	#+	#+	#+	#+	#+	#+	.	.	.	.	.
Xerophyta retinervis [form] (*W13208*)	VELL	.	$r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Zantedeschia jucunda	ARAC	l$+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Z. pentlandii	ARAC	.	R#+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SCPE endemics		2	5	5	5	5	5	5	4	4	3	5	7	1	0	1	1	1
SCPE near-endemics		0	6	5	7	6	4	6	5	3	3	6	7	1	0	1	0	0
Red Data List		2	7	7	7	5	6	6	5	2	2	3	3	2	2	3	1	1
Restricted to syntaxon		2	5	1	1	0	0	0	0	1	0	1	4	0	0	0	0	1
Restricted to association		2	5	6						2		7		2			0	1
Total syntaxon		3	15	15	17	14	13	15	12	9	8	11	14	3	2	4	2	2
Total association		3	15	22						11		15		4			2	2

Endemism: $, endemic; #, near-endemic.
Red Data List: I, Indeterminate; K, Insufficiently Known; R, Rare; N, Not threatened in northern provinces of South Africa, but in other areas of southern Africa.
Abundance in communities: 1, abundant; +, frequent; r, rare; . absent.
Collectors: P = P.S. Swartz; S = S.J. Siebert; W = A.E. van Wyk.
Blocks represent community/syntaxon specific taxa.

da and *Olinia emarginata*. Diagnostic forbs are *Thesium burkei*, the succulents *Crassula sarcocaulis* and *Aloe pretoriensis*, and the geophytes *Boophone disticha* and *Zantedeschia pentlandii*. *Aristida junciformis* and *Cymbopogon excavatus* are the diagnostic grasses of this association. Prominent plants are the succulent *Aloe castanea*, the shrubby *Rhoicissisus tridentata* and the grasses *Eragrostis pseudosclerantha*, *Themeda triandra* and *Tristachya leucothrix*.

Floristic diversity: this association exhibits a typical floristic relationship with other grasslands of the SCPE (Table 1a). The average number of species encountered per sample plot is 36, with 105 species the total number recorded for the association (five relevés) (Table 3). Fifteen taxa of conservation significance are present in the association (Table 2), five are SCPE endemics, six are SCPE near-endemics and seven are Red Data List taxa. This association has a high number of plant taxa with conservation status in the southern region of the SCPE. The association also has a high number of plant taxa with conservation status restricted to it, such as *Asclepias* sp. (*Siebert 27*) (endemic), *Eucomis montana*

(Rare), *Xerophyta retinervis* form (endemic) and *Zantedeschia pentlandii* (endemic, Rare).

3. *Brachiario serratae–Melhanietum randii* ass. nova hoc loco

Nomenclatural type: relevé 321 (holotypus).

Environmental data: short, dense grassland associated with plateaus or terraces on rocky undulating hills. The association is found on all aspects, on gentle to moderate slopes (5–15°) of footslopes, midslopes, scarps and crests (Table 3). Soils are characterized by a melanic A-horizon underlain by hard rock (Milkwood Form) or a soft carbonate horizon (Steendal Form). Rock cover is 15–75% and rock diameter 0.1–1 m (Table 3).

Diagnostic and dominant/prominent taxa: characteristic species of the association are represented by species group C (Table 1a). The dominant diagnostic forbs are *Callilepis leptophylla*, *Dicoma zeyheri*, *Gnidia capitata*, *Melhania randii* and *Vernonia oligocephala*. Woody species typical of the association include the geoxylic

TABLE 3.—Environmental factors and selected attributes associated with different plant communities

Factors/attributes								Syntaxa										
	1	2	3.1.1	3.1.2	3.2.1	3.2.2	3.3	3.4	4.1	4.2	5.1	5.2	6.1	6.2	6.3	7	8
Total no. species	40	105	112	130	119	95	109	77	84	65	70	72	51	42	52	52	24
No. relevés	2	5	7	7	6	3	6	4	4	4	4	5	4	3	4	4	2
Ave. no. spp. per relevé	30	36	47	51	48	50	46	44	46	41	39	33	28	27	25	27	20
No. endemics/near-endemics	2	11	10	12	11	9	11	9	7	6	11	14	2	0	2	1	1
No. Red Data List taxa	2	7	7	7	5	6	6	5	2	2	3	3	2	2	3	1	1
Topographic position*	C	C	CS	M	CM	CM	MF	F	F	V	F	F	M	M	CV	V	C
Slope (°)	1–3	1–5	5–9	3–7	3–15	5–15	5–9	3–5	3–5	1–3	7–9	5–7	5–7	0–1	0–1	3–5	0–1
Aspect	E	ESW	NESW	NESW	EW	EW	EW	EW	EW	EW	NS	NESW	-	-	-	-	-
Predominant soil type**	My	Ms	My	Mw	Mw/Sd	Mw/Sd	Mw	Ar	Sn	Ar	Ms	Ms	-	-	-	-	-
Rock cover percentage (%)	15–20	50–70	20–40	25–50	25–50	25–75	35–40	15–30	20–25	5–10	60–70	20–70	35–45	5–15	10–20	20–30	5–10
Average rock size (mm)	300–500	>1000	200–950	150–450	450–950	100–250	400–750	100–250	50–150	50–150	100–400	100–200	350–750	50–100	50–100	150–200	10–50

* C, crest; S, scarp; M, midslope; F, footslope; V, valley.

** Ms, Mispah; Ar, Arcadia; Sn, Steendal; My, Mayo; Mw, Milkwood; Sd, Shortlands.

suffrutices *Elephantorrhiza elephantina* and *Rhus wilmsii*, and the small trees *Acacia caffra*, *Protea caffra* and *Vitex obovata* subsp. *wilmsii*. Other prominent forbs include *Clerodendrum triphyllum*, *Senecio latifolius* and *Tephrosia purpurea*. Prominent grasses for the association are *Andropogon chinensis*, *Brachiaria serrata*, *Setaria sphacelata*, *Themeda triandra*, *Trachypogon spicatus* and *Tristachya leucothrix*.

Floristic diversity: the average number of species encountered per sample plot in this association is 48, with the total number of plant species being a minimum of 119 taxa (29 relevés) (Table 3). There are 25 plant taxa of conservation value in the association, of which four are restricted to it. These include taxa such as the near-endemics, *Argyrolobium wilmsii* and *Pachycarpus transvaalensis* (Table 2). Red Data List taxa include *Callilepis leptophylla* (status is Rare in KwaZulu-Natal), *Melhania randii* (status is Insufficiently Known in the northern provinces) and *Scilla natalensis* (status is Vulnerable in the Free State and KwaZulu-Natal). This association harbours the highest number of plant taxa with conservation status in the southern region of the SCPE and, together with plant community 2, the highest number of Red Data List taxa.

3.1. *Brachiario serratae–Melhanietum randii helichrysetosum rugulosi* subass. nova hoc loco

Nomenclatural type: relevé 321 (holotypus).

Environmental data: short rocky grassland communities on clay soils such as Mayo and Milkwood Forms, occurs on midslopes, scarps and crests of undulating norite hills on slopes of 3–9° on all aspects. Rock cover is 20–50% with rock size of 0.15–1 m in diameter (Table 3).

Diagnostic and dominant/prominent taxa: species group F contains the diagnostic species for this subassociation, with the taxa *Helichrysum rugulosum*, *Pimpinella caffra* and *Tephrosia elongata* (Table 1a). Other characteristic species include the forbs *Acalypha punctata*, *Leonotis ocymifolia* and *Senecio lygodes*, as well as the grasses *Panicum natalense* and *Tristachya biseriata*. Trees that are prominent are *Euclea crispa* and *Vitex obovata* subsp. *wilmsii*. Predominant grasses are *Themeda triandra* and *Tristachya leucothrix*.

Floristic diversity: a strong floristic affinity exists with all the subassociations of the association (Table 1a). The average number of species encountered per sample

plot in this subassociation is 49, with the total number of plant species being a minimum of 130 taxa (14 relevés) (Table 3). Two plant taxa of conservation value are restricted to the subassociation (Table 2).

3.1.1. *Digitaria eriantha* Variant

Environmental data: rocky grassland on shallow clay soils of moderately sloped hill scarps and crests (Table 3). Rock size is 600 mm in diameter and cover is 25% (Table 3).

Diagnostic and dominant/prominent taxa: diagnostic taxa include the forbs *Agapanthus inapertus*, *Berkheya densifolia*, *Cyanotis speciosa*, *Indigofera hedyantha*, *Monsonia attenuata* and *Tephrosia longipes* and the grass *Digitaria eriantha* (species group D; Table 1a). Other frequently occurring grasses are *Andropogon schirensis*, *Brachiaria serrata* and *Setaria sphacelata*.

Floristic diversity: a strong floristic similarity exists with plant community 3.2.1, probably due to the similarity in their rock size and cover (species group H; Table 1a & Table 3). Five SCPE endemics, five near-endemics and seven Red Data List taxa are found in this variant (Table 2). Of the 112 taxa recorded for the variant (seven relevés), only 15 are of conservation value (one is restricted to it). The average number of species encountered per sample plot is 47 (Table 3).

3.1.2. *Alloteropsis semialata* Variant

Environmental data: rocky grasslands on shallow clay soils occurring on relatively steep midslopes of hills. Rock cover is 35%, with rocks 350 mm in diameter (Table 3).

Diagnostic and dominant/prominent taxa: *Berkheya onopordifolia*, *Helichrysum albilanatum*, *H. nudifolium* and the succulent *Kalanchoe rotundifolia*, are the diagnostic forbs, with *Alloteropsis semialata* and *Sporobolus pectinatus* the diagnostic grasses species (species group E; Table 1a). Dominant dwarf shrubs are *Clutia pulchella* and *Rhus discolor*.

Floristic diversity: the community shares a floristic identity within various species groups (Table 1a). Five SCPE endemics, and seven near-endemics and seven Red Data List taxa are found in this variant (Table 2). It has 17 taxa of conservation value, the highest number for this paper, with only one taxon restricted to it. The average number of species recorded per sample plot is 51 (richest plant diversity of all the study area's grassland

communities), with a total number of 130 plant taxa (seven relevés) (Table 3).

3.2. *Brachiario serratae–Melhanietum randii argyrolobietosum transvaalense* subass. nova hoc loco

Nomenclatural type: relevé 8 (holotypus).

Environmental data: a relatively tall, rocky grassland of midslopes and crests of undulating norite hills, occurs on soils of the Milkwood and Steendal Forms. It lies on relatively steep, sloped areas (3–15°). Rock cover is 25–75%, with rock diameter 100–950 mm (Table 3).

Diagnostic and dominant/prominent taxa: diagnostic species for this vegetation type is *Berkheya seminivea* and *Drimiopsis atropurpurea*. This subassociation is characterized by group G (Table 1a). Prominent taxa that occur in this vegetation unit are the forbs *Acalypha punctata*, *Argyrolobium transvaalense*, *Barleria ovata*, *Pachycarpus transvaalensis*, *Rhynchosia spectabilis*, *Tephrosia purpurea* and *Vernonia natalensis*. Important grasses for this vegetation type are *Brachiaria serrata*, *Diheteropogon amplectens*, *Setaria sphacelata* and *Themeda triandra*. Prominent woody species include the geoxylic suffrutices *Elephantorrhiza elephantina* and *Rhus discolor*.

Floristic diversity: the community exhibits a strong floristic affinity with all the grasslands of the study area (Table 1a). The average number of species encountered per sample plot in this subassociation is 49, with the total number of plant species being a minimum of 119 taxa (nine relevés) (Table 3). No plant taxa of conservation value are restricted to it (Table 2).

3.2.1. *Koeleria capensis* Variant

Environmental data: relatively tall rocky mountain grassland on east-west aspects of steep midslopes and crests occurs on shallow clay soils, is covered by ± 30% rock, with a relatively large rock diameter (on average 650 mm) (Table 3).

Diagnostic and dominant/prominent taxa: no diagnostic species occur in this variant. Character species include the prominent forbs *Crabbea hirsuta* and *Ipomoea obscura*, and prominent grasses are *Eulalia villosa* and *Koeleria capensis* (species group G; Table 1a). Other dominant plants include the geoxylic suffrutex *Rhus discolor* and the small tree *Euclea crispa*. Grass cover is dense and species rich.

Floristic diversity: a strong floristic similarity is shared with plant community 3.1.1, probably due to similarity in rock size and cover (species group H; Table 1a & Table 3). Of the 14 taxa of conservation value in this variant, five are SCPE endemics, six near-endemics and five Red Data List taxa (Table 2). The average number of species encountered per sample plot is 48, with a total of 119 plant species (6 relevés), the second richest plant diversity in the study area's grasslands (Table 3).

3.2.2. *Berkheya seminivea* Variant

Environmental data: rocky grassland communities on shallow clays of moderate midslopes and crests that are situated on east-west aspects (Table 3). Average rock size is 200 mm and cover is 40% (Table 3).

Diagnostic and dominant/prominent taxa: there are no diagnostic species, but characteristic species for this variant include the forbs *Berkheya seminivea*, *Drimiopsis atropurpurea*, *Helichrysum cephaloideum* and *Thesium magalismontanum* the most frequent (species group G; Table 1a). Other important taxa are *Andropogon schirensis*, *Argyrolobium transvaalense*, *Eragrostis chloromelas* and *Rhynchosia spectabilis*.

Floristic diversity: this variant is floristically typical of its association, but is characterized by the absence of the sister variant's character species (species group H; Table 1a). Of its 13 taxa of conservation value, five are SCPE endemics, four near-endemics and six Red Data List taxa (Table 2). The average number of species encountered per sample plot is 50, with the total being 95 taxa (three relevés) (Table 3).

3.3. *Brachiario serratae–Melhanietum randii gnidietosum capitatae* subass. nova hoc loco

Nomenclatural type: relevé 86 (holotypus).

Environmental data: rocky grassland communities on black clay soils. The habitat is found on footslopes and midslopes of undulating norite hills. The gentle slopes vary from 5–9°, with an east-west aspect the norm. Soils characteristic of these slopes is the Milkwood Form. Rock cover varies from 35–40% and rock size from 400–750 mm in diameter.

Diagnostic and dominant/prominent taxa: species group J contains the characteristic species for this subassociation, with prominent forbs such *Becium obovatum*, *Convolvulus sagittatus*, *Gerbera ambigua* and *Vernonia galpinii* (Table 1a). The forbs *Senecio microglossus* and *S. latifolius*, and the grasses *Themeda triandra* and *Tristachya leucothrix* are the most dominant in this subassociation. Other important taxa are the woody species *Elephantorrhiza elephantina* and *Euclea crispa*, succulents *Aloe castanea* and *A. greatheadii*, and grass species such as *Eragrostis superba*, *Setaria sphacelata*, *Sorghum bicolor* and *Tristachya rehmannii*.

Floristic diversity: a strong floristic affinity exists with certain plant communities of the association (species group J), but excludes plant communities 3.1.1 and 3.4 (Table 1a). The average number of species encountered per sample plot in this subassociation is 46, the total number of plant species being 109 (six relevés) (Table 3). Although 15 taxa with conservation value occur in this subassociation (Table 2), namely five SCPE endemics, six near-endemics and six Red Data List taxa, no plant taxa with conservation value are restricted to it.

3.4. *Brachiario serratae–Melhanietum randii setarietosum nigrirostis* subass. nova hoc loco

Nomenclatural type: relevé 64 (holotypus).

Environmental data: moist rocky mountain grassland on black turf soils lies on the lower part of gentle, sloped footslopes, 3–5°. It is found predominantly on soils of the Arcadia Form. Rock cover is ± 15–30%, rocks, with a relatively small average size of 100–250 mm in diameter (Table 3).

Diagnostic and dominant/prominent taxa: diagnostic species are represented by species group L (Table 1a).

Diagnostic forbs are *Lotononis adpressa* and *Scleria dieterlenii*, and the grass *Setaria nigrirostis*. No tree species are diagnostic, but *Protea caffra* is extremely prominent in this subassociation. Other important forbs are *Bulbostylis contexta, Lotononis macrosepala* and *Pegolettia lanceolata. Berkheya insignis, Hermannia antonii, Hypoxis rigidula, Melhania randii, Senecio microglossus* and *Thesium gracilentum* are prominent forbs. Prominent grasses of the subassociation are *Elionurus muticus* and *Eragrostis nindensis*. Grasses found frequently are *Brachiaria serrata, Diheteropogon amplectens, Themeda triandra, Trachypogon spicatus* and *Tristachya leucothrix*.

Floristic diversity: the subassociation shows its strong floristic affinity within association 3 in species groups C and M (Table 1a). More detailed future studies could suggest its upgrading to the level of association. The average number of species encountered per sample plot in this subassociation is 44, with 77 plant species the total number (four relevés) (Table 3). Twelve taxa with conservation value occur in this subassociation (Table 2), namely four SCPE endemics, five SCPE near-endemics and five Red Data List taxa. No plant taxa with conservation value are restricted to it.

4. *Elionuro mutici–Trachypogonetum spicati* ass. nova hoc loco

Nomenclatural type: relevé 112 (holotypus).

Environmental data: this rocky mountain grassland occurs on deep black turf soils (500–750 mm) which lie on moderately sloped, lower footslopes and valley bottoms, 5–15°. It is found predominantly on vertic Arcadia and Steendal Forms. Rock cover is 10–40% and rocks have a small average size of 100–150 mm in diameter (Table 3).

Diagnostic and dominant/prominent taxa: diagnostic species are presented in species groups N (Table 1a) and are characterized by the small trees *Rhamnus prinoides* and *Rhus rogersii*, the grasses *Brachiaria eruciformis* and *Setaria incrassata*, and the forbs *Indigofera evansiana, Kohautia caespitose* and *Striga elegans*. Forbs are abundant in the vegetation unit and prominent species include *Albuca setosa, Berkheya onopordifolia, Felicia muricata, Helichrysum albilanatum, H. nudifolium, Justicia anagalloides, Kalanchoe rotundifolia* and *Rubia horrida*. Prominent grasses of the association are *Alloteropsis semialata* and *Sporobolus pectinatus*, and dominant grasses such as *Brachiaria serrata, Eragrostis chloromelas, Heteropogon contortus* and *Panicum natalense*.

Floristic diversity: the average number of species encountered per sample plot in this association is 44, with the total number of plant species being a minimum of 84 taxa (12 relevés) (Table 3). There are 11 plant taxa of conservation value in the association (Table 2), of which two are restricted to it, including *Rhus rogersii*, a shrub assessed as Insufficiently Known for Swaziland in the Red Data List.

4.1. *Elionuro mutici–Trachypogonetum spicati bewsietosum biflorae* subass. nova hoc loco

Nomenclatural type: relevé 42 (holotypus).

Environmental data: moist, cool mountain grassland on turf soils, lies on gentle, sloped footslopes, 3–5°, restricted to deep Steendal soils. Rock cover is ± 20–25% and rocks have an average diameter of 50–150 mm (Table 2).

Diagnostic and dominant/prominent taxa: diagnostic species are represented by species group O (Table 1a). Only one woody species, the shrubby *Rhus tumulicola* var. *meeuseana*, is diagnostic of the subassociation, with *Acacia karroo* being a dominant and extremely common tree. *Argyrolobium amplexicaule, Conyza podocephala, Helichrysum* spp., *Rhynchosia albissima* and *Senecio* spp. are the diagnostic forbs. *Bewsia biflora* is the only diagnostic grass. Other prominent forbs include *Pearsonia grandifolia, Senecio microglossus* and *Striga elegans*. Dominant grasses include *Brachiaria eruciformis, B. serrata, Diheteropogon amplectens, Elionurus muticus* and *Themeda triandra*.

Floristic diversity: a floristic link with plant community 4.2 in species group N, indicates the relationship between these two subassociations on turf (Table 1a), although the environmental data differ to a great extent. The average number of species encountered per sample plot is 46. The total number for this subassociation is 84 (four relevés) (Table 3). One plant taxon with conservation value, the near-endemic *Rhus tumulicola* var. *meeuseana*, is restricted to it. Nine taxa with conservation value occur in this subassociation and comprise four SCPE endemics, three near-endemics and two Red Data List taxa (Table 2).

4.2 *Elionuro mutici–Trachypogonetum spicati acacietosum tortilis* subass. nova hoc loco

Nomenclatural type: relevé 112 (holotypus).

Environmental data: wooded grassland communities on black turf soils. These units occur in valley bottoms between undulating norite hills. The gentle slope varies from 1–3° and eastern or western aspects are predominant. Soil characteristic of these slopes is the Arcadia Form. Rock cover is 5–10% and rock diameter is 50–100 mm (Table 3).

Diagnostic and dominant/prominent taxa: species group P contains the diagnostic species for this association (Table 1a). Two trees are diagnostic for the association, namely *Acacia tortilis* and *Dichrostachys cinerea*. These taxa are often dominant in the *Panico maximi–Acacietea tortilis* class (Winterbach *et al.* 2000), a class representing microphyllus savanna in the central Bushveld of South Africa. Diagnostic grasses for the subassociation are *Digitaria sanguinalis, Panicum deustum, P. maximum* and *Sporobolus fimbriatus*. The association is dominated by forbs such as *Chrysanthemoides monilifera, Indigastrum burkeanum, Jasminum quinatum* and *Kyphocarpa angustifolia*. Other prominent taxa include the woody species *Rhamnus prinoides* and *Acacia karroo*, the herbaceous species *Asparagus suaveolens, Berkheya insignis, Gnidia caffra* and *Senecio microglossus*, and the grasses *Cymbopogon validus, Dihetero-*

pogon amplectens, Elionurus muticus, Hyparrhenia fili-pendula, Loudetia simplex, Setaria sphacelata and *Themeda triandra*.

Floristic diversity: a floristic link exists with the more herbaceous plant community 4.1, in species group N (Table 1a), but a difference in vegetation structure is apparent. The average number of species encountered per sample plot is 41 (Table 3). The total number of plant species for this subassociation is 65 (four relevés). No plant taxa with conservation value are restricted to the community, although three SCPE endemics, three SCPE near-endemics and two Red Data List taxa were recorded.

5. *Jamesbrittenio macranthae–Loudetietum simplicis* ass. nova hoc loco

Nomenclatural type: relevé 47 (holotypus).

Environmental data: wooded grassland associated with anomalous habitats (Siebert 1998) occurs on red clay and white loam soils of predominantly the Mispah Form that are characterized by serpentiniferous chemical compositions. It lies on moderate footslopes of 5–9° on all aspects of undulating hills. Rock cover is ± 20–70% and with large rocks 100–400 mm in diameter (Table 3).

Diagnostic and dominant/prominent taxa: characteristic species are represented by species group S (Table 1a). Herbs are diagnostic of this community, namely *Helichrysum uninervium, Jamesbrittenia macrantha, Lotononis wilmsii, Polygala hottentotta* and *Rhynchosia komatiensis. Elephantorrhiza praetermissa* is the characteristic woody species and *Aristida adscensionis* and *Melinis repens* the characteristic grasses. Prominent forbs are *Dicoma anomala, Gnidia caffra, Melhania prostrata* and *Thesium multiramulosum*. Grasses of importance include *Aristida congesta, Diheteropogon amplectens, Elionurus muticus, Eragrostis nindensis, Loudetia simplex, Themeda triandra* and *Tristachya leucothrix. Protea caffra* and *Vitex obovata* subsp. *wilmsii* are prominent trees and *Rhus wilmsii* is a prominent geoxylic suffrutex of the association.

Floristic diversity: the average number of species encountered per sample plot is 36, with the total number of plant species being a minimum of 72 taxa (nine relevés) (Table 3). Fifteen taxa of conservation value occur and the association (Table 2) has the highest number of taxa with conservation status restricted to it (seven), and includes plant species such as the near-endemics *Helichrysum uninervium* and *Lotononis wilmsii*, and the endemic and Red Data-listed *Jamesbrittenia macrantha*.

5.1. *Jamesbrittenio macranthae–Loudetietum simplicis combretetosum hereroense* subass. nova hoc loco

Nomenclatural type: relevé 47 (holotypus).

Environmental data: wooded grassland of rocky footslopes with clay soils. It lies on moderate slopes of 7–9° on north-south aspects of rocky ridges of magnetite. Soils are predominantly the Mispah Form. Rock cover is ± 60–70% and large rocks, 100–400 mm in diameter (Table 3).

Diagnostic and dominant/prominent taxa: the diagnostic species are represented by species group T (Table 1a), and include one tree species, *Combretum hereroense*. The forbs *Aneilema longirrhizum, Chamaecrista comosa, Hemizygia petrensis, Ledebouria marginata, Lotononis calycina, Phyllanthus incurvus* and *Triumfetta sonderi* are diagnostic. The most important dominant grasses include *Loudetia simplex, Themeda triandra, Tristachya leucothrix* and *T. rehmannii*. Other dominant taxa include *Protea caffra, Rhus wilmsii* and *Senecio microglossus*.

Floristic diversity: the subassociation shows a floristic affinity with the turf grasslands of the Roossenekal Subcentre in species groups V and W (Table 1a). A specific link with the grasslands of the study area, which includes its sister subassociation, is indicated in species group X. The average number of species encountered per sample plot is 39, with the total number for this subassociation being 70 (four relevés) (Table 3). Five SCPE endemics, six near-endemics and three Red Data List taxa are found in this subassociation (Table 2). Of its 11 taxa of conservation value, only the near-endemic *Aneilema longirrhizum* is restricted to it.

5.2. *Jamesbrittenio macranthae–Loudetietum simplicis eucleetosum linearis* subass. nova hoc loco

Nomenclatural type: relevé 106 (holotypus).

Environmental data: wooded, rocky grassland on white loam soils and is restricted to exposed norite surfaces. It lies on moderately sloped footslopes of 5–7° on all aspects. Soils are predominantly the Mispah Form. Rock cover is ± 20–70% and large rocks, 100–200 mm in diameter (Table 3).

Diagnostic and dominant/prominent taxa: species group U (Table 1a) represents the diagnostic species of the subassociation. The diagnostic grass species of the subassociation is *Andropogon chinensis*. Six forbs are diagnostic, namely *Indigofera tristoides, Ipomoea bathycolpos* var. *sinuatodentata, Jamesbrittenia burkeana, Phyllanthus glaucophyllus, Polygala* sp. nov. (*Siebert 449*) and *Seddera capensis. Euclea linearis* is the diagnostic woody species of the subassociation. Dominant plants in the community are the forbs *Dicoma anomala* and *Helichrysum uninervium*, and grasses *Aristida adscensionis, Diheteropogon amplectens* and *Elionurus muticus. Protea caffra, Rhus wilmsii* and *Vitex obovata* subsp. *wilmsii* are dominant woody species.

Floristic diversity: a slight floristic affinity is visible between this subassociation and plant communities 4.2 and 5.1 in species group V (Table 1a). The average number of species encountered per sample plot is 33, with the total number for this subassociation being 72 (five relevés) (Table 3). It is one of the syntaxa with the highest numbers of SCPE endemics and SCPE near-endemics. It also has three Red Data List taxa (Table 2). Of its 14 taxa of conservation value, four taxa, namely the SCPE near-endemics *Rhus keetii* and *Euclea linearis* (form), and the SCPE endemics *Ipomoea bathycolpos* var. *sinuatodentata* and *Polygala* sp. (*Siebert 449*), are restricted to it. This number is the second highest for any community in the Roossenekal Subcentre.

II. *Miscanthus junceus–Schoenoplectus corymbosus* Alliance (Bloem 1988)

6. *Fuireno pubescentis–Schoenetum nigricantis* ass. nova hoc loco

Nomenclatural type: relevé 73 (holotypus).

Environmental data: within the Roossenekal and Leolo Subcentres, this association represents hygrophilous vegetation of mountain streams and seepage areas and occurs on wet sites where rocks of ± 150 mm diameter cover ± 25% of the soil surface. These areas have gentle slopes (3°) and the soils are typically clay on solid rock, with a sandy alluvial layer on the surface.

Diagnostic and dominant/prominent taxa: species group AA (Table 1b) contains the diagnostic species. Dense stands of the diagnostic sedge *Schoenus nigricans* and the diagnostic grass *Hyparrhenia tamba* dominate the vegetation. Other diagnostic forbs are *Chironia purpurascens*, *Equisetum ramosissimum* and *Hypoxis argentea*. Sedges such as *Fuirena pubescens* and *Schoenoplectus corymbosus* are also prominent, while *Andropogon eucomis*, *Cymbopogon validus*, *Hyparrhenia filipendula* and *Imperata cylindrica* are prominent grasses. *Acacia karroo* and *Rhus leptodictya* are the woody species that may occur in the association.

Floristic diversity: a strong floristic affinity with the wetland community 7 is indicated in species group AI and some relationships exist with the grasslands (species group Y) (Table 1b). The azonal wetland vegetation is not as rich in plant diversity as the grasslands. The average number of species encountered per sample plot is only 27, with the total number of plant species being a minimum of 52 taxa (11 relevés) (Table 3). There are, however, four taxa of conservation value that occur in this association (Table 2), and two taxa with conservation status restricted to it, namely the Red Data listed orchid *Disa rhodantha* (Insufficiently Known), and the shrub, *Nuxia gracilis* (Insufficiently Known).

6.1. *Fuireno pubescentis–Schoenetum nigricantis triraphietosum andropogonoidis* subass. nova hoc loco

Nomenclatural type: relevé 73 (holotypus).

Environmental data: sparsely wooded, moist herbland and grassland along non-perennial mountain streams in rocky areas lying on gentle to moderate midslopes (5–7°). Rock size 350–750 mm in diameter and rock cover is 35–45%.

Diagnostic and dominant/prominent taxa: species group AB (Table 1b) contains the diagnostic species for this subassociation, which include the woody species *Acacia karroo*, *Nuxia gracilis* and *Rhus leptodictya*. Diagnostic forbs are the fern *Adiantum capillus-veneris*, and the sedges *Coleochloa setifera*, *Dittrichia graveolens* and *Juncus punctorius*. *Triraphis andropogonoides* is a diagnostic grass. Prominent forbs are the sedges *Fuirena pubescens*, *Schoenoplectus corymbosus* and *Schoenus nigricans*. *Andropogon eucomis*, *Aristida bipartita* and *Cymbopogon validus* are the most dominant grasses.

Floristic diversity: a notable relationship exists with plant community 6.2 in species group AC (Table 1b).

The average number of species encountered per sample plot is 28, with the total number for this subassociation being 51 (four relevés) (Table 3). The association has three taxa of conservation value, including one SCPE endemic, one SCPE near-endemic and two Red Data List taxa (Table 2).

6.2. *Fuireno pubescentis–Schoenetum nigricantis pycnostachetosum reticulatae* subass. nova hoc loco

Nomenclatural type: relevé 23 (holotypus).

Environmental data: dense moist herbland (reedbed) and grassland along permanent mountain streams occurs on gentle midslopes and footslopes of 1–3°. Rock cover is ± 5–15% and small rocks, 50–150 mm in diameter (Table 3).

Diagnostic and dominant/prominent taxa: characteristic species are represented by species group AC and AG (Table 1b). No woody or grass species are diagnostic of this community. Characteristic forb species include the sedges *Cyperus sexangularis* and *Kyllinga erecta*, and the forb *Berula erecta*. Dominant grass species are *Miscanthus junceus* and *Phragmites australis*, the forbs *Pycnostachys reticulata* and *Senecio gerrardii*, and the sedges *Fuirena pubescens*, *Schoenoplectus corymbosus* and *Schoenus nigricans*. *Andropogon eucomis*, *Cymbopogon validus* and *Hyparrhenia filipendula* are prominent grasses.

Floristic diversity: a floristic affinity exists with the adjacent grassland plant community 3.4 (species group L) (Table 1a), and with the wetland plant community 7 (species group AG) (Table 1b). The average number of species encountered per sample plot is 27, with the total number for this subassociation being 42 (three relevés) (Table 3). Only two taxa of conservation value, namely Red Data List taxa, are found in this subassociation (Table 2).

6.3. *Fuireno pubescentis–Schoenetum nigricantis bulbostylietosum hispidulae* subass. nova hoc loco

Nomenclatural type: relevé 34 (holotypus).

Environmental data: herbland and grassland occurs in moist valley bottoms or on mountain crests, usually in non-permanent seepage areas along streams. It is associated with gentle slopes of 1–3°. Scattered stones cover ± 10–20% of the soil surface with an average diameter of 50–100 mm (Table 3).

Diagnostic and dominant/prominent taxa: diagnostic species are presented in species group AD (Table 1b), including the forbs, *Alepidea amatymbica* and *Bulbostylis hispidula*, and the grasses, *Bothriochloa insculpta* and *Microchloa caffra*. The woody *Rhus leptodictya* is a prominent species. Predominant forbs include *Artemisia afra* and *Cliffortia nitidula*, and the sedges *Mariscus congestus* and *Schoenus nigricans*. *Andropogon eucomis*, *Cymbopogon validus*, *Hyparrhenia filipendula*, *Ischaemum fasciculatum* and *Miscanthus junceus* are the dominant grasses.

Floristic diversity: a strong floristic affinity exists with the grassland community 4.1 (species group O), but

a distinct affinity also exists with the wetland plant community 7 in species group AH (Table 1b). In this subassociation the sedges are less prominent and should be seen as a moist grassland-wetland ecotone. The average number of species encountered per sample plot is 25, with 52 taxa the total number for this subassociation (four relevés) (Table 3). There are four taxa of conservation value that include one SCPE endemic, one SCPE near-endemic and three Red Data List taxa (Table 2).

7. *Andropogono eucomusae–Fimbristyletum ferrugineae* ass. nova hoc loco

Nomenclatural type: relevé 192 (holotypus).

Environmental data: wooded herbland and grassland along larger rivers in valleys, such as the Steelpoort River. The vegetation covers the zone directly adjacent to streams, on permanently moist soils. The area has a gentle slope of 1–3°. Rock cover is ± 20–30% and rock diameter is 150–200 mm (Table 3).

Diagnostic and dominant/prominent taxa: diagnostic species are represented by species group AF (Table 1b). The vegetation unit is dominated by diagnostic forbs, which include the prominent weedy aliens *Conyza bonariensis* and *Flaveria bidentis*, the sedges *Cyperus marginatus*, *Mariscus rehmannianus*, *M. sumatrensis*, and the forb *Polygonum meisnerianum*. The presence of weeds is the result of disturbance caused by annual floods. *Salix mucronata* is the diagnostic woody species and *Eragrostis gummiflua* the diagnostic grass. Hygrophilous grasses and sedges such as *Miscanthus junceus* and *Schoenoplectus corymbosus* are dominant. *Acacia karroo* and *Rhus leptodictya* are common small trees of the association. *Andropogon eucomis*, *Cymbopogon validus*, *Hemarthria altissima*, *Hyparrhenia hirta* and *Imperata cylindrica* are dominant grasses of the association.

Floristic diversity: a strong floristic affinity exists with the wetland plant community 6 (species group AI) and a weaker affinity with the grasslands (species group Y) (Table 1b). The average number of species encountered per sample plot is 27, with the total number of plant species being 52 taxa (four relevés) (Table 3). This association has the lowest number of taxa with a conservation status (Table 2), including the Red Data List taxon *Eucomis autumnalis* subsp. *clavata*, which is classified as Rare in the Free State and Vulnerable in KwaZulu-Natal, and the SCPE endemic form of *Acacia karroo*.

III. Drakensberg escarpment wetlands (Hilliard & Burtt 1987)

8. *Limosello maioris–Ranunculetum meyeri* ass. nova hoc loco

Nomenclatural type: relevé 410 (holotypus).

Environmental data: this rare association represents dense herbland of moist seepage areas, recorded only on the summit plateaus of the Leolo Mountains around 1 800 m and is usually associated with black, marshy clay soils. A short, dense cover of nongrassy forbs dominates the vegetation. It lies on gentle slopes of 1–3° and ± 10% of the soil surface is covered by small stones with

an average diameter of 50 mm (Table 3).

Diagnostic and dominant/prominent taxa: diagnostic species are represented by species group AJ (Table 1b). The most predominant diagnostic taxa of the association are the small forbs *Limosella maior*, *Ranunculus meyeri* and *R. multifidus*. *Sporobolus centrifugus* is the diagnostic grass. *Schoenoplectus corymbosus* is a dominant sedge in the association.

Floristic diversity: a very slight floristic affinity exists with the other wetland plant communities of the area (species group AK) and also with the grasslands of the study area (species group Y) (Table 1b). It is much related to similar wetland communities below the Drakensberg escarpment above 1 800 m (Hilliard & Burtt 1987). The average number of species encountered per sample plot is 20, with the total number of plant species being 24 taxa (two relevés) (Table 3). Together with plant community 7, this association has the lowest number of taxa with a conservation status, namely two. These include the Red Data List species *Eucomis autumnalis* subsp. *clavata*, and the undescribed SCPE endemic *Tulbaghia* sp. (*Siebert 1304*), which may be a new genus of the Alliaceae.

Vegetation key

A dichotomous vegetation key is presented to facilitate identification of the various syntaxa found in the study area (Table 4). The definitions are broad indications of the syntaxa and should be seen as a guideline, rather than precise descriptions. A diagnostic characteristic of the vegetation or habitat is given, followed by the most diagnostic and conspicuous species of a particular syntaxon. The first species listed is restricted to the specific syntaxon only, and the second is dominant in the syntaxon, but may occur in other syntaxa. Where one species is given, no species were restricted to the particular syntaxon only.

Ordination

A scatter diagram displaying the distribution of the relevés along the second and third ordination axes is presented for both grassland and wetlands in Figure 2 (eigen values: axis 2 = 0.471; axis 3 = 0.325) and Figure 3 (eigen values: axis 2 = 0.458; axis 3 = 0.256) respectively. Vegetation units are represented as clusters, their distribution on the scatter diagram corresponding with certain physical environmental conditions. The gradient described by the x-axis in both instances, is related to drainage and hence, soil moisture. In the grasslands, the communties with the highest available soil moisture are situated at the left of the diagram (Figure 2), but communities of the wetlands with poor drainage on waterlogged soils are to the right (Figure 3). In addition, communities of the grasslands on clay soils of steep slopes are situated to the left of the diagram and communities on gravel soils of steep slopes to the right (Figure 2). The clay soils have the highest moisture availability, although the run-off is high. Grassland communities of turf soils on moderate slopes are positioned in the centre of the diagram, because these soils have a high soil moisture percentage, which is unavailable due to reten-

TABLE 4.—Key to syntaxa of grasslands and wetlands of undulating norite hills of Sekhukhuneland Centre of Plant Endemism

Leads/description		Go to/syntaxon
1a Grassland (*Tristachya leucothrix* & *Senecio microglossus*)	**2**	
b Wetland (*Schoenoplectus corymbosus* & *Cymbopogon validus*)	**3**	
2a Mispah soils on footslopes (*Jamesbrittenia macrantha* & *Dicoma anomala*)	**4**	
b Other soils and terrain types (*Tristachya leucothrix*)	**5**	
3a High-altitude seepage (*Ranunculus meyeri* & *Schoenoplectus corymbosus*)	**8** *Limosello maioris–Ranunculetum meyeri*	
b Streams/rivers (*Fuirena pubescens* & *Schoenoplectus corymbosus*)	**6**	
4a Gentle sloped (*Euclea linearis* & *Loudetia simplex*)	**5.2** *Jamesbrittenio macranthae–Loudetietum simplicis eucleetosum linearis*	
b Larger rock size and cover (*Combretum hereroense* & *Brachiaria serrata*)	**5.1** *Jamesbrittenio macranthae–Loudetietum simplicis combretetosum hereroense*	
5a Higher altitudes (*Helichrysum splendidum* & *Pentanisia prunelloides*)	**1** *Helichryso splendidi–Tristachyetum leucothricis*	
b Lower altitudes (*Acacia caffra*)	**7**	
6a Valley rivers (*Mariscus rehmannianus* & *Andropogon eucomis*)	**7** *Andropogono eucomusaes–Fimbristyletum ferrugineae*	
b Mountain streams (*Schoenus nigricans* & *Miscanthus junceus*)	**8**	
7a Larger rock size and cover (*Zantedeschia pentlandii* & *Aloe castanea*)	**2** *Zantedeschio pentlandi–Aloetum castaneae*	
b No Mispah soils (*Trachypogon spicatus*)	**9**	
8a Rocky streams (*Cyperus sexangularis* & *Hyparrhenia tamba*)	**10**	
b Stream seepage (*Bulbostylis hispidula* & *Chironia purpurascens*)	**6.3** *Fuireno pubescentis–Schoenetum nigricantis bulbostylietum hispidulae*	
9a Vertic A-horizon (*Rhamnus prinoides* & *Setaria sphacelata*)	**11**	
b Melanic A-horizon (*Rhynchosia spectabilis* & *Protea caffra*)	**12**	
10a Level slope (*Cyperus sexangularis* & *Berula erecta*)	**6.2** *Fuireno pubescentis–Schoenetum nigricantis pycnostachetosum reticulatae*	
b Steeper slope, more rocky (*Triraphis andropogonoides* & *Kyllinga erecta*)	**6.1** *Fuireno pubescentis–Schoenetum nigricantis triraphietosum andropogonoidis*	
11a Lower rock cover percentage (*Acacia tortilis* & *Hyparrhenia filipendula*)	**4.2** *Elionuro mutici–Trachypogonetum spicati acacietosum tortilis*	
b Steeper slope (*Pearsonia grandifolia* & *Senecio microglossus*)	**13**	
12a All aspects (*Helichrysum rugulosum* & *Clerodendrum triphyllum*)	**14**	
b East-west aspects (*Vernonia oligocephala*)	**15**	
13a Steendal soils (*Bewsia biflora* & *Tephrosia purpurea*)	**4.1** *Elionuro mutici–Trachypogonetum spicati bewsietosum biflorae*	
b Arcadia soils (*Setaria nigrirostris* & *Callilepis leptophylla*)	**3.4** *Brachiario serratae–Melhanietum randii setarietosum nigrirostris*	
14a Milkwood soils, midslopes (*Alloteropsis semialata* & *Hyparrhenia hirta*)	**3.1.2** *Brachiario serratae–Melhanietum randii helichrysetosum rugulosi, Alloteropsis semialata* variant	
b Mayo soils, scarps and crests (*Digitaria eriantha* & *Tetraselago wilmsii*)	**3.1.1** *Brachiario serratae–Melhanietum randii helichrysetosum rugulosi, Digitaria eriantha* variant	
15a Footslopes/midslopes (*Vernonia galpinii*)	**3.3** *Brachiario serratae–Melhanietum randii gnidietosum capitatae*	
b Midslopes/crests (*Berkheya seminivea*)	**16**	
16a Higher rock cover (*Argyrolobium transvaalense*)	**3.2.2** *Brachiario serratae–Melhanietum randii argyrolobietosum transvaalense, Berkheya seminivea* variant	
b Larger rock size (*Koeleria capensis*)	**3.2.1** *Brachiario serratae–Melhanietum randii argyrolobietosum transvaalense, Koeleria capensis* variant	

tion by the soil particles. The gradient shown by the y-axis for communities of wetlands is that of topographic position (Figure 3). Here, the water systems of mountain slopes with a faster run-off are placed at the top of the scatter diagram. Perennial seepage systems of plateaus are centred in the middle of the diagram, and communities of permanent, slow-flowing rivers are located at the bottom.

The gradient along the first axis of Figure 2 is also an indication of the species diversity in the grasslands, with the species diversity at the left of the diagram being high-er than that of the communities at the right. This phenomenon can be attributed to the heterogeneous environment experienced by most *Brachiario serratae–Melhanietum randii* rocky grassland communities.

The gradients that have been identified are associated with each other and have a strong influence on the vegetation. The three most dominant and conspicuous taxa of each growth form (trees/shrubs/suffrutices, forbs/sedges and grasses) are given for each of the eight major vegetation types depicted in the scatter diagram (Table 5).
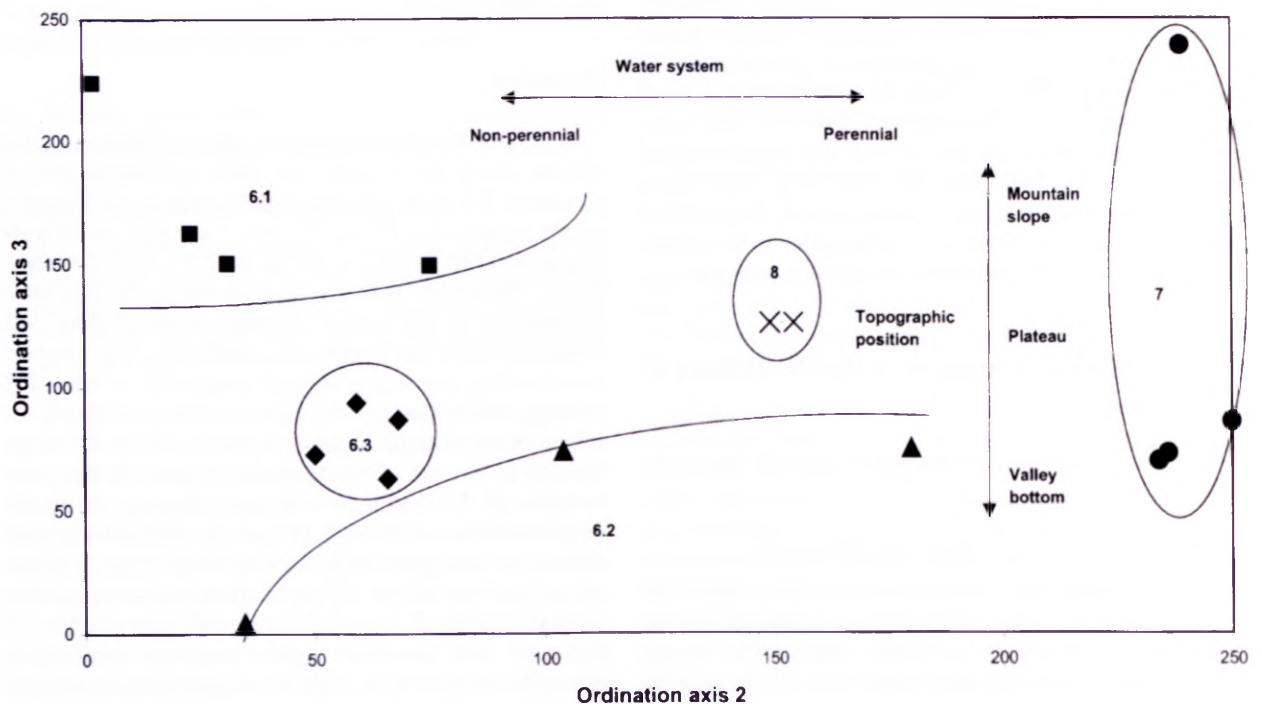

FIGURE 3.—Relative positions of all the releves along the second and third axis of the ordination of the wetland vegetation of the Sekhukhuneland Centre of Plant Endemism. Numbers correspond with those of syntaxa in Table 1b and in the text.

TABLE 5.—Three most dominant and conspicuous plant taxa of each growth form recorded for the major vegetation types depicted in DECORANA scatter diagrams (Figures 2, 3)

| Major vegetation type | Growth form | | |
	Trees/shrubs/suffrutecis	Forbs/sedges	Grasses
1 *Helichryso splendidi–* *Tristachyetum leucothricis*	*Buddleja saligna* *Clutia pulchella* *Protea caffra* [form]	*Euryops brevipapposus* *Helichrysum splendidum* *Pentanisia prunelloides*	*Eragrostis capensis* *Eragrostis curvula* *Tristachya leucothrix*
2 *Zantedeschio pentlandi–* *Aloetum castaneae*	*Apodytes dimidiata* *Canthium suberosum* *Halleria lucida*	*Aloe castanea* *Crassula sarcocaulis* *Zantedeschia pentlandii*	*Aristida junciformis* *Cymbopogon excavatus* *Eragrostis pseudosclerantha*
3 *Brachiario serratae–* *Melhanietum randii*	*Elephantorrhiza elephantina* *Protea caffra* [form] *Rhus wilmsii*	*Clerodendrum triphyllum* *Melhania randii* *Vernonia oligocephala*	*Andropogon chinensis* *Brachiaria serrata* *Tristachya leucothrix*
4 *Elionuro mutici–* *Trachypogonetum spicati*	*Rhamnus prinoides* *Rhus rogersii* *Vitex obovata*	*Berkheya insignis* *Cephalaria zeyheriana* *Gnidia caffra*	*Elionurus muticus* *Setaria sphacelata* *Trachypogon spicatus*
5 *Jamesbrittenio macranthae–* *Loudetietum simplicis*	*Elephantorrhiza praetermissa* *Protea caffra* [form] *Vitex obovata*	*Helichrysum uninervium* *Jamesbrittenia macrantha* *Thesium multiramulosum*	*Aristida adscensionis* *Loudetia simplex* *Melinis repens*
6 *Fuireno pubescentis–* *Schoenetum nigricantis*	*Acacia karroo* *Nuxia gracilis* *Rhus leptodictya*	*Fuirena pubescens* *Schoenus nigricans* *Typha capensis*	*Hyparrhenia filipendula* *Hyparrhenia tamba* *Imperata cylindrica*
7 *Andropogono eucomusae–* *Fimbristyletum ferrugineae*	*Acacia karroo* *Rhus leptodictya* *Salix mucronata*	*Cyperus sphaerospermus* *Fimbristylis ferruginea* *Mariscus rehmannianus*	*Andropogon eucomis* *Eragrostis gummiflua* *Phragmites australis*
8 *Limosello maioris–* *Ranunculetum meyeri*	No trees/shrubs	*Limosella maior* *Ranunculus meyeri* *Ranunculus multifidus*	*Eragrostis capensis* *Heteropogon contortus* *Sporobolus centrifugus*

DISCUSSION

Plant diversity and geographic variations over southern Africa are best explained by the geology (soils) and climate, with topographic diversity explaining much of the remaining variance (Holland 1978; Schulze & McGee 1978). Much of the distribution of the syntaxa in the study area can be attributed to fire, and the vegetation dynamics and historic evolution of the flora of the region (Siebert 1998), which is influenced by the above-mentioned three factors.

The TWINSPAN classification and its subsequent refinement by Braun-Blanquet procedures resulted in the delineation of 17 syntaxa. These plant communities can be related to certain environmental factors, the gradients of which are illustrated in the DECORANA scatter diagrams. The major gradient relates to soil moisture, which in turn is a direct consequence of run-off and drainage in the case of grasslands, permanent water bodies/sources in the case of wetlands, and temperature (drought stress) in both cases. Soil moisture availability is determined by the soil type, which in turn was determined by the topographical position of the substrate during pedogenesis. The gradients of the diagram are therefore a direct consequence of topography and climate.

In the SCPE, soils of ultramafic origin have caused the development of syntaxa adapted to the specific soil conditions, with high concentrations of certain elements, notably heavy metals. Such a plant community (syntaxon)-soil association on ultramafic substrates has previously been identified for southern Africa, on the Great Dyke of Zimbabwe (Werger *et al.* 1978) and the Barberton Greenstone Belt in South Africa (Morrey *et al.* 1989). Because of the ultramafic nature of the norites of the Roossenekal and Leolo Subcentres, many taxa of the study area are uncommon or absent in other grassland areas of southern Africa.

Among the 17 plant communities, 44 plant species/infraspecific taxa were identified as of conservation significance. Fifteen were SCPE endemics and 19 SCPE near-endemics. Of the 44, 17 were listed in the southern African Red Data List for plants (Hilton-Taylor 1996). This number compares well with serpentine sites elsewhere in the world, namely 18 rare plants and endemics in central Queensland, Australia (Batianoff *et al.* 1995), 20 endemics on the Great Dyke, Zimbabwe (Wild 1965) and 22 endemics in southern Mpumalanga, South Africa (Balkwill *et al.* 1995).

Species richness of Sekhukhuneland grassland communities is high when compared with the grassland species richness of other parts of South Africa. Sekhukhuneland grasslands have a species richness of 20 to 51 species per 100 m^2 with a mean of 38 species (Table 3). This mean is higher than that recorded for the grasslands of the northeastern Drakensberg (Mpumalanga) and southern Drakensberg (Eastern Cape), but is lower than that of the Highveld (Gauteng/Mpumalanga) (Hoare & Bredenkamp 2001). Floristically the Grasslands of the study area are related to those described by Bloem (1988), Deall *et al.* (1989), Matthews *et al.* (1992a), Burgoyne (1995) and Smit *et al.* (1997).

Throughout the SCPE, the remaining natural populations of plants and animals are under intense pressure from exploitative land uses. There are certain areas with specific syntaxa that should be considered as a priority for conservation purposes. Some plant endemics of the southern region of the SCPE are restricted to specific syntaxa and these habitats therefore require urgent attention for conservation as a result of the rapid expanding

mining industry, a common threat to southern Africa's rich plant diversity (Dold & Johnson 1997). Biodiversity increases ecosystem stability by promoting diversity among species in their responses to environmental fluctuations (Naeem & Li 1997; Grime 1998; Ives *et al.* 1999) and hence, is imperative for successful conservation initiatives. The establishment of nature reserves or protected areas is one solution to this problem of biodiversity loss; this is best achieved through land use stratification derived from a holistic overview. Such a strategic environmental assessment, which includes an adequate database of natural features and other land uses (Bedward *et al.* 1992), should be a priority for conservation agencies in the region.

The priority vegetation types for conservation (hotspots) are associations 2, 3 and 4, of which subassociation 3.1, the *Brachiario serratae–Melhanietum randii helichrysetosum rugulosi* rocky grassland on the scarps and crests of norite hills, is probably the most important and threatened. It should also be noted that the wetlands are sensitive systems that are easily disturbed and should be protected (Doust & Doust 1995; Van Wyk *et al.* 2000). Important wetlands to conserve are the seepage areas, namely the *Limosello maioris–Ranunculetum meyeri* Association and the *Fuireno pubescentis–Schoenetum nigricantis bulbostylietosum hispidulae* Subassociation.

Alien species primarily invade areas of high indigenous species richness (Lonsdale 1999; Stohlgren *et al.* 1999), such as the grasslands of southern Africa. *Acacia dealbata*, an alien tree from Australia, has invaded large areas of the Roossenekal Subcentre and especially the adjacent Steenkampsberg. Removing these trees is totally dependent on the owner of the land, with no large-scale projects being implemented. It is an ironic situation, with people 50 km to the north extensively chopping down indigenous bushveld trees for firewood.

This description and classification of the syntaxa of the study area is a contribution towards the understanding of the vegetation and flora in the southern parts of the SCPE and the region as a whole. The information supplied here should be applied in the management and conservation of the vegetation and habitats, especially the rocky grasslands that are threatened by the mining industry and inappropriate forms of land use, specifically overgrazing by domestic stock. This paper provides a basis for proper and sound assessment of the region's vegetation, as it includes aspects such as species richness, rarity and habitat preference. Detailed site-specific studies, using this paper as a reference, remain a prerequisite before suggestions concerning mining or conservation can be made. The region boasts a rich natural and human history (Pollock *et al.* 1963), and representative ecologically viable portions of the grasslands of the region, as well as the wetlands, should be protected and conserved for future generations.

REFERENCES

ACOCKS, J.P.H. 1988. Veld types of South Africa, edn 3. *Memoirs of the Botanical Survey of South Africa* No. 57.

BALKWILL, K., WILLIAMSON, S.D., KIDGER, C.L., ROBINSON, E.R., STALMANS, M. & BALKWILL, M-J. 1995. Diversity and conservation of serpentine sites in southern Mpumalanga (Eastern Transvaal), South Africa. In T. Jaffre, R.D. Reeves & T. Becquer, *The ecology of ultramafic and metalliferous areas*: 133–138. Centre de Noumea, III, Orstom.

BATIANOFF, G.N., REEVES, R.D. & SPECHT, R.L. 1995. The effect of serpentine on vegetation structure, species diversity and endemism in central Queensland. In T. Jaffre, R.D. Reeves & T. Becquer, *The ecology of ultramafic and metalliferous areas*: 147–153. Centre de Noumea, III, Orstom.

BEDWARD, M., PRESSEY, R.L. & KEITH, D.A. 1992. A new approach for selecting fully representative reserve networks: addressing efficiency, reserve design and land suitability with an iterative analysis. *Biological Conservation* 62: 115–125.

BLOEM, C. 1988. 'n Plantsosiologiese studie van die Verlorenvallei-natuurreservaat, Transvaal. M.Sc. thesis, University of Pretoria, Pretoria.

BUCKLE, C. 1996. *Weather and climate in Africa*. Addison Wesley Longman, Harlow.

BURGOYNE, P.M. 1995. *Phytosociology of the north-eastern Transvaal high mountain grasslands*. M.Sc. thesis, University of Pretoria, Pretoria.

BURGOYNE, P.M., BREDENKAMP, G.J. & VAN ROOYEN, N. 2000. Wetland vegetation in the North-eastern Sandy Highveld, Mpumalanga, South Africa. *Bothalia* 30: 187–200.

DEALL, G.B., THERON, G.K. & WESTFALL, R.H. 1989. The vegetation ecology of the Eastern Transvaal escarpment in the Sabie area. 2. Floristic classification. *Bothalia* 19: 69–89.

DOLD, T. & JOHNSON, K. 1997. Concern for Coega Kop. *Veld & Flora* 83: 40, 41.

DOUST, L.L. & DOUST, J.L. 1995. Wetland management and conservation of rare species. *Canadian Journal of Botany* 73: 1019–1028.

DU PREEZ, P.J. & BREDENKAMP, G.J. 1991. *Vegetation classes of the southern and eastern Orange Free State (Republic of South Africa) and highlands of Lesotho*. Navorsinge van die Nasionale Museum, Bloemfontein 7: 477–526.

EDWARDS, D. 1983. A broad-scale structural classification of vegetation for practical purposes. *Bothalia* 14: 705–712.

EDWARDS, D. 1984. Fire regimes in the biomes of South Africa. In P. de V. Booysen & N.M. Tainton, *Ecological effects of fire in South African ecosystems*. Springer-Verlag, Berlin.

ERASMUS, J.F. 1985. *Rainfall deciles for the Transvaal Region*. Soil and Irrigation Research Institute Report GB/A/87/18: 147–216. Pretoria.

GRIME, J.P. 1998. Benefits of plant diversity to ecosystems: immediate, filter and founder effects. *Journal of Ecology* 86: 902–910.

HENNEKENS, S. 1996a. *MEGATAB: a visual editor for phytosociological tables*. User's guide, Version 1.0. Giesen & Geurts, Ulft.

HENNEKENS, S. 1996b. *TURBOVEG: software package for input, processing, and presentation of phytosociological data*. User's guide, July version. IBN-DLO, Lancaster University.

HILL, M.O. 1979a. *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.

HILL, M.O. 1979b. *DECORANA—a FORTRAN program for detrended correspondence analysis and reciprocal averaging*. Cornell University, Ithaca, New York.

HILLIARD, O.M. & BURTT, B.L. 1987. The botany of the southern Natal Drakensberg. *Annals of Kirstenbosch Botanic Garden* 15.

HILTON-TAYLOR, C. 1996. Red Data List of southern African plants. *Strelitzia 4*. National Botanical Institute, Pretoria.

HOARE, D.B. & BREDENKAMP, G.J. 2001. Syntaxonomy and environmental gradients of the grasslands of the Stormberg/Drakensberg mountain region of the Eastern Cape, South Africa. *South African Journal of Botany* 67: 595–608.

HOLLAND, P.G. 1978. An evolutionary biogeography of the genus *Aloe*. *Journal of Biogeography* 5: 213–226.

IVES, A.R., GROSS, K. & KLUG, J.L. 1999. Stability and variability in competitive communities. *Science* 286: 542–544.

JONSSON, B.G. & MOEN, J. 1998. Patterns in species associations in plant communities: the importance of scale. *Journal of Vegetation Science* 9: 327–332.

KENT, M. & BALLARD, J. 1988. Trends and problems in the application of classification and ordination methods in plant ecology. *Vegetatio* 78: 109–124.

LAND TYPE SURVEY STAFF. 1987. Land types of the maps: 2526 Rustenburg; 2528 Pretoria. *Memoirs on the Agricultural Natural Resources of South Africa* No. 8. Department of Agriculture and Water Supply, Pretoria.

LONSDALE, W.M. 1999. Global patterns of plant invasions and the concept of invasibility. *Ecology* 80: 1522–1536.

LOW, A.B. & REBELO, A.G. (eds). 1996. *Vegetation of South Africa, Lesotho and Swaziland*. Department of Environmental Affairs & Tourism, Pretoria.

MACVICAR, C.N., BENNIE, A.T.P. & DE VILLIERS, J.M. 1991. *Soil classification: a taxonomic system for South Africa*. Department of Agricultural Development, Pretoria.

MATTHEWS, W.S., BREDENKAMP, G.J. & VAN ROOYEN, N. 1992a. The phytosociology of the high altitude hygrophilous vegetation regions of the north-eastern mountain sourveld in the Transvaal, South Africa. *Phytocoenologia* 20: 559–574.

MATTHEWS, W.S., BREDENKAMP, G.J. & VAN ROOYEN, N. 1992b. The vegetation of the dry dolomitic regions of the north-eastern mountain sourveld of the Transvaal escarpment, South Africa. *Phytocoenologia* 20: 467–488.

MATTHEWS, W.S., VAN WYK, A.E. & BREDENKAMP, G.J. 1993. Endemic flora of the North-eastern Transvaal Escarpment, South Africa. *Biological Conservation* 63: 83–94.

MEADOWS, M.E. & LINDER, H.P. 1989. A reassessment of the biogeography and vegetation history of the southern Afromontane Region. In C.J. Geldenhuys, *Biogeography of the mixed evergreen forests of southern Africa*: 15–29. Ecosystem Programme Occasional Report.

MORREY, D.R., BALKWILL, K. & BALKWILL, M-J. 1989. Studies on serpentine flora: preliminary analyses of soils and vegetation associated with serpentine rock formations in the southeastern Transvaal. *South African Journal of Botany* 55: 171–177.

MUCINA, L., BREDENKAMP, G.J., HOARE, D.B. & MCDONALD, D.J. 2000. A national vegetation database for South Africa. *South African Journal of Science* 96: 497, 498.

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

NAEEM, S. & LI, S. 1997. Biodiversity enhances ecosystem reliability. *Nature* 390: 507–509.

POLLOCK, N.C., LITT, B. & AGNEW, S. 1963. *An historical geography of South Africa*. Hazell Watson & Viney, Aylesbury.

RETIEF, E. & HERMAN, P.P.J. 1997. Plants of the northern provinces of South Africa: keys and diagnostic characters. *Strelitzia* 6. National Botanical Institute, Pretoria.

RHOADS, A.F. & THOMPSON, L. 1992. Integrating herbarium data into a geographic information system: requirements for spatial analysis. *Taxon* 4: 43–49.

SCHULZE, R.E. & MCGEE, O.S. 1978. Climatic indices and the classifications in relation to the biogeography of southern Africa. In M.J.A. Werger, *Biogeography and ecology of southern Africa*: 21–50. Junk Publishers, The Hague.

SIEBERT, S.J. 1998. *Ultramafic substrates and floristic patterns in Sekhukhuneland, South Africa*. M.Sc. thesis, University of Pretoria, Pretoria.

SIEBERT, S.J., VAN WYK, A.E. & BREDENKAMP, G.J. 2001. Endemism in the flora of ultramafic areas of Sekhukhuneland, South Africa. *South African Journal of Science* 97: 529–532.

SIEBERT, S.J., VAN WYK, A.E. & BREDENKAMP, G.J. 2002. The physical environment and major vegetation types of Sekhukhuneland, South Africa. *South African Journal of Botany* 68: 127–142.

SMIT, C.M., BREDENKAMP, G.J., VAN ROOYEN, N., VAN WYK, A.E. & COMBRINCK, J.M. 1997. Vegetation of the Witbank Nature Reserve and its importance for conservation of threatened Rocky Highveld Grassland. *Koedoe* 40: 85–104.

SOUTH AFRICAN WEATHER BUREAU. 1998. Unpublished report. Department of Environmental Affairs and Tourism, Pretoria.

STOHLGREN, T.J., BINKLEY, D. & CHONG, G.W. 1999. Exotic plant species invade hot spots of native plant diversity. *Ecological Monographs* 69: 25–46.

VAN WYK, A.E. & SMITH, G.F. 2001. *Regions of floristic endemism in southern Africa*. Umdaus Press, Pretoria.

VAN WYK, A.E & VAN WYK, P. 1997. *Field guide to trees of southern Africa*. Struik Publishers, Cape Town.

VAN WYK, E., CILLIERS, S.S. & BREDENKAMP, G.J. 2000. Vegetation analysis of wetlands in the Klerksdorp Municipal Area, North West Province, South Africa. *South African Journal of Botany* 66: 52–62.

VISSER, D.J.L., COERTZE, F.J. & WALRAVEN, F. 1989. *Explanation of the 1:1000000 geological map, fourth edition, 1984: the geology of the Republics of South Africa, Transkei, Bophuthatswana, Venda and Ciskei and the Kingdoms of Lesotho and Swaziland*. The Government Printer, Pretoria.

WEBER, H.E., MORAVEC, J. & THEURILLAT, J-P. 2000. International Code of Phytosociological Nomenclature. 3rd edition. *Journal of Vegetation Science* 11: 739–768.

WERGER, M.J.A., WILD, H. & DRUMMOND, B.R. 1978. Vegetation structure and substrate of the northern part of the Great Dyke, Rhodesia: environment and plant communities. *Vegetatio* 37: 79–89.

WHITTAKER, R.H. 1977. Evolution of species diversity in land communities. *Evolutionary Biology* 10: 1–67.

WILD, H. 1965. The flora of the Great Dyke of southern Rhodesia with special reference to the serpentine soils. *Kirkia* 5: 49–86.

WINTERBACH, R., BREDENKAMP, G.J., DEUTSCHLÄNDER, M.S. & MUCINA, L. 2000. Preliminary syntaxonomic scheme of vegetation classes for the Central Bushveld of South Africa. In P.S. White, L. Mucina, J.S. Leps & E. van der Maarel, *Proceedings IAVS Symposium*: 123–127. Opulus Press, Uppsala.