Bothalia 29,2: 305–325 (1999)

Ordination and classification of vegetation of Songimvelo Game Reserve in the Barberton Mountainland, South Africa for the assessment of wildlife habitat distribution and quality

M. STALMANS*†, E.R. ROBINSON* and K. BALKWILL*

Keywords: Barberton Mountainland, CANOCO, classification, habitat suitability, ordination, PATN, South Africa, vegetation sampling

ABSTRACT

A vegetation survey was undertaken of the 49 000 ha Songimvelo Game Reserve in the Barberton Mountainland of Mpumalanga, South Africa with the aim to identify constituent plant communities and to assess their relative value to wild herbivores. The vegetation is highly diverse with representation of three biomes; Savanna, Grassland and Forest. A total of 428 plots were sampled by means of a semi-quantitative technique. Data were subjected to ordination (CANOCO) and classification (PATN). The composition of the 19 distinct communities is determined through an intricate combination of environmental factors as evident from the ordination results. Firstly 'drainage line' position is critical, followed by land use history and further by the interplay between elevation and geology. These findings are in line with results obtained from other studies along the eastern Escarpment. Alluvium, mafic and ultramafic lavas support mixed veld, whereas felsic lavas, sandstones and quartzites support sour veld which has a very low forage value in the dry season. Each community, through its specific species assemblage, structure and location, forms a distinctly different habitat in terms of its value to the various species of herbivores in the SGR.

INTRODUCTION

The 49 000 ha Songimvelo Game Reserve (SGR) is located within an area of great conservation and biogeographic value (Fourie *et al.* 1988; Matthews *et al.* 1993), of internationally renowned geological interest (Lowe & Byerly 1999) and with aesthetically striking landscape attributes (Anon. 1986). The vegetation is highly diverse with representation of three biomes; Savanna, Grassland and Forest.

These conservation and scientific values are of limited consequence to the impoverished rural communities living alongside the Reserve. Tangible economic benefits through tourism are essential to obtain local community acceptance and support for the use of the land for conservation. Successful ecotourism development in this area depends largely on the introduction and maintenance of a large wild herbivore component (Anon. 1998).

A description of the vegetation and an understanding of the underlying causal factors are required in order to assess habitat suitability for wild herbivores and in order to formulate appropriate management guidelines. Prior to the present study, no comprehensive vegetation survey had been undertaken of this area and consequently little information was available on the vegetation-herbivore interrelationships.

Vegetation composition has direct bearing on the quality and seasonality of available feed (Barnes *et al.* 1984; Eckhardt *et al.* 1993; Fabricius & Mentis 1990). Vegetation structure (height and density) largely controls its availability to herbivores (Fabricius & Mentis 1992).

The aims of this study were firstly to classify the vegetation of the SGR into identifiable plant communities based on composition and structure, secondly to identify the main environmental factors responsible for this vegetation pattern, and lastly to assess the relative value of the identified plant communities to the wild herbivores.

STUDY AREA

The SGR is located in the southeastern part of Mpumalanga on the South African-Swaziland border at latitude 25° 45'–26° 5' S and longitude 30° 46'–31° 16' E (Figure 1).

Geology, soils, topography and drainage

The SGR is situated in the Barberton Mountainland which forms part of the African erosion surface (Partridge & Maud 1987). Elevation ranges from 600 to 1 900 m above sea level. The SGR is drained by numerous perennial rivers and streams of which the Komati is the most important. The Komati Valley represents some 10 000 ha of relatively gentle topography, whereas the remainder of the Reserve is more rugged.

The Barberton Mountainland represents an early Precambrian greenstone belt (Viljoen & Viljoen 1971). The entire succession of supracrustal rocks constituting the greenstone belt is known as the Swaziland Sequence and has been divided into three groups. The Onverwacht Group represents the initial volcanic phase of the belt. For purposes of the study, this group was divided in two units. The Tjakastad unit combines the Komati and Theespruit formations consisting of basaltic and peridotitic komatiite

* Department of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Private Bag 3, 2050 Wits, South Africa.
† Present address: Mpumalanga Parks Board, P.O. Box 1990, 1200 Nelspruit, South Africa. e-mail: stalmans@mweb.co.za
MS. received: 1999-01-04.

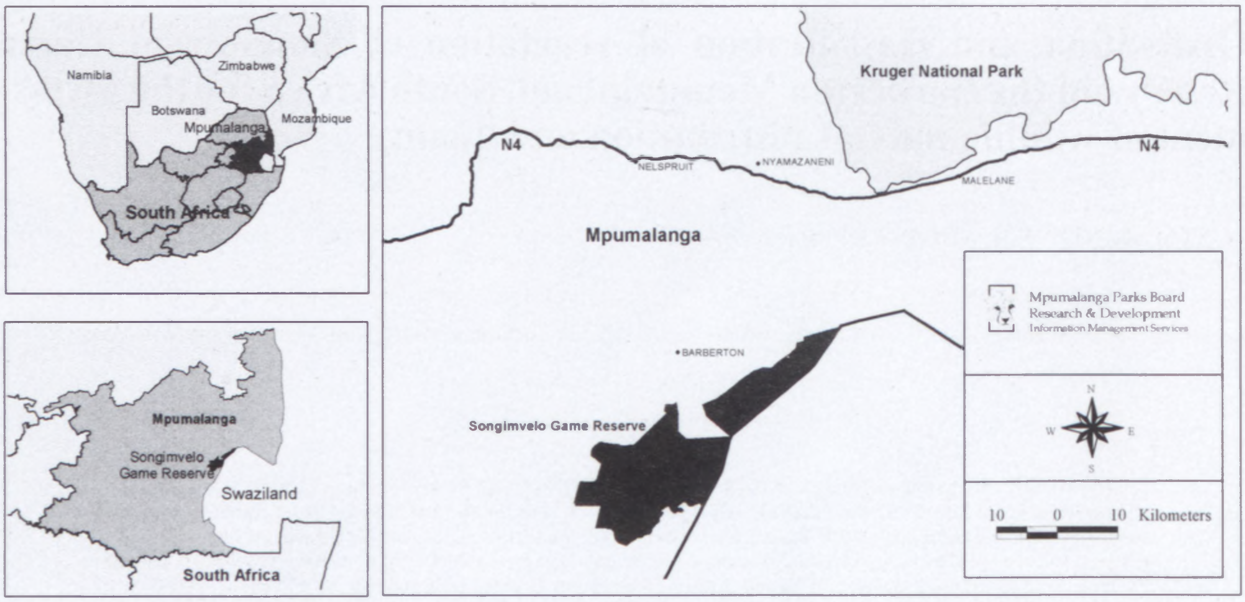

FIGURE 1.—Location of the study area in Mpumalanga, South Africa (information source Mpumalanga Parks Board).

and tholeite with various mafic and ultramafic schists. Alluvial deposits in the lower Komati Valley were lumped with this group. The Geluk unit combines the Zwartkoppie, Kromberg and Hooggenoeg formations and includes mostly mafic and felsic volcanic rocks, agglomerates, breccia, chert and shales. The Onverwacht Group is overlain by an argillaceous group (Figtree) and an arenaceous group (Moodies). These include sandstones, quartzites, shales, agglomerate and conglomerate. Acid igneous intrusives occur in the form of biotite trondhjemite gneisses in the southwestern corner and granodiorite-adamellite along the southern edge of the SGR.

Geology and elevation are not independent of each other. The different groups stretch in a wedge shape, from the broad low-lying Komati Valley in the southwest to the narrow band of mountains in the northeast. Ultramafic and mafic substrates generally occur at lower elevation, whereas felsic lavas, quartzites and sandstones are found at higher elevations. Average elevation increases from 919 m for the Tjakastad unit, 1 098 m for Geluk to 1 219 m for Figtree and Moodies. A corresponding increase in average annual rainfall contributes to more leached and acid soils derived from the Geluk and Figtree units with lowest pH values of 4.4 as compared to the highest pH value of 7.1 in the lower Komati Valley (Anon. 1986).

Climate

Rainfall, which is concentrated between November and March, varies from less than 800 mm per year in the low-lying southwestern area to over 1 600 mm in the high-lying northeastern parts (Gamble 1988). Mean minimum and maximum monthly temperatures are 5.4°C and 7.9°C in July and 22°C and 34°C in January for the highland and lowland areas respectively (Anon. 1986). Frost is common during winter months in the Komati Valley.

Archaeology and land use history

The SGR is characterised by a long and diverse history of land use. Witt (1983) reports middle Stone Age artefacts dating back 30 000 to 50 000 years. Stone-walled sites of the Later Iron Age (the last 1 000 years) are common (Anon. 1986). The SGR area was settled by the bakaNgwane (people of Swaziland) during the reign of King Mswati II (1840–1868) (Van der Merwe & Retief 1995). During the last 100 years gold and asbestos mining took place. The area was used for winter grazing of sheep from the turn of the century. In 1985, some 350 households were living within the future SGR. The total area under dryland cultivation was ± 850 ha. Since then the number of residents has declined with only 40 families remaining in 1997. By 1985, only limited numbers of small game still occurred. Since 1986 a total of 20 species of large herbivores totalling more than 2 000 animals have been re-introduced.

Vegetation

The vegetation of the higher-lying regions of the SGR belongs to the Grassland Biome. The lower-lying Komati Valley falls within the Savanna Biome (Rutherford & Westfall 1986). Three of Acocks's (1975) veld types occur. Veld types 8 (North-eastern Mountain Sourveld) and 63 (Piet Retief Sourveld) correspond to the North-eastern Mountain Grassland of the Grassland Biome as defined by Low & Rebelo (1996). Veld type 9 (Lowveld Sour Bushveld) corresponds to the Sour Lowveld Bushveld of the Savanna Biome. The Forest Biome is represented by numerous isolated patches of forest, mostly at higher elevation and along drainage lines.

METHODS

Sampling approach

Edwards' (1983) structural classes were used to describe the overall structural properties of the sampled plots. Overall cover was estimated for the woody, grass, forb and geophyte component respectively, using the semi-quantitative measures of the Braun-Blanquet approach (Mueller-Dombois & Ellenberg 1974). Cover and height classes were recorded for individual woody and grass species. Individual geophytes and forbs were omitted from the list of species for three reasons. Firstly, grasses and woody species are of most importance to the herbivores. Secondly, the great diversity of forbs would have significantly increased sampling time and would therefore have decreased the possible number of sample plots. Thirdly, because of logistical constraints, sampling was spread across seasons which would have resulted in a differential presence of geophytes depending on the sampling date. Records of environmental data included elevation, by means of an altimeter (± 20 m) and the 1:50 000 topocadastral maps; geology, according to 1:250 000 geological survey maps (Geological Survey 1986); and locally at a finer scale through personal observations; landscape position (Land Type Survey Staff 1989), aspect (whether predominantly N, E, S or W), slope steepness (class estimate), soil texture (using the sausage method (National Working Group for Vegetation Ecology 1986)) and rockiness (estimated as a percentage of the ground cover).

It was deemed important to achieve a high number and sufficient spread of sampling plots for two reasons. Firstly, Austin & Heyligers (1989) argue that where there is no existing information on vegetation (as was largely the case in this instance), surveys should sample various combinations of environmental variables as a means of obtaining a representative sample. Secondly, they contend that sampling the full range of environments ensures that predictive models derived from survey data can be used for interpolation rather than extrapolation. Furthermore, in resource surveys in which a major objective is the detection of as much diversity as possible, randomisation is largely irrelevant (Gillison & Brewer 1985). In this instance the authors were not concerned with a statistical estimation of the proportions of the survey area covered by different vegetation communities. Provided there has been sufficient ground coverage to ensure correct interpretation, these areas can be measured, for example, from aerial photographs or satellite imagery with sufficient accuracy.

Different combinations of environmental variables and different vegetation communities were sampled in 428 plots of 30 × 30 m which were subjectively located. Although the whole Reserve was covered, samples tend to be clustered as dictated by terrain accessibility (Figure 2). The question with regard to this approach is whether it adequately captures the floristic diversity and the large range of abiotic conditions which might determine community composition. This was investigated in two ways. Firstly, the coverage by sample plots of different combinations of environmental factors was determined. The combinations of environmental factors such as elevation and geology were obtained through the use of the IDRISI Geographic Information System (Eastman 1992). The geographic position of the samples was determined in the field by means of a Global Positioning System (GPS) and incorporated into the GIS. Secondly, the adequacy in capturing the floristic diversity was assessed by direct comparison of the sample data with the known woody and grass diversity of the SGR.

Ordination

The CANOCO computer package (Ter Braak 1992) was selected to analyse relationships between the data set of 428 plots by 346 species and the underlying environmental factors. CANOCO allows for canonical ordination which is an intermediate technique which combines aspects of regular ordination with aspects of regression (Jongman *et al.* 1987). The resulting ordination diagram expresses not only the pattern of variation in species composition but also the main features of species distributions along the gradient of environmental variables (Ter Braak 1986). A step-wise approach was followed in which groups of plots, determined by specific environmental conditions identified in the previous ordination run, were removed from the remaining data set for the next ordination. Both Principal Components Analysis (and its canonical equivalent Redundancy Analysis—henceforth RDA) and Correspondence Analysis (and its canonical equivalent Canonical Correspondence Analysis—henceforth CCA) were used, based on the type of response model exhibited by the local species. As a practical guideline, Ter Braak & Prentice (1988) sug-

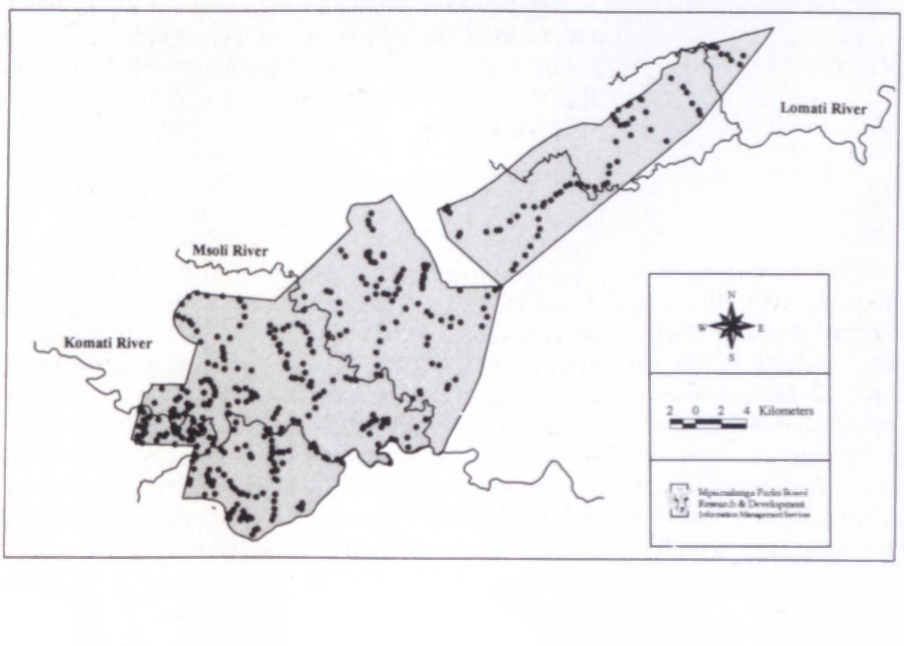

FIGURE 2.—Distribution of 428 semi-quantitative sample plots (depicted as ●) across the Songimvelo Game Reserve.

gested that most species are behaving monotonically if the gradient length is less than 1.5 sd [standard deviation or unit of ordination-length as defined by Hill & Gauch (1980)]. Gradients longer than 3 sd can be analysed using CA and related techniques. The range 1.5–3 sd for the first axis represents a 'window' over which both PCA/RDA and CA/DCA/CCA can be used to good effect. In practice, the data set was subjected to a DECORANA run (Hill 1979a) which led to the identification of a gradient length of 5.347 sd along the first axis.

Classification

Classification or cluster analysis was used to identify groups and to impose structure on the raw data (Jongman *et al.* 1987). The PATN software package (Belbin 1988) was used. PATN incorporates a host of classification techniques including TWINSPAN (Hill 1979b). In particular, the ALOC module was used.

ALOC stands for 'allocation' and implements a simple non-hierarchical clustering strategy. In a first phase the first sample plot in the data set is used as a 'seed' to create a starting configuration that ALOC can iterate on. Each object in the data set is compared to each seed. If the resulting association is greater than an allocation radius between zero and one, the object itself becomes a seed and the number of groups increases with one. The process continues until all objects have been compared with all seeds. The second phase begins with object 1 and sequentially allocates each object to the nearest seed as generated in the first phase. The third phase dismisses the seeds and calculates the group centroids based on the objects which were assigned to each group in phase 2. The fourth phase is iteration and re-location. Each iteration sequentially extracts each object from the group it currently belongs to and allocates it to the group with the nearest centroid. Groups may disintegrate down to a single object, by the process of re-allocating them to other groups.

The PATN outcome was evaluated subjectively by testing the obtained entities against photographs of each sample plot and field knowledge. The criteria used were the homogeneity of the units and their identifiability in the field.

RESULTS AND DISCUSSION

Sampling adequacy

Landscape diversity

Based on initial field observations and a study in a similar environment (Deall & Theron 1990), elevation and geology were identified as being of major importance. Using six elevation classes, starting at 600 m asl and each spanning 200 m, and the 12 geological substrates, a total of 51 elevation-geology combinations are present in the SGR. Marked differences could be observed in the field across a 200 m elevation difference, in particular when comparing different aspects. Thirteen elevation-geology combinations were not sampled. However, these 13 combinations cover only 1.9% of the SGR with the largest combination standing at only 0.4% of the total surface area. Another seven combinations representing 1.2% of the surface area, only have one sample plot each. Thus, only 3.1% of the surface area in terms of elevation-geology combinations was not sampled at all or was sampled without replication. Sixteen combinations covering 75.4% of the Reserve are represented by more than 10 sample plots per combination. The 428 plots are thus considered to be adequately spread across the SGR.

Floristic diversity

A total of 348 species was recorded for the 428 plots; 247 woody and 101 grass species. A total of 288 woody species is known for the SGR based on independent surveys and ongoing collecting by several taxonomists. The sampled species thus represent 85.8% of this total. Species which were not encountered include *inter alia Calodendrum capense, Encephalartos paucidentatus, Kiggelaria africana, Nuxia floribunda, Piper capense, Rhoicissus digitata, Rhus discolor, R. gerrardii, Scutia myrtina, Syzygium guinense* and *Warburgia salutaris*. They are mostly found in forests which cover less than 10% of the Reserve and where they do not constitute a dominant component. The known number of grasses based on ongoing collecting and previous research projects is 136 species (after lumping both in the total list and in the sample plots the subspecies of *Aristida congesta, Bothriochloa* spp., *Cymbopogon* spp., *Festuca* spp. and the different varieties of *Setaria sphacelata* as a single species each). It was necessary to lump some of these species and subspecies as sampling conditions covered a wide range of conditions in terms of the length and age of the sward making identification problematic in instances where heavy grazing was experienced or where a fire had recently occurred. The sampled species represent 74.3% of the known total. Species which were not encountered during the sampling are mostly *Eragrostis* spp., *Sporobolus* spp. and *Digitaria* spp., none of which were important in the field.

Ordination results

The first CCA ordination led to a dense cloud of plots representing the major part of the sample, with plots along drainage lines falling outside of this cloud. Eigenvalues of the first and second axes are respectively 0.57 and 0.56.

Plots in 'drainage' positions are covered by forests and thickets, as well as more open wetland or riverine vegetation (Figure 3). Drainage positions have a higher moisture availability and are sheltered from fires. Thickets, which are more prominent at low elevation and on northerly aspects are characterised by species such as *Grewia occidentalis, Olea europaea* subsp. *africana* and *Ruttya ovata*. In contrast, forests are much more mesic, occurring at higher elevation and on more southerly aspects, and are characterised by species such as *Combretum kraussii, Halleria lucida, Keetia gueinzii* and *Schefflera umbellifera*. The wetland and forest communities which these plots represent are clearly defined

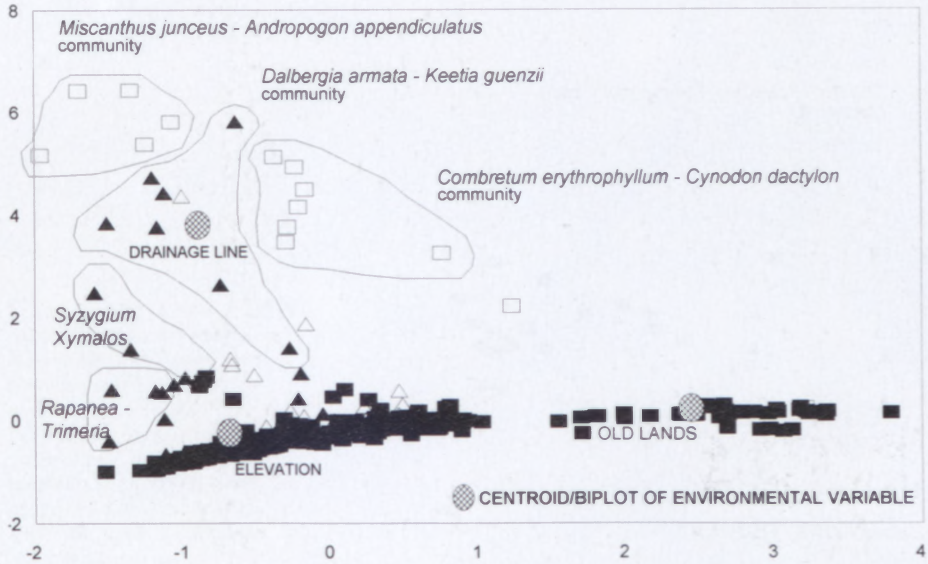

FIGURE 3.—Ordination diagram of the CCA of 428 plots with elevation, drainage position and land use as environmental variables. Forests, ▲; Thicket, Δ; Riverine/wetland, ❑; others, ■.

within the ordination diagram (Figure 3) (see 'Classification' results for an explanation of the community names used).

The 60 forest/thicket/riverine/wetland plots identified through the first CCA were removed from the original data set. The remaining 368 plots were again subjected to CCA ordination. Eigenvalues of the first and second axes are 0.71 and 0.41 respectively. A dense cloud of 'undisturbed' samples spread along an elevation gradient was plotted against a group of samples on old lands and old settlement sites (Figure 4). Within the ordination diagram a clear spatial definition is obvious between the plant communities on old lands at higher elevation (*Lippia javanica–Hyparrhenia* spp. Community) as compared to the lower elevation old lands which are covered by the *Cynodon dactylon–Melinis repens* Community.

The 65 old land and settlement sites identified in the second CCA were subjected to a separate RDA ordination. Resulting eigenvalues were very low at 0.07 and 0.05 for the first two axes respectively. Old lands and old settlements are not so much different in terms of composition as they are structurally distinct. Both sets of plots share species such as *Acacia nilotica, Cynodon dactylon* and *Heteropogon contortus. A. nilotica* occurs as scattered low shrubs on old lands but as dense mature thickets on settlement sites. The greater woody cover on old settlement sites probably reflects a longer time span from abandonment and/or the result of better fire protection afforded by old walls. Other typical species are *Hippobromus pauciflorus* and *Pappea capensis*.

After removal of the 65 old land and settlement sites, the remaining 303 plots were again subjected to a CCA ordination. The eigenvalues were relatively high; 0.58 for the first axis and 0.36 for the second axis. Both elevation and geological substratum are clearly important factors but their respective influence could not immediately be ascertained.

Their relative importance was evaluated by ordinating a subset formed by all the plots falling between 900–1 100 m and 1 500–1 700 m in the Geluk and Figtree/Moodies units. The choice of these two elevation belts and substrata was made subjectively in order to obtain enough samples (respectively 33, 19, 13 and 14 plots) while having a large enough difference in elevation (400 m minimum) to ensure the likelihood of elevation-induced vegetation differences.

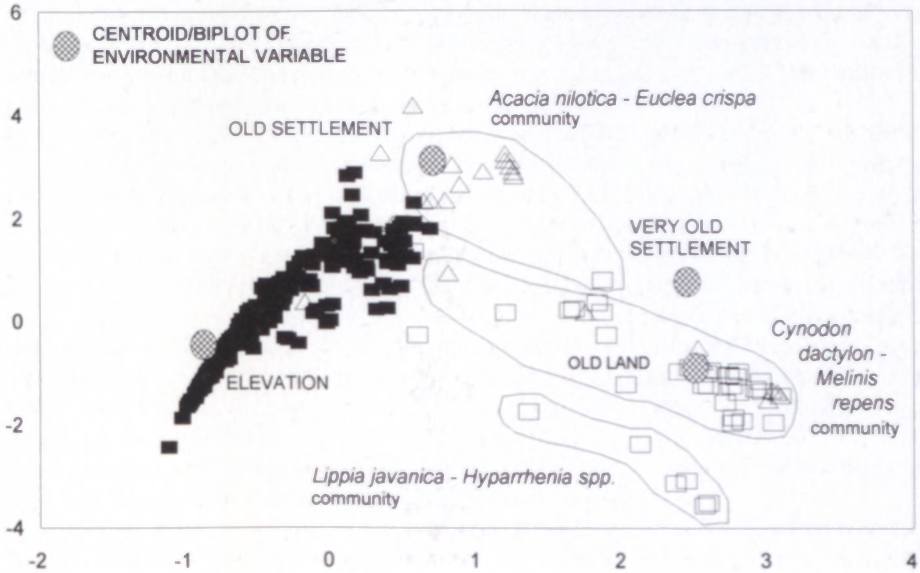

FIGURE 4.—Ordination diagram of the CCA with elevation and land use history as environmental variables of 368 plots remaining after removal of forest and thicket plots. Old settlement, Δ; old lands, ❑; others, ■.

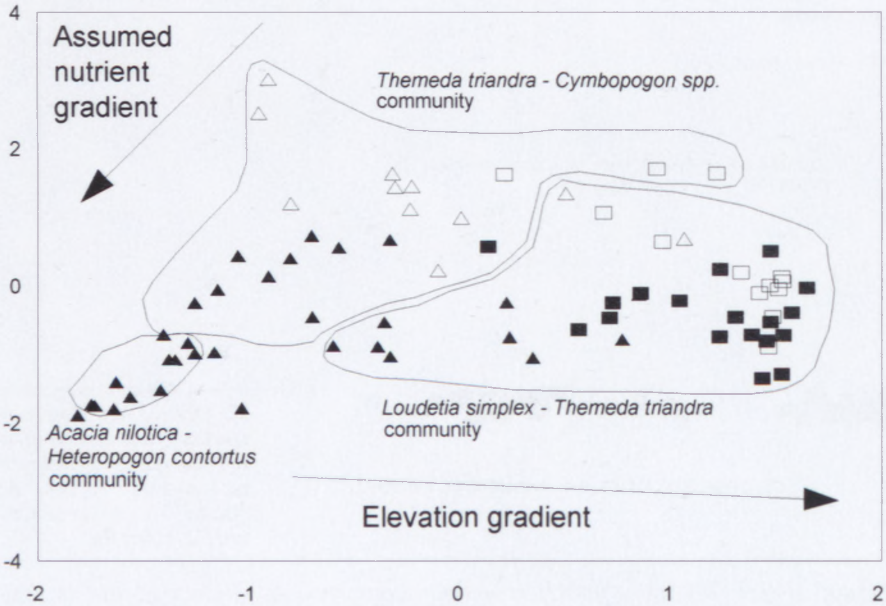

FIGURE 5.—CCA of 4 groups of samples representing combinations of two geological substrates and two elevation belts. Note the separation in ordination space between elevation/geology combinations. 900–1 100 m on mafic/felsic lava, ▲; 1 500–1 700 m on mafic/felsic lava, ■; 900–1 100 m on sandstone/quartzite, Δ; 1 500–1 700 m on sandstone/quartzite, ❑.

The resulting diagram clearly shows a split between low and high elevation plots within each geological unit and a split between geological units within each elevation belt (Figure 5). The CCA ordination yielded eigenvalues of 0.47 and 0.26 for the first two axes. High t-values and inter-set correlations of -0.84 and 0.63 for elevation on the first and geology on the second axis indicate the importance of these two factors. A total of 74.7% of these sample plots are classified into three communities which are spatially distinctly defined in the ordination diagram.

Based on the above, the subsets formed by the three major geological units were ordinated separately. The 45 plots occurring on alluvium and the Tjakastad subgroup were ordinated using CCA. The eigenvalues for the first axis was 0.45 and for the second 0.27. They generally represent the lowest-lying area of the Reserve as well as the least broken part. Elevation is an important factor, but landscape position is also critical. The plains and footslopes are characterised by grass species such as *Aristida congesta*, *Eragrostis chloromelas* and *Heteropogon contortus* and woody species such as *Acacia caffra*, *A. nilotica* and *Combretum hereroense*. Upper slopes are typically covered by *Combretum apiculatum* while with elevation an increase in the more sour grass species such as *Loudetia simplex*, *Panicum natalense*, *Trachypogon spicatus* and *Tristachya leucothrix* is apparent.

The CCA ordination diagram for the 153 plots on the Geluk subgroup again yielded elevation as being the most important environmental factor. The eigenvalue for the first axis was 0.49 and 0.21 for the second. At high elevation, *Erica drakensbergensis*, *Koeleria capensis* and *Protea roupelliae* are found. Warmer, northerly aspects are often characterised by *Combretum apiculatum*, *Gymnosporia buxifolia* and *Pterocarpus angolensis*. On cooler and moister southerly aspects sour species such as *Alloteropsis semialata* subsp. *eckloniana* are prominent. *Aristida canescens/transvaalensis* and *Xerophyta* spp. are associated with steep westerly and northerly slopes.

Elevation was also the most important factor according to the CCA ordination diagram for the 81 plots on Figtree and Moodies substrata. Eigenvalues were 0.34 and 0.24 for the first two axes respectively. *Alloteropsis semialata* subsp. *eckloniana*, *Koeleria capensis*, *Protea caffra* and *Rendlia altera* are representative of a large proportion of the vegetation.

Classification results

The ALOC classification results are presented by means of a dendrogram. The y-axis represents decreasing association (or increasing 'distance') between groups of sample plots. A total of 24 classification groups were produced (Figure 6).

The three main splits represent respectively, mixed, 'forest/thicket' and sour communities. Sour refers to vegetation of which the forage quality declines sharply towards the dry and cold winter making it less acceptable to herbivores. Mixed communities are intermediate between sour and sweet communities. The latter retain their forage quality during the dry season (Ellery *et al.* 1995).

Based on the frequency distribution of the cover classes, each main split exhibits a particular combination of woody, grass and forb cover (Figure 7). Mixed communities are generally more wooded and have a less dense grass layer. Forests and thickets have per definition a closed to virtually closed woody layer and a low grass cover. The sour communities are less wooded and have a very dense grass layer. These three main splits reflect the major physiognomic characteristics of the three biomes that occur in the Reserve, namely Savanna, Forest and Grassland (Rutherford & Westfall 1986).

Grass species were classified in terms of their palatability, particularly late into the growth season and into the dry season (Ellery *et al.* 1995; Van Oudtshoorn 1991). Based on the frequency distribution across different cover classes, a cover value was approximated for each species in the mixed and sour communities. The unpalatable or sour species make up more than 60% of total cover in the sour split, whereas the palatable sweet

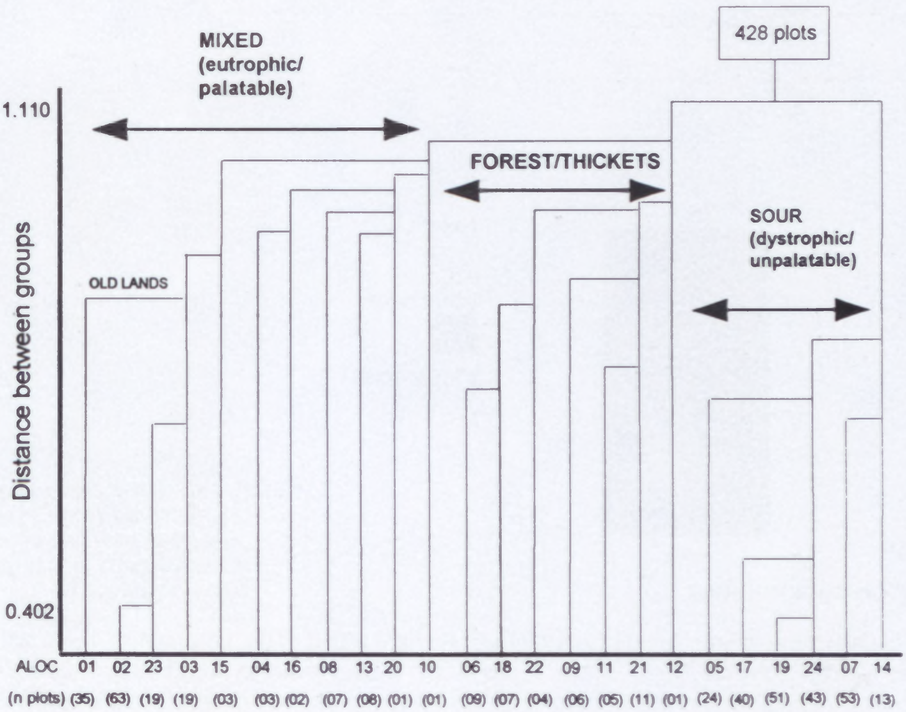

FIGURE 6.—Dendrogram of the ALOC classification of 428 sample plots.

grasses contribute less than 10% (Figure 8). This neatly fits the definition for sour grasslands derived by Ellery *et al.* (1995). The mixed split similarly fits the definition by being intermediate between the sour and sweet grassland with the latter having more than 20% sweet grasses and a cover of less than 30% by sour grasses.

These sour communities occur at elevations above 1 000 m where the high rainfall results in leached soils on mostly Geluk, Figtree and granitic substrates which are dystrophic (Anon. 1986). Within the sour split, groups 5, 17, 19 and 24 represent the typical sour grasslands. Groups 7 and 14 represent mixed communities with a higher cover of woody species.

Below this first split, the next branch defines the mixed communities and the forests and thickets. Classification groups 6, 18, 22, 9, 11 and 21 make up the forests and thickets. The mixed communities occur generally at lower elevation and are more wooded and are generally situated on nutrient rich alluvium and Tjakastad geology.

Within the mixed split, the riverine and wetland communities (groups 4, 16, 8, 13, 20 and 10) are isolated. The remainder of the mixed split comprises the drier communities with *Acacia nilotica* as a visually striking element (groups 1, 2, 23, 3 and 15). The further division (group 1) comprises old lands.

Description of plant communities

Of the 24 classification groups, it is difficult to differentiate in the field between groups 2 and 23, groups 4 and 16, groups 17, 19 and 24, as well as groups 7 and 14. After lumping these groups, 19 units or communities remain. The community concept is applied in its broad sense and reflects a recurring assemblage of grass and woody species of characteristic composition and struc-

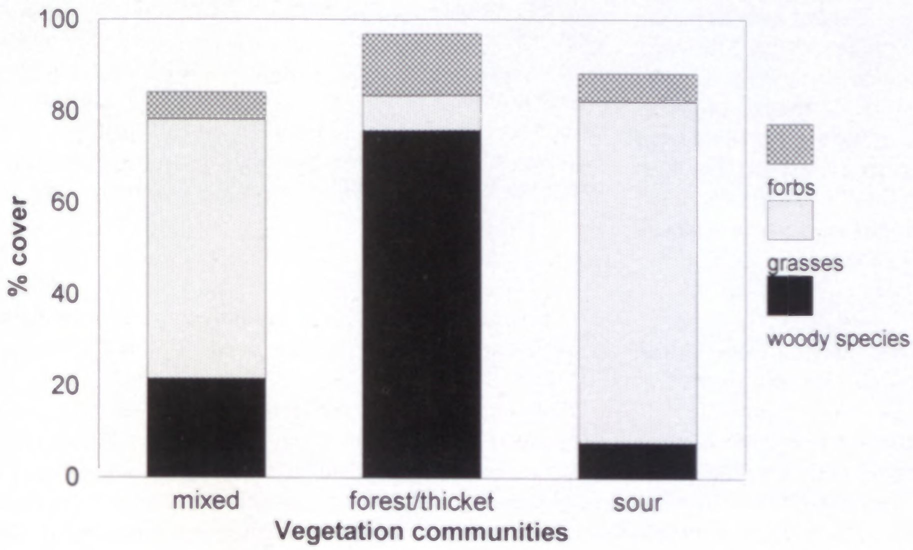

FIGURE 7.—Main ALOC groups; summarised woody, grass and forb cover values based on frequency distribution of sample plots across cover classes.

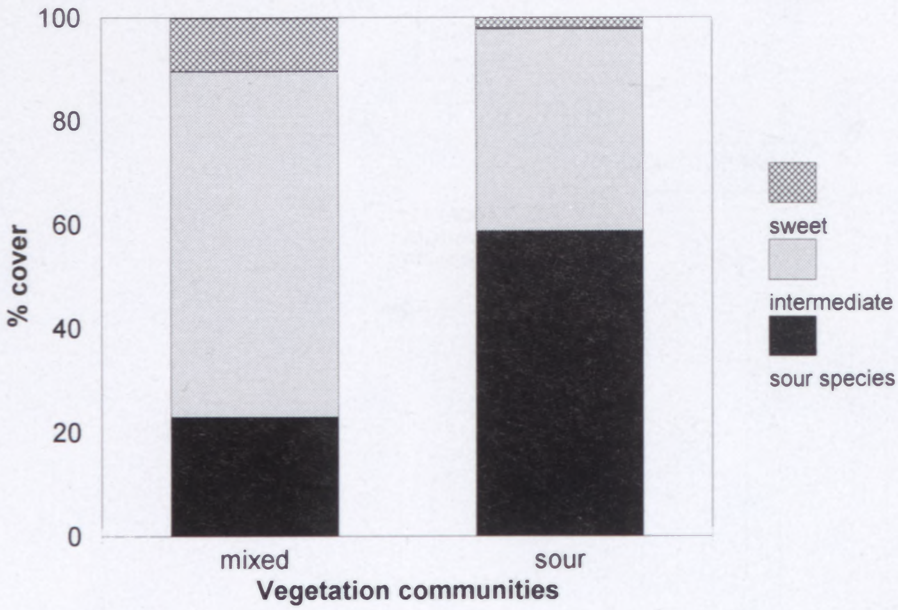

FIGURE 8.—Relative contribution of palatable, intermediate and unpalatable grass species to the mixed and sour split in the ALOC dendrogram.

ture, growing in an area of essentially similar environmental conditions and land use history (adapted from Gabriel & Talbot (1984)). These communities occur both on a micro- (1 m^2 to 10^6 m^2) and meso-scale (10^6 m^2 to 10^{10} m^2) (Delcourt & Delcourt 1988). Community names were chosen subjectively so as to have practical value in the field through the use of two species which are visually and/or diagnostically important. Structural information with regard to vegetation height and openness follows Edwards (1983). A synoptic table with constancy values for all species in the 19 plant communities is provided (Appendix).

1. *Cynodon dactylon–Melinis repens* Short Shrubland (classification group 1, n = 35 sample plots)

This community is mostly found in the lower-lying Komati Valley below 1 000 m. It occupies footslopes and river terraces which have been cultivated or settled in the past. Soils are clayey. More than half of the sample plots had a woody cover of less than 5%. The most frequently occurring shrub is *Acacia nilotica* (Table 1). A further 31 woody species were recorded, typically including *Dichrostachys cinerea, Euclea crispa, Rhus pentheri, Sclerocarya birrea,* and *Ziziphus mucronata.* The grass component is generally less than 0.5 m tall with a characteristic combination of two or more of the following species: *Bothriochloa* spp., *Cynodon dactylon* and *Heteropogon contortus* (Table 1). In total 41 species of grasses was recorded. More than half of the sample plots were subject to moderate or heavy grazing pressure. The forb component as observed in the field comprises alien species such as *Conyza* spp., *Acanthospermum australe* and *Schkuhria pinnata.*

2. *Acacia nilotica–Heteropogon contortus* Low Woodland (classification group 2 & 23, n = 82)

This community also occurs in the low-lying Komati Valley (Figure 9). It forms the broad matrix within which patches of the first (*Cynodon dactylon–Melinis repens*) and third community (*Acacia nilotica–Euclea crispa* Community) are embedded. This community itself has been exposed for a long time to wood extraction and heavy grazing by livestock, but its soil surface has not been directly modified. This is probably because of the often extremely rocky character of the habitat. Only 5 out of 82 sample plots occupy sites of old lands or settlement.

The woody component is generally open to closed. A total of 74 woody species was recorded with *Acacia nilotica* as the most frequently occurring tree in association with *Euclea crispa* shrubs (Table 1). The dominant species in the grass layer is *Heteropogon contortus*. A total of 55 grass species was encountered.

3. *Acacia nilotica–Euclea crispa* Low Woodland (classification group 3, n = 19)

This community has many species in common with the previous one, but is generally a closed formation occurring as discrete patches on mostly old settlement sites, but also on dolerite dykes. These sites are mostly situated in the Komati Valley. *Acacia nilotica* is the dominant woody element, often forming a closed, even-aged canopy. Of particular importance is the occurrence of valuable browse species such as *Berchemia zeyheri*. In total, 61 woody species was observed. Only 29 grass species were recorded of which *Heteropogon contortus* was dominant. *Cynodon* is also important. The forb component as observed in the field harbours the alien *Zinnia peruviana*. *Ornithogalum saundersiae* is a conspicuous geophyte which is found along old settlement walls of packed rock.

4. *Combretum apiculatum–Xerophyta retinervis* Low Woodland (classification group 15, n = 3)

This community is confined to moderately steep to very steep rocky upper slopes overlooking the Komati River on an ultramafic substrate. It is physiognomically very distinct with the tall fibrous perennial *Xerophyta retinervis* under a canopy of *Combretum apiculatum*. The

TABLE 1.—Synoptic table with constancy values for selected common and diagnostic species in 19 plant communities of the Songimvelo Game Reserve. Community numbers refer to text (communities 8, 9 and 16 are only represented by 1 sample plot each). Symbols refer to the following constancy ranges: * 1–25%, ** 26–50%, *** 51–75%, **** 76–100%

	'mixed' split in ALOC dendrogram									thicket/forest split							'sour' split		
	mixed			old land		wetland/ river		alien		thicket			forest				sour grassland		
Community number ➡	2	3	4	1	7	5	6	8	9	13	14	15	16	10	11	12	17	18	19
Group A: sweet species																			
Acacia nilotica	***	****	****	***						**		*						*	*
Aristida congesta	***	****	****	****						**							*	*	*
Eragrostis chloromelas	***	**		**								*					*	*	
Melinis repens	***	**	**	****	****					**	*	*					*	*	*
Gymnosporia buxifolia	**	**		*	**		**			***		*						*	*
Group B: old land/disturbance spp.																			
Bothriochloa spp.	*	**		****	***	*													*
Cynodon dactylon	*	***		****	**	**	****	****	****										*
Hyparrhenia coarse spp.	*	*	*	*	***		**	****											*
Sporobolus pyramidalis/fimbriatus	*			**	*	*	*	****											*
Group C: wetland/riverine species																			
Imperata cylindrica				*		**													
Andropogon appendiculatus						**													
Eragrostis lappula						**													
Phragmites spp.				*		**	****							*					
Group D: thicket species																			
Ficus ingens										**	***	*							*
Iboza sp.	*	*								***	*	**							
Obetia tenax										**	*	*		*					
Euphorbia ingens	*	*		*						**	****	**		*					
Hippobromus pauciflorus	*	**		*			*			**	***	****		*	*				
Pappea capensis	*	**		*			*			***	**	***		*			*		
Panicum maximum	*	**		*			***	****		****	**	**			*				*
Group E: thicket and forest species																			
Rapanea melanophloes											*			**	****	***	*	*	*
Zanthoxylum capense	*						*	*		*	*	***		*	**	*			
Englerophytum magalismontanum	*									**	*	*		***	*	***	*	*	*
Maytenus undata	*						*			**	****	***		*	**		*		
Cussonia spicata	*	*	*	*			*				****	***	****	***	****	***			*
Dalbergia armata	*										**	***		****	*	*			*
Pittosporum viridiflorum											*			**	**	**			
Plectranthus sp.											*	*	****		**	***			
Rhus chirindensis	*			*							****	**	****	*	*	***			*
Syzygium gerrardii												*		*	*	****			
Tricalysia sp.												*		*	***	***			
Trimeria grandifolia												*		*	****	*			
Allophylus sp.											*	**		**	**				
Apodytes dimidiata												*		**	**	*			
Canthium inerme		*									*	*		*	*	**	*		*
Carissa bispinosa												*	****		**	***			
Clausena anisata		*								*	*	*		*	***	**			
Combretum kraussii								****				*		**	**	**			
Ekebergia capensis												*		*	**	**			
Group F: forest species																			
Curtisia dentata														*	**	****			
Rhoicissus rhomboidea														**	**	***			
Oplismenus spp.									****					****	**	****			*
Group G: sour species																			
Alloteropsis semialata subsp. *ecklonii*																	*	***	*
Cephalanthus natalensis																	*	*	*
Ctenium concinnum																	**	**	*
Erica drakensbergensis																	*	*	*
Eulalia villosa																	*	**	**
Panicum ecklonii																	*	**	*
Protea caffra																	*	**	*
Rendlia altera																	*	***	*
Aristida canescens/transvaalensis	*				*					*							****	*	*
Diheteropogon filifolius					*												**	***	*
Loudetia simplex	**		**		*				*	*							****	****	***
Melinis nerviglume	*									*							***	**	**
Monocymbium ceresiiforme	*		**														*	***	*
Panicum natalense	*		**														***	****	***
Trachypogon spicatus	**		**														**	***	**

TABLE 1.—Synoptic table with constancy values for selected common and diagnostic species in 19 plant communities of the Songimvelo Game Reserve. Community numbers refer to text (communities 8, 9 and 16 are only represented by 1 sample plot each). Symbols refer to the following constancy ranges: * 1–25%, ** 26–50%, *** 51–75%, **** 76–100% (continued)

	'mixed' split in ALOC dendrogram									thicket/forest split							'sour' split		
	mixed			old land		wetland/ river		alien		thicket			forest				sour grassland		
Community number ➡	2	3	4	1	7	5	6	8	9	13	14	15	16	10	11	12	17	18	19
Group H: important but non-diagnostic grass species																			
Heteropogon contortus	****	****	***	***	***	*	*			****	*	*					***	*	**
Themeda triandra	***	***	*	*	****	**	**	****			**	***			*		***	****	****
Eragrostis curvula	*	**		**	***	**	**	****	****	*	***	***			*		**	*	*
Cymbopogon spp.	**	*	***	*	**	**	*				*	*					**	*	****
Group I: important but non-diagnostic woody species																			
Euclea crispa	***	****		**	*	*	***	****	****	**	****	****		***	***		**	*	**
Rhoicissus tridentatus	*	**		*	*		**		****	**	****	***		**	***			*	*
Rhus pentheri	**	****		*			**			**	**	***			**		*	*	*

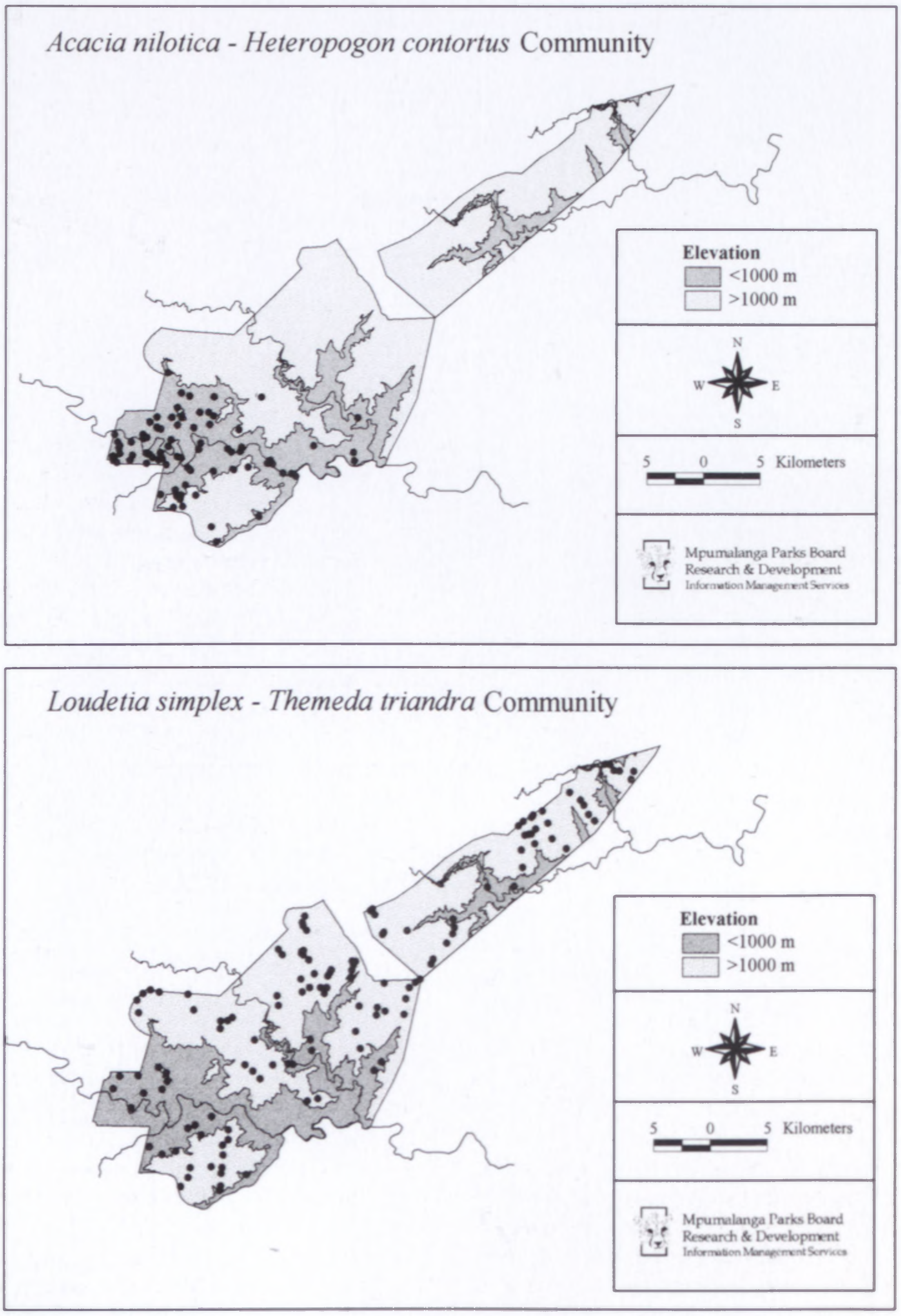

FIGURE 9.—Respective occurrence of the *Acacia nilotica–Heteropogon contortus* and the *Loudetia simplex–Themeda triandra* Community based on sampling localities. Note the former community occurring mostly below 1 000 m and the latter above 1 000 m elevation including some higher hills within the lower Komati Valley.

grass layer is also very distinct compared to any other community encountered. *Andropogon chinensis* is most conspicuous. As with other communities in the Komati Valley, *Heteropogon contortus* is one of the most important components out of a total of 19 grass species recorded. Grazing pressure was very light probably because of the very steep nature of the terrain.

5. *Miscanthus junceus–Andropogon appendiculatus* Short Grassland (classification group 4 & 16, n = 6)

This is an azonal landscape unit of wetlands along small perennial rivers and in seepage areas at low to medium elevation. It is a fairly open unit with generally only a sparse to open shrub component. Only small areas of this unit occur on the SGR. Classification groups 4 and 16 are floristically fairly dissimilar, but a unique combination of grass species still typifies these wetlands. These are *Agrostis lachnantha, Andropogon eucomus, A. appendiculatus, Eragrostis lappula, Ischaemum fasciculatum* and *Miscanthus junceus* (Table 1). Total grass diversity is 24 species.

6. *Combretum erythrophyllum–Cynodon dactylon* Low Woodland (classification group 8, n = 6)

This community occurs as a narrow strip of riverine vegetation on the banks of the Komati River. *Combretum erythrophyllum* is the dominant woody component. Another 35 woody species were recorded. Further downstream, east of the Kromberg, more tropical elements such as *Breonadia salicina* and *Ficus sycomorus* start appearing. The highest annual mean of daily maximum and monthly means of daily minimum temperatures for the Reserve are expected for this specific part of the Reserve based on the results of climatic modeling (Anon. 1986). Alien species of note are *Melia azedarach* and *Sesbania punicea*. Other alien species of lesser importance are *Acacia mearnsii, Cassia floribunda, Lantana camara* and *Psidium guajava*. The grass cover is generally less than 50% with *Cynodon dactylon, Panicum maximum* and *Phragmites* sp. being most prominent. In total, 15 grass species were recorded.

7. *Lippia javanica–Hyparrhenia* spp. Short Shrubland (classification group 13, n = 8)

This community is physiognomically dominated by tall 'thatch' grass species such as *Cymbopogon* spp., *Hyparrhenia* spp. and *Hyperthelia dissoluta* (Table 1). Other common tall grass species are *Bothriochloa* spp., *Eragrostis curvula, Sporobolus africana* and *S. pyramidalis*. Total grass diversity is 25 species. It is essentially the counterpart of the *Cynodon dactylon–Melinis repens* Community on old lands but occurs at elevations above 1 000 m as small patches of old lands or in small saddles in the landscape. The old lands are not much grazed, but the saddle positions are much favoured by cattle for grazing and resting. This is probably because of the gentler topography, sheltered microclimate and increased nutrient cycling established through the more concentrated activities of animals on these particular sites (Blackmore *et al.* 1990). Only eight woody species were recorded of which only *Lippia javanica* is fairly ubiquitous.

8. *Acacia mearnsii–Eragrostis curvula* Short Woodland (classification group 20, n = 1)

This alien-dominated community is found north of the Msoli River along some drainage lines and in areas of previous disturbance such as mining, roadsides and settlement sites. The most conspicuous feature is the dominance of *Acacia mearnsii* (black wattle) coupled with a low diversity of other species. Grass cover is sparse with *Eragrostis curvula* being the most prominent species. Only seven grass species were recorded.

9. *Solanum aculeastrum–Eragrostis curvula* High Shrubland (classification group 10, n = 1)

This community was only observed in a few small patches. It occurs as a closed shrubland of *Solanum aculeastrum* on disturbed sites at elevations above 1 400 m in moist areas in the north and east of the SGR. It is a species-poor community containing certain forest elements such as *Celtis africana, Halleria lucida* and the grass *Oplismenus* sp. under its cover and protection from fire. Only four grass species were recorded on this sample plot.

10. *Dalbergia armata–Keetia gueinzii* Tall Forest (classification group 6, n = 9)

This community is found towards the eastern side of the SGR at relatively low elevations of 800 to 1 200 m along drainage lines. It is particularly prominent along the lower reaches of the Msoli River and through the central valleys of the northeastern panhandle extension of the Reserve. It is a closed dry forest with an important thorny and spiny element (*Acacia ataxacantha* and *D. armata*) (Table 1). A total of 91 different woody species was recorded which is more than in any other community. The grass component of nine species is more diverse than any of the other forest communities, probably because the lower canopy and frequent gaps allow more light to reach the forest floor. The most common species however is *Oplismenus hirtellus* which is a typical forest-floor species (Table 1).

11. *Rapanea melanophloeos–Trimeria grandifolia* Short Forest (classification group 18, n = 7)

This forest community is not necessarily associated with drainage lines in the landscape, unlike Community 10. It occurs mostly in areas with annual rainfall above 1 100 mm on upper slopes in the landscape in the north and northeastern part of the Reserve. The canopy is characterised by a combination *of Cussonia spicata, Rapanea melanophloeos* and *Trimeria grandifolia* (Table 1). Elements from drier communities occur, namely *Acacia ataxacantha, Clausena anisata, Diospyros whyteana* and

Euclea crispa. Total woody species diversity is 64 species. The grass component is mostly limited to *Ehrharta erecta* and *Oplismenus hirtellus*. Forbs have a relatively high cover of 25–50%.

12. *Syzygium gerrardii–Xymalos monospora* Tall Forest (classification group 22, n = 4)

This tall forest occurs in wet areas in the east that receive more than 1 200 mm of annual rainfall. *Syzygium gerrardii* is the typical dominant upper canopy species. Another 63 woody species were recorded. Grasses are limited to typical forest species such as *Oplismenus hirtellus, Panicum deustum, Setaria megaphylla*, and the climbing *Prosphytochloa prehensilis*.

13. *Ptaeroxylon obliquum–Panicum maximum* Short Thicket (classification group 9, n = 6)

This community occurs at low elevation in the Komati and Msoli Valleys where it is found on steep, mostly north-facing slopes overlooking the river. Due to its low elevation, steep slope with shallow soils and northern aspect, this is probably one of the most xeric habitats in the SGR. This includes some extremely broken dolerite ridges. Soils are mostly sandy loam with 15% to 20% clay. The woody component is relatively diverse with 64 species recorded. *Ptaeroxylon obliquum* and *Ruttya ovata* are the most frequently occurring woody species. Common species also found in closed communities at low elevation are *Olea europea* subsp. *africana, Pappea capensis* and *Zanthoxylum capense*. This is the only community in which *Spirostachys africana* was encountered. *Croton gratissimus* was observed on dolerite ridges. *Panicum maximum* was recorded in each of the six sample plots belonging to this community (Table 1). Only 14 other grass species were recorded of which *Heteropogon contortus* is the most prominent. Forb cover is generally below 5%. A succulent component mostly consisting of *Aloe* spp., *Euphorbia ingens* and *E. evansii* (only recorded in this community) was encountered in every plot.

14. *Acacia caffra–Dombeya rotundifolia* Short Thicket Community (classification group 11, n = 5)

This closed community occurs exclusively on the granodiorite-adamellite outcrops in the southern foothills of the Kromberg. Sample plots were located on south to southwest aspects. Soils consisted of loamy sand (10–15% clay). The community is found on steep slopes but also in some old, deeply incised (3–5 m) erosion gullies. *Acacia caffra, Cussonia spicata, Diospyros whyteana* and *Dombeya rotundifolia* have a 100% constancy value (Table 1). Another 50 woody species were identified. Forest species such as *Rhus chirindensis* occur within the shelter offered by the erosion gullies. Only 13 grass species were recorded with limited cover values because of the dense woody canopy. As a consequence, the grass component contains several species with forest affinities, such as *Panicum deustum* and *Setaria megaphylla*.

15. *Diospyros whyteana–Hippobromus pauciflorus* Short Thicket (classification group 21, n = 11)

This closed community is found at the transition of the Komati Valley to the mountains in the north and the Kromberg in the south. There are many similarities with the previous community both in terms of structure and composition. As in the previous community *Acacia caffra, Cussonia spicata, Diospyros whyteana* and *Dombeya rotundifolia* are prominent. *Hippobromus pauciflorus* occurs much more frequently and with higher cover values. However, the greatest difference lies in the occurrence of *Berchemia zeyheri, Grewia occidentalis* and *Olea europea* subsp. *africana*. These important browsing species were not encountered in the previous community. The limited grass cover of only 12 species consists mostly of shade loving grasses. Forb cover is mostly in the 5–25% class.

16. *Buddleja saligna–Aloe arborescens* Short Forest (classification group 12, n = 1)

This short forest is only known from an isolated patch on a steep, rocky, south-facing upper slope of the Kromberg. It is a very distinct community in terms of composition. *Aloe arborescens, Buddleja saligna* and *Chionanthus foveolatus* make up most of the cover. *B. saligna* was only observed in this sample plot. No grasses were observed. The forb cover of 5–25% consisted mostly of Acanthaceae. Fern cover was 1–5% with *Asplenium* sp. and *Elaphoglossum* sp. being observed.

17. *Loudetia simplex–Aristida canescens* Low Grassland (classification group 5, n = 24)

This community is characteristically found on chert ridges often in an exposed summit position or on steep north-facing upper slopes of the Kromberg and the northern mountains. The sample sites were invariably extremely rocky. This combination of factors results in a xeric community despite its generally high elevation. Woody cover is mostly below 25%. A total of 48 woody species was recorded in this sparse to open shrubland. *Xerophyta retinervis* is a conspicuous element. The grass layer is fairly open for this type of sour grassland. Total grass diversity was 46 species. This community is subject to higher grazing pressures than Community 18. Thirty percent of the sample plots had a medium to high grazing pressure as compared to only 3% in the *Loudetia simplex– Themeda triandra* Community. *Aristida canescens, Diheteropogon amplectens, Loudetia simplex* and *Themeda triandra* occur in more than 75% of the plots and achieve cover values of 25% or more. Of interest is the relatively high frequency of *Heteropogon contortus*, whereas this species is generally not prevalent at elevations above 1 200 m. This reflects the relatively sweet nature of this community. Almost 50% of the sample plots had a small succulent component as compared to only 15% in Community 18.

18. *Loudetia simplex–Themeda triandra* Low Grassland (classification group 17,19 & 24, n = 134)

This community is found across all physiographic units including isolated higher hills within the Komati

Valley (Figure 9). It is the dominant community in all the higher parts of the SGR in a variety of landscape positions and aspects. It is a typical sour grassland in which the woody component is absent in 28% of the samples. A total of 55 woody species was recorded. The presence of several species of *Protea* (*P. caffra*, *P. gaguedii*, *P. roupelliae* and the Barberton endemic *P. comptonii*) is characteristic. The grass layer is generally very dense and shorter than 0.5 m. A total of 53 species was recorded of which 10 with frequencies exceeding 60% consistently make up the bulk of the community in terms of cover and phytomass. These include *Loudetia simplex*, *Panicum natalense*, *Themeda triandra*, *Trachypogon spicatus* and *Tristachya leucothrix* (Table 1). A number of 'wire' grasses occur, namely *Diheteropogon filifolius*, *Elionurus muticus*, *Microchloa caffra* and *Rendlia altera*. A large diversity of forbs is present, but their cover does generally not exceed 5%. Geophytes, including *Brunsvigia* sp., *Eucomis* sp., *Ledebouria* spp., *Scilla* sp. and *Watsonia* spp. occur.

19. *Themeda triandra–Cymbopogon* spp. Short Grassland (classification group 7 & 14, n = 66)

This community is also widespread outside of the Komati Valley. Its peak distribution is at lower elevation than the typical sour grassland of Community 18. It is also found less on the sandstones and quartzites of the Figtree and Moodies subgroups. A total of 65% of the sample plots have soils heavier than loamy sand (10–15% clay) compared to 48% in Community 18. It is generally a more mixed community with more woody elements (both in terms of species and cover). A total of 55 woody species was recorded in both communities but the previous community had twice as many sample plots. Only 12% of the sample plots had no woody species present compared with 28% in Community 18. No single woody species characterises this community. A combination of some of the following species is often found: *Acacia caffra*, *Euclea crispa*, *Faurea speciosa*, *Lippia javanica* and *Rhoicissus tridentata*. If the habitat factors and woody species are taken into account, this community represents a broad transition from woodlands in the Komati Valley to the sour grasslands in the higher mountains. The grass layer is taller than in Community 18 at 0.5 to 1 m. It is also more diverse with a total of 60 species having been recorded. The very dense grass layer has as most important species *Themeda triandra* and *Cymbopogon* spp. (mostly *C. excavatus*). Forb cover is between 5% and 25% in half of the sample plots.

Vegetation of the SGR in relation to similar environments

Broad environmental determinants of grass and woody structure and composition have been identified for the SGR including land use history, elevation and geology. These are the same as those identified for similar montane habitats along the eastern Escarpment (Matthews *et al.* 1994).

At the SGR, disturbance, particularly in the form of cropping and settlement, results in a very specific vegetation overriding other factors. This is similar to findings for the Legalameetse Nature Reserve, 220 km to the north of the SGR (Stalmans 1990) and the high-altitude grasslands of northern KwaZulu-Natal, 200 km to the south (Eckhardt *et al.* 1996).

The mixed and sour communities found in the SGR are respectively linked to the alluvial and mafic/ultramafic volcanic substrata on the one hand and the dystrophic felsic lavas, and sedimentary sandstones/quartzites on the other hand. Similarly, the first split in the classification of the vegetation of the Suikerbosrand Nature Reserve, 250 km west of the SGR, could be ascribed to the occurrence of two very different geological substrates, namely one of volcanic origin and one consisting of sedimentary dystrophic quartzite (Bredenkamp & Theron 1976).

Within individual geological substrata, elevation plays an important role in governing water availability (Ferrar & Scheepers 1988) both through increased rainfall and reduced evapotranspiration (Scheepers 1978). In the SGR, this is reflected in the occurrence of sour grasses at high elevation and on cooler and moister southern aspects of sour grasses, whereas mixed and sweet species occur at lower elevation and on warmer, northerly aspects (Figure 9). The same pattern has been observed in the Natal Drakensberg (Walker 1988) and the Bewaarkloof Mountains, 250 km to the northwest of the SGR (Stalmans & De Klerk 1992).

Individual communities could not be exactly matched to each other across different studies as only grass and woody species were used in the SGR survey as compared to the full species cover assessment in most other studies. Scaling issues remain a problem, particularly as the scale of results is often determined by the study objectives. Notwithstanding the differences in approach, certain mixed, sour and forest communities of the SGR are mirrored in other areas.

With regard to mixed communities, the *Cynodon dactylon–Melinis repens* Short Shrubland in the SGR is similar to the *Sporobolus africanus–Eragrostis curvula* Young Secondary Grassland on abandoned fields in the Mlilwane Wildlife Sanctuary, 50 km south of the SGR (Coetzee & Nel 1978). Mlilwane is underlain by granites and the *Combretum molle–Dombeya rotundifolia* Subhumid Mountain Bushveld corresponds to the *Acacia caffra–Dombeya rotundifolia* Short Thicket Community occurring on the granodiorite-adamellite outcrops of the SGR.

With regard to sour communities, the *Loudetia simplex–Themeda triandra* Low Grassland found in the SGR has many affinities to communities such as the *Helichrysum wilmsii–Andropogon schirensis* Low Closed Grassland of the Subhumid Mistbelt and several communities of the Humid Mistbelt grasslands of the Plateau Escarpment as defined by Deall *et al.* (1989) for the Sabie area, 150 km to the north of the SGR. This SGR community also corresponds to the *Loudetio simplicis–Alloteropsidetea semi-alatae* class (as defined by Matthews *et al.* 1994) of the relatively low altitude (below 1 600 m asl) areas of the North-eastern Mountain Sourveld in the Sabie area.

With regard to forest communities, the *Syzygium gerrardii–Xymalos monospora* Tall Forest in the SGR has great affinities with other mesophytic forests along the escarpment (Von Breitenbach 1990). *Cassipourea malosana, Cola greenwayi, Englerophytum natalense, Garcinia gerrardii, Micrococca capensis* and *Ocotea kenyensis* are exclusive to this moist forest. During a survey of Swaziland forests (Masson 1991), these species were only recorded on the Swaziland side of the Mlembe Mountain which straddles the SGR/Swaziland border. The presence of *O. kenyensis* was seen as a strong link to the Transvaal Drakensberg escarpment forests to the north, whilst *G. gerrardii* provides a link with the Indian Ocean coastal belt forests to the south (Masson 1991). Morgenthal & Cilliers (1997) similarly list *C. greenwayi, O. kenyensis* and *G. gerrardii* as species of phytogeographical importance in the 85 ha Pedlar's Bush forest, which is situated less than 3 km northwest of the SGR. They consider this as an area where an unique overlap of species common to the Transvaal and Natal forest has occurred.

Plant community suitability for herbivores

The value to herbivores of the communities described above needs to be evaluated at different scales following the ecological hierarchies identified by Senft *et al.* (1987).

Out of the 428 sample plots, a total of 342 are accessible to the herbivores. Their location is not far enough away from a perennial source of water as to markedly influence herbivore distribution. The grazing impact on these plots was rated from none to light (factor 1), medium (factor 2) and heavy (factor 3). Based on the frequency distribution of the grazing classes, a composite value was determined for each community.

In terms of their ranked grazing values (Table 2), the first six communities are all found on the mixed and forest/thicket side of the primary split in the dendrogram (Figure 6). This supports the premise that this cluster represents the more eutrophic and palatable part of the SGR. These communities occur on a basic geology at lower elevation, mostly in the Komati Valley. Forests within this cluster, however, are not much utilised.

The presence of more palatable species such as *Berchemia zeyheri* in the *Diospyros whyteana–Hippobromus pauciflorus* Community as opposed to the otherwise very similar *Acacia caffra–Dombeya rotundifolia* Community is reflected in their respective rankings. Similarly, the transitional nature of the *Themeda triandra–Cymbopogon* spp. Community which falls between the mixed communities in the Komati Valley and the typical sour grasslands of the *Loudetia simplex–Themeda triandra* Community on the higher mountain slopes, is correctly reflected in its ranking. The low ranking of the *Combretum apiculatum–Xerophyta retinervis* and *Ptaeroxylon obliquum–Panicum maximum* Communities reflects their occurrence on extremely steep slopes or low cliffs which makes access to herbivores extremely difficult.

The ranked utilisation value of the communities thus reflects the theoretical delineation into mixed and sour communities based on palatability values obtained from the literature. This is also an indication that the delineation of individual communities based on their floristic make-up is relevant in terms of their significance to herbivore utilisation. Therefore this delineation becomes useful from a game management perspective.

TABLE 2.—Rank of the plant communities in the SGR based on the frequency distribution of grazing values in the sample plots. Ranking is in descending order from most to least utilised. Forest and alien communities are not listed

Rank	Community name	ALOC group	Community number
1	*Cynodon dactylon–Melinis repens*	1	1
2	*Acacia nilotica–Euclea crispa*	3	3
3	*Miscanthus junceus–Andropogon appendiculatus*	4,16	5
4	*Combretum erythrophyllum–Cynodon dactylon*	8	6
5	*Lippia javanica–Hyparrhenia* spp.	13	7
6	*Acacia nilotica–Heteropogon contortus*	2,23	2
7	*Loudetia simplex–Aristida canescens*	5	17
8	*Diospyros whyteana–Hippobromus pauciflorus*	21	15
9	*Acacia caffra–Dombeya rotundifolia*	11	14
10	*Themeda triandra–Cymbopogon* spp.	7,14	19
11	*Loudetia simplex–Themeda triandra*	17,19,24	18
12	*Combretum apiculatum–Xerophyta retinervis*	15	4
13	*Ptaeroxylon obliquum–Panicum maximum*	9	13

ACKNOWLEDGEMENTS

Staff of Songimvelo Game Reserve and of the R & D division assisted with field sampling. Staff of the Information Management Services within the R & D division (and in particular Anthony Emery) provided assistance with map production. Herbarium specimens were identified by the staff of the C.E. Moss Herbarium at the University of the Witwatersrand. Ed Witkowski provided useful comments.

REFERENCES

ACOCKS, J.P.H. 1975. Veld types of South Africa, edn 3. *Memoirs of the Botanical Survey of South Africa* No. 40.

ANON. 1986. *Master plan and management guidelines for the Songimvelo Natural Resources Area.* Chris Mulder Assoc. Unpublished.

ANON. 1998. *Phase 3 report in respect of a study to examine the socio-economic impact of the Maputo Development Corridor on tourism in Mpumalanga Province.* Grant Thornton Kessel Feinstein. Unpublished report to the Maputo Development Corridor Provincial Technical Committee.

AUSTIN, M.P. & HEYLIGERS, P.C. 1989. Vegetation survey design for conservation: gradsect sampling of forests in north-eastern New South Wales. *Biological Conservation* 50: 13–32.

BARNES, D.L., RETHMAN, N.F.G., BEUKES, B.H. & KOTZE, G.D. 1984. Veld composition in relation to grazing capacity. *Journal of the Grassland Society of southern Africa* 1: 16–19.

BELBIN, L. 1988. *PATN: Pattern Analysis Package Reference Manual.* CSIRO Division of Wildlife and Ecology, Canberra, Australia.

BLACKMORE, A.C., MENTIS, M.T. & SCHOLES, R.J. 1990. The origin and extent of nutrient-enriched patches within a nutrient-poor savanna in South Africa. *Journal of Biogeography* 17: 463–470.

BREDENKAMP, G.J. & THERON, G.K. 1976. Vegetation units for management of the grasslands of the Suikerbosrand Nature Reserve. *South African Journal of Wildlife Research* 6: 113–122.

COETZEE, B.J. & NEL, P.J. 1978. A phytosociological reconnaissance of Mlilwane Wildlife Sanctuary, Swaziland. *Koedoe* 21: 1–36.

DEALL, G.B. & THERON, G.K. 1990. Ordinations as a tool for substantiating and interpreting floristic classifications: a case study. *Bothalia* 20: 223–227.

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.

DELCOURT, H. R. & DELCOURT, P.A. 1988. Quarternary landscape ecology: relevant scales in space and time. *Landscape Ecology* 2: 23–44.

EASTMAN, J.R. 1992. *IDRISI*. Clark University Graduate School of Geography. Worcester, Massachusetts.

ECKHARDT, H.C., VAN ROOYEN, N. & BREDENKAMP, G.J. 1993. Use of Braun-Blanquet data for the assessment of veld condition and grazing capacity in grassland. *African Journal of Range & Forage Science* 10,1: 41–46.

ECKHARDT, H.C., VAN ROOYEN, N. & BREDENKAMP, G.J. 1996. The plant communities and species richness of the *Alepidea longifolia–Monocymbium ceresiiforme* High-altitude Grassland of northern KwaZulu-Natal. *Koedoe* 39,1: 53–68.

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

ELLERY, W.N., SCHOLES, R.J. & SCHOLES, M.C. 1995. The distribution of sweetveld and sourveld in South Africa's grassland biome in relation to environmental factors. *African Journal of Range & Forage Science* 12,1: 38–45.

FABRICIUS, C. & MENTIS, M.T. 1990. Seasonal habitat selection by eland in arid savanna in southern Africa. *South African Journal of Zoology* 25: 238–244.

FABRICIUS, C. & MENTIS, M.T. 1992. Modelling the habitat relations of kudu in arid savanna. *South African Journal of Science* 88: 280–284.

FERRAR, A.A. & SCHEEPERS, J.C. 1988. Vegetation types. In A.A. Ferrar, G. Isaacs & J.R. Stacey, *Environmental conservation features of the Transvaal Escarpment*. Occasional Report 31. CSIR, Pretoria.

FOURIE, S.P., JACOBSEN, N.H.G., KLEYNHANS, C.J. & TARBOTON, W. 1988. Biogeographical importance and species/area warranting particular conservation attention. In A.A. Ferrar, G. Isaacs & J.R. Stacey, *Environmental conservation features of the Transvaal Escarpment*. Occasional Report 31. CSIR, Pretoria.

GABRIEL, H.W. & TALBOT, S.S. 1984. *Glossary of landscape and vegetation ecology for Alaska*. BLM-Alaska Technical Report 10. US Department of the Interior.

GAMBLE, F. 1988. Climate of the Transvaal Escarpment. In A.A. Ferrar, G. Isaacs & J.R. Stacey, *Environmental conservation features of the Transvaal Escarpment*. Occasional Report 31. CSIR, Pretoria.

GEOLOGICAL SURVEY 1986. *Geology map 1:250 000 geological series: 2430 Barberton*. Government Printer, Pretoria.

GILLISON, A.N. & BREWER, K.R.W. 1985. The use of gradient directed transects or gradsects in natural resource surveys. *Journal of Environmental Management* 20: 103–127.

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

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

HILL, M.O. & GAUCH, H.G. 1980. Detrended correspondence analysis: an improved ordination technique. *Vegetatio* 42: 47–58.

JONGMAN, R.H.G., TER BRAAK, C.F.J. & VAN TONGEREN, O.F.R. 1987. *Data analysis in community and landscape ecology*. Pudoc, Wageningen.

LAND TYPE SURVEY STAFF 1989. Land types of the map 2530 Barberton. *Memoirs of the Agricultural Natural Resources of South Africa* 13.

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

LOWE, D.R. & BYERLY, G.R. (eds). 1999. Geologic evolution of the Barberton Greenstone Belt, South Africa. *Geological Society of America Special Paper* 329.

MASSON, P.H. 1991. *The conservation status of highveld forests in Swaziland*. Flora Conservation Committee Report No. 91/3. Botanical Society of South Africa.

MATTHEWS, W.S., BREDENKAMP, G.J. & VAN ROOYEN, N. 1994. The phytosociology and syntaxonomy of relatively low-altitude areas in the North-eastern Mountain Sourveld, in the eastern Transvaal Escarpment region. *Koedoe* 37,2: 73–87.

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

MORGENTHAL, T.L. & CILLIERS, S.S. 1997. *The ecology and conservation of Pedlar's Bush*. Potchefstroom University. Unpublished.

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

NATIONAL WORKING GROUP FOR VEGETATION ECOLOGY 1986. *Soil classification according to the binomial classification system*. Technical Communication 3.

PARTRIDGE, T.C. & MAUD, R.R. 1987. Geomorphic evolution of southern Africa since the Mesozoic. *South African Journal of Geology* 90: 179–208.

RUTHERFORD, M.C. & WESTFALL, R.H. 1986. Biomes of southern Africa—an objective categorisation. *Memoirs of the Botanical Survey of South Africa* No. 54.

SENFT, R.L., COUGHENOUR, M.B., BAILEY, D.W., RITTENHOUSE, L.R., SALA, O.E. & SWIFT, D.M. 1987. Large herbivore foraging and ecological hierarchies. *BioScience* 37: 789–799.

SCHEEPERS, J.C. 1978. Vegetation of the Westfalia Estate on the Northeastern Transvaal Escarpment. *Memoirs of the Botanical Survey of South Africa* No. 42.

STALMANS, M. 1990. *Vegetation survey for the scientific management of the Lekgalameetse Nature Reserve*. M.Sc. (Botany), University of the Witwatersrand.

STALMANS, M. & DE KLERK, G. 1992. Protea landscapes in the Bewaarkloof Mountains, Transvaal. *Protea Atlas Newsletter* 14: 8, 9.

TER BRAAK, C.J.F. 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. *Ecology* 67: 1167–1179.

TER BRAAK, C.J.F. 1992. *CANOCO—a FORTRAN program for canonical community ordination*. Microcomputor Power, Ithaca, New York, USA.

TER BRAAK, C.J.F. & PRENTICE, I.C. 1988. A theory of gradient analysis. *Advances in Ecological Research* 18: 271–317.

VAN DER MERWE, P.D.R. & RETIEF, E.F. 1995. *The Songimvelo Game Reserve inhabitants: individual data and background information*. Department of Constitutional Development. Unpublished.

VAN OUDTSHOORN, F.P. 1991. *Guide to grasses of South Africa*. Briza Publications, Pretoria.

VILJOEN, R.P. & VILJOEN, M.J. 1971. The geological and geochemical evolution of the Onverwacht volcanic group of the Barberton Mountain land, South Africa. *Geological Society of Australia Special Publication* 3: 133–149.

VON BREITENBACH, F. 1990. *Reports on indigenous forests*. Part 1. Department of Environment Affairs, Forestry Branch, Pretoria.

WALKER, R.S. 1988. A gradient analysis of grassed mountain catchments in the Natal Drakensberg. *Journal of the Grassland Society of southern Africa* 5: 179–185.

WITT, J. 1983. *Preliminary report on prehistoric and historic artefacts in nature reserves in the Barberton district*. Unpublished.

APPENDIX.—Synoptic table with constancy values (%) for all species in 19 plant communities of the Songimvelo Game Reserve. Community numbers refer to text (communities 8, 9 and 16 are only represented by 1 sample plot each)

	Community number																		
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Acacia																			
ataxacantha		4	11			33				67	71		17	20	55	100			
burkei		2																	
caffra	11	49	21										50	100	82		8	10	23
davyii			5		17														14
karroo	17	13	11		17	33									9			1	6
mearnsii						17		100		22									
nilotica	74	68	100	67									33		9			3	9
robusta		4													9				
sieberiana			5																
Acalypha glabrata													17	20					
Agrostis lachnanta					50														
Allophylus																			
melanocarpus															9				
sp.										33	43			20	45				
Alloteropsis semialata																			
subsp. *semialata*																			2
subsp. *ecklonii*																	8	53	14
Aloe																			
arborescens												25		20	18	100			2
marlothii	6	52	32	33									50	40	9		33	6	15
sp.													17						
Andropogon																			
appendiculatus					33														
chinensis/fastigiatus		2	5	67															
eucomus					33														
schirensis		18											33				29	60	38
Annona senegalensis	3	2					13												2
Anthocleista grandiflora										11									
Anthospermum sp.																		1	
Antidesma venosum																			2
Aphloia theiformis										11		75							
Apodytes dimidiata										33	29	25			9				
Aristida																			
bipartita		2																1	2
canescens/transvaalensis		7					13						17				100	16	11
congesta	77	73	79	100									33				13	4	6
diffusa		28	5	67													13	3	8
junciformis	6	4															4		2
Barleria rotundifolia			5										17						
Bauhinia galpinii		6	16			17				11			17		18			1	2
Berchemia zeyheri		9	32										17		36			1	
Bersama sp.										11	14								
Bewsia biflora		50		33													42	20	33
Boscia sp.			5										17						
Bothriochloa spp.	77	13	47		17		63												2
Bowkeria cymosa										33									2
Brachiaria																			
brizantha	3	10											17					1	2
deflexa													17						
eruciformis	3																		
serrata		39		33			13										29	25	20
Brachylaena discolor										11	29	25			9				3
Breonadia salicina						17				11									
Bridelia micrantha										33									
Bromus hordeaceus																			2
Buddleja																			
salicina																100			
salviifolia					17					22									5
auriculata										11	29								
Burchellia bubalina										44	29	25						1	
Caesalpinia decapetala										11									
Calpurnia aurea																			2
Canthium																			
ciliatum										11		25							
inerme			5							11	14	50		20	9		4		2
Carissa bispinosa											43	75			18	100			
Casearia gladiiformis										11									
Cassia floribunda						17													
Cassine papillosa											14								
Cassinopsis																			
ilicifolia										33	71				9				
tinifolia										33									

APPENDIX.—Synoptic table with constancy values (%) for all species in 19 plant communities of the Songimvelo Game Reserve. Community numbers refer to text (communities 8, 9 and 16 are only represented by 1 sample plot each) (continued)

Species	Community number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Cassipourea malosana												25							
Catha edulis						17								20	27				3
Celtis africana									100	22	43			20	9				
Cephalanthus natalensis																	4	1	14
Chaetacme aristata		1																	
Chionanthus foveolatus		1														100	4		
Chloris virgata	6																		
Choristylis rhamnoides										11	14								
Clausena anisata			5							11	57	50	17	20	27				
Clerodendrum																			
glabrum	3	1											17	20	18				
suffruticosum															9				
Cliffortia sp.					17														
Clutia pulchella												25							
Coddia sp.		6	21	33		50								20	45				3
Cola greenwayii												25							
Combretum																			
apiculatum		44	21	67									67				4	2	5
erythrophyllum						100													
hereroense		20	5	33									17					4	2
kraussii								100		44	29	50			9				
molle		11	11										33	60	45		8	2	
zeyheri		18	5	33													13	4	3
Commiphora marlothii		1	5							11			33		36		4		
Croton gratissimus													17						
Cryptocarya																			
liebertiana												25							
woodii												25							
Ctenium concinnum																	38	34	3
Curtisia dentata										11	43	100							
Cussonia																			
natalensis		4											17		9		17	1	
paniculata		4																1	2
spicata	3	1	5			17				56	86	75		100	64	100			6
Cyathea dregei					17					22		25							
Cymbopogon spp.	9	35	21	67	33	17	38							20	9		46	24	80
Cynodon dactylon	94	10	58		33	100	25	100	100										2
Dais cotinifolia					17					22									
Dalbergia armata		2								78	14	25		40	55				2
Dichrostachys cinerea	20	12	37										17				4	1	5
Digitaria																			
diagonalis		1					13										8	7	21
flaccida																		7	
longiflora	11	4				17													
ternata						17													
Diheteropogon																			
amplectens		22		67			25										75	60	50
filifolius							13										42	73	21
Diospyros																			
lycioides	14	7	16		17	83	13			11					18		8	1	5
whyteana	3	5	26							67	57		17	100	91		21	1	6
Dombeya																			
burgessiae										56									8
rotundifolia	3	41	47	67		50							50	100	82		13	2	20
Dovyalis lucida/Scolopia mundtii												25							
Dracaena hookerana										11	14								
Ehretia spp.			11										17	20					
Ehrharta erecta var. *erecta*						17				22	57			20	18				
Ekebergia capensis										22	29	50			9				
Eleusine indica					17														2
Elionurus muticus/Digitaria monodactyla	3	28	5				13										8	32	11
Encephalartos heenanii																		1	
Englerodaphne pilosa												25							
Englerophytum																			
magalismontanum		1								67	14	75	33	20	9		17	4	2
natalense												25							
Enneapogon scoparius		2		33									17						
Eragrostis																			
aspera		1																	
capensis		11			17		13										21	21	9
chloromelas	31	55	47												9		4	2	
cilianensis	3		5																
curvula	31	21	42		50	50	63	100	100		14		17	60	55		38	7	20

APPENDIX.—Synoptic table with constancy values (%) for all species in 19 plant communities of the Songimvelo Game Reserve. Community numbers refer to text (communities 8, 9 and 16 are only represented by 1 sample plot each) (continued)

	Community number																		
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Eragrostis (cont.)																			
gummiflua	3	2																	
inamoena	6	1																	
lappula					33														
plana											14								
racemosa	6	32	5				13										25	52	17
rigidior	3		5																
sclerantha subsp. *sclerantha*																	4	2	2
superba	26	23	11			17												1	
Erica drakensbergensis																	4	13	6
Erythrina lysistemon			5												18				
Erythroxylum																			
delagoense	3	2	5							11			17		9				
emarginatum													17						
Euclea																			
crispa	31	67	79		17	67	25	100	100	67	57		33	80	82		29	8	32
natalensis			11							33	43				18				
Eulalia villosa																	8	37	36
Euphorbia																			
evansii													17						
ingens	3	5	5							11			50	80	45				
Eustachys paspaloides		16	5															1	
Faurea																			
galpinii											14								
saligna		1																2	5
speciosa		5												20			25	15	23
Festuca spp.																		19	12
Ficus																			
craterostoma												25							
glumosa		2											33		9				
ingens													50	60	9				2
natalensis														20					
salicifolia													17						
sur					17	33				44				40	27				6
Garcinia gerrardii												25							
Gerrardina foliosa																		2	
Grewia																			
monticola		6											33		9				
occidentalis	3	5	26			17		100		33	43		33		73				2
Greyia sp.											29			20	9	100		1	3
Gymnosporia																			
buxifolia	3	38	37			33	13						67		9			1	9
cf. *senegalensis*				33						11	29				9				
mossambicensis									100		43	25			9				
Halleria lucida						17			100	44	43	50		20					2
Harpephyllum caffrum										11	14								
Harpochloa falx																		5	3
Heteromorpha trifoliata											43			20	18				2
Heteropogon contortus	71	99	95	67	17	17	75						83	20	9		54	22	32
Heteropyxis																			
canescens										44							4	1	
natalensis	3	7	5											40	36		8		8
Hippobromus pauciflorus	3	7	37			17				22	14		33	60	82				
Hyparrhenia																			
spp. (*filipendula*/*tamba*)	11	1	5			33	75	100											8
spp. (cf. *hirta*)	37	43	16		17		63	100						20			25	8	21
Hyperacanthus amoenus		2													9				
Hyperthelia dissoluta	46	62	42	33			13						33	20			17	6	6
Iboza sp.		6	21										67	20	45				
Ilex mitis										11		25							
Imperata cylindrica	3				33														
Indigofera swaziensis																			3
Ischaemum fasciculatum					33					11									
Jasminum sp.		1																	
Justicia campylostemon												25							
Keetia gueinzii										78		50							
Koeleria capensis																		19	5
Kotzschia parvifolia																		2	3
Lannea discolor		16	11	33									33		18			1	2
Lantana camara	3	1				17								20			4		
Leucosidea sericea																			2
Lippia javanica	17	7	26			17	88	100						40			17		21
Lopholaena sp.																	4		2

APPENDIX.—Synoptic table with constancy values (%) for all species in 19 plant communities of the Songimvelo Game Reserve. Community numbers refer to text (communities 8, 9 and 16 are only represented by 1 sample plot each) (continued)

	Community number																		
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Loudetia simplex		34		33			13						17				92	96	53
Mackaya bella												25							
Maerua																			
angolensis		1																	
racemulosa												25							
rosmarinoides													17						
Maesa lanceolata					17				100	44		50						1	6
Maytenus																			
acuminata											14	50			9				
peduncularis										33	29				9				
undata		5				17				11	29		33	80	64		4		
Melia azedarach						33													
Melinis																			
nerviglume		20											17				67	29	44
repens	86	61	37	33			88						33	20	18		13	4	8
Michrochloa caffra	3	9															21	14	12
Micrococca capensis												25							
Mimusops zeyheri			5																
Miscanthus junceus					50														
Monanthotaxis caffra										22		25			9				
Monocymbium ceresiiforme		1		33													8	62	14
Mundulea sericea		2	5	33															
Myrica pilulifera																		1	2
Myrothamnus flabellifolia																	4		
Myrsine africana			5								14				9				
Nuxia congesta											14								
Obetia tenax										22			33	20	9				
Ochna																			
cf. *natalitia*													17				21		
forest											29	75			9				
Ocotea kenyensis												25							
Olea																			
capensis subsp. *enervis*													17				4		
europaea		2	32			33							50		73				
Oplismenus spp.									100	78	29	100							2
Otholobium sp.																		1	2
Oxyanthus speciosus												100							
Ozoroa sphaerocarpa		27	11	33													4	6	8
Pachystigma macrocalyx										11				20			13		2
Panicum																			
deustum												25		20	36				
ecklonii																	4	50	20
maximum	11	7	32			83		100			14		100	40	36			1	3
natalense		4		33													71	79	53
Pappea capensis	3	6	32			17				11			67	40	55		4		
Parinari curatellifolia																		5	
Paspalum																			
scrobiculatum	6	1			17		25										4	4	9
urvillei					17														
Passerina filiformis					33					11									
Pavetta																			
edentula	3	27		33									17		9		21	4	3
galpinii												25							
gardeniifolia										22			17		18				
Peddia africana										11		50							
Peltophorum africanum	14	20	26			17							50		27		4	1	3
Pennisetum																			
clandestinum							13												
macrourum					17														2
Pentaschistis chippindalliae																		2	
Perotis patens	9	6															4		
Phragmites spp.	9				33	83				22									
Phyllanthus reticulatus			5								14								
Phymaspermum bolusii																			3
Pittosporum viridiflorum										33	43	50		20					
Plectranthus sp.											29	75		20	18	100			
Podocarpus latifolius												75							
Pogonarthria squarrosa	23	12	5														8		2
Prosphytochloa prehensilis												25						1	
Protea																			
caffra																	8	36	18
comptonii																	4	3	
gaguedii																		1	3

APPENDIX.—Synoptic table with constancy values (%) for all species in 19 plant communities of the Songimvelo Game Reserve. Community numbers refer to text (communities 8, 9 and 16 are only represented by 1 sample plot each) (continued)

	Community number																		
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Protea (cont.)																			
roupelliae																	4	13	
Protorhus longifolia										33	14	50			9				
Prunus africana										11									
Psidium guajava						17													
Psychotria capensis												50		20			21	8	8
Psydrax sp.												25				100	4		
Ptaeroxylon obliquum			5										83		9				
Pterocarpus angolensis		4	11														8	1	3
Pterocelastrus echinatus										11	29			20			17	3	5
Rapanea melanophloes										33	86	75		20			4	2	5
Rauvolfia caffra										44									
Rawsonia lucida										22									
Rendlia altera																	25	69	12
Rhamnus prinoides			5							22	57								
Rhoicissus																			
revoilii											29					100			
rhomboidea										33	29	75							
tomentosa										56					9				
tridentatus	6	20	42			50	25		100	33	57		33	80	64			1	23
Rhus																			
chirindensis	3	1								11	43	75		80	36	100			2
lancea						17													
lucida						17				44	71								
pentheri	20	33	79			17					29		33	40	73		8	1	6
pyroides					17					11	29				9				8
rehmanniana		9	11				25							40			21	2	12
rogersii																			2
sp.		4	5																2
transvaalensis																			2
tumilicola			5				25										4	12	14
Rinorea angustifolia												25							
Rothmannia globosa												25							
Rubus sp.									100	33	14								3
Ruttya ovata		4	5							11			83		18				
Salix mucronata						33													
Sarcostemma viminale		1											17	20	9				
Sartidia sp.																	8	2	5
Schefflera umbellifera										22		100							
Schizachyrium sanguineum		23		33									17				50	29	29
Schrebera alata		1	5							11			33		9		8	1	2
Sclerocarya birrea	20	26	47										17		18		4		
Sclerochiton harveyanus												25							
Scolopia zeyheri		5	16			17					29				27	100			
Securinega virosa	3		5			17							17						
Senecio sp.		1											17						
Sesbania sesban	6					50													
Setaria																			
cf. *megaphylla*		11	11	33						11			33	80	18				3
megaphylla	3					17				56		25			9				2
sphacelata	3	43	5		17		25								18		29	17	45
Solanum																			
rigescens																			2
aculeastrum									100										
sp.	3																		
Sorghum sp.	3																		
Species *Stalmans 2887* (cf. *Panicum* sp.)		12	5	67															3
Spirostachys africana													33						
Sporobolus																			
africanus	17	2	5		17	17	38		100					20			4	1	3
centrifugus		11															4	8	2
pectinatus		4															17	18	3
pyramidalis/fimbriatus	29	1			17	17	13	100											2
stapfianus	3	20	32											20			4		
Steganotaenia araliaceae													50		9				
Strelitzia caudata												25							
Strychnos																			
madagascariensis		9											17						
spinosa		5		33															
Suregada africana										11									
Syzygium																			
cordatum					17					56				20	9		8	4	3
gerrardii										11	14	100			9				

APPENDIX.—Synoptic table with constancy values (%) for all species in 19 plant communities of the Songimvelo Game Reserve. Community numbers refer to text (communities 8, 9 and 16 are only represented by 1 sample plot each) (continued)

	Community number																		
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Tarchonanthus																			
camphoratus													17						
trilobus														20	9			1	2
Tarenna barbertonensis												25			9				
Themeda triandra	9	71	58	67	33	33	88	100			14			40	55		75	89	97
Trachypogon spicatus		32		33													50	73	48
Tragus berteronianus	20	5	11																
Trema orientalis										22									
Tricalysia sp.										11	57	100			9				
Trichilia dregeana					17					11	14							1	
Trichocladus grandiflorus		30								11							4		2
Tricholaena monachme	3																		
Trichoneura grandiglumis		30								11							4		2
Trichopteryx dregeana					17					11	14							1	
Trimeria grandifolia										22	86	25			9				
Tristachya leucothrix	3	13					25										8	63	35
Urochloa mossambicensis	23		5																
Uryletrum agropyroides																	4	2	
Vangueria infausta		6	21					100		11	14		17	40	9		8		3
Vepris																			
reflexa/Oricia sp.												50							
undulata														20					
Vernonia																			
neocorymbosa																			2
stipulacea										33	29								2
Vitex sp.		1											17		9				
Xerophyta sp.		11	5	67													58	7	6
Ximenia caffra		6											17		9				
Xymalos monospora										11	43	100							
Zanthoxylum																			
capense		5				17				22	43	25	50	20	64				
davyii												50							
Ziziphus mucronata	17	9	11		17	50		100		11	14			40	27				6