The plant communities of the Roodeplaat Experimental Farm, Gauteng, South Africa and the importance of classification verification

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A classification and a map of the Sourish Mixed Bushveld on the ARC-Roodeplaat Experimental Farm is presented. Plant communities need to be verified and this was done in this study by means of a classification efficiency value, examination of the spatial integrity of relevé-groups, floristic and habitat correlation, the validity of the community composition analysis and ground-truthing. Five woodland communities, differentiated floristically, are identified and quantitative results for each community include a short description, community statistics, species and growth form relations and community cover. Three of the five woodland communities occur on flats and the other two occur on crests and slopes. All five plant communities have *Acacia* trees as the dominant species and four of the five have grasses as diagnostic species. The vegetation on the farm is in a degraded condition and *Aloe greatheadii* var. *davyana* occurs in all the communities as a strong competitor. Management proposals include conservative stocking rates and the removal of sheep.

Keywords: Classification, phytosociology, plant communities, vegetation, verification, Sourish Mixed Bushveld.

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Introduction

Vegetation science includes both structural and spatial changes in the floristic composition of natural vegetation (Mueller-Dombois & Ellenberg 1974). User demand has necessitated a change in method from the qualitative vegetation descriptions of the past to a quantitative verifiable product.

The African Wildlife Management Unit at the Range and Forage Institute decided to introduce game to the section of the Roodeplaat Experimental Farm (REF) north of the Pienaars River. Therefore, a complete inventory, classification and community analysis of the vegetation became a necessity because the natural vegetation of the REF has never been surveyed (R. Drewes, pers. comm. Transvaal Region, Private Bag X180, Pretoria 0001).

The permutations possible with a relevé sequence are a factorial of the number of relevés. Many of these permutations will show some sort of community pattern (Westfall 1992). It is therefore, essential when classifying vegetation to verify the proposed plant communities.

The aims of this study are, therefore, to identify and map relatively homogeneous areas suitable for natural resource management, analyse the vegetation resource within these units in order to determine the quality and quantity of the vegetation resource and to show the necessity for community verification.

Study Area

The study area comprises the natural vegetation (2 067 ha) of the REF which is situated in the Gauteng Province, South Africa, approximately 30 km north-east of Pretoria, between southern latitudes 25°20' and 25°40' and eastern longitudes 28°17' and 28°25'. The main physiographic features of the study area are the Buffelsdrif Ridge in the south, the Pienaars River bisecting and draining the farm in a north-westerly direction and a plateau in the north.

The study area is situated on the Roodeplaat Igneous Complex which belongs to the Post-Waterberg Formation. The Roodeplaat Igneous Complex is a unique ring-shaped structure with a diameter of approximately 16 km and is also referred to as the 'Roodeplaat volcano' (Verwoerd 1966, 1967 cited by Jansen 1977). No detailed soil survey exists for the study area.

Schulze (1965) categorizes the area in which the study area is situated as the Northern Transvaal climatic region which receives an annual precipitation of between 380 and 700 mm. The average annual rainfall for Roodeplaat is 646 mm (AGROMET 1994). The average daily maximum and minimum temperatures for this climatic region are 32°C and 18°C in January and 22°C and 4°C in July. (Roodeplaat = 29°C and 20°C, and 16°C and 2°C respectively (AGROMET 1994)).

The vegetation in the study area is described as Savanna (Rutherford & Westfall 1986), Clay Thorn Bushveld (Low & Rebelo 1996) and as Sourish Mixed Bushveld (Veld Type 19) (Acocks 1988). Van Rooyen (1983) mapped the vegetation of the Roodeplaat Dam Nature Reserve (RNR) which is adjacent to the south-eastern boundary of the REF at a scale of 1:33 000. He classified the nature reserve into six communities, two of which he sub-divided into another seven variations. Three of these vegetation units adjoin the REF, namely: the *Acacia karroo* closed woodland; the *Setaria perennis–Polygala hottentotta* grassland; and the *Acacia caffra–Setaria perennis* closed woodland (Van Rooyen 1983). Although not one of the primary aims of this study, a floristic affinity analysis was conducted on the REF and RNR data sets.

Work done in Sourish Mixed Bushveld (Acocks 1988), at less detailed scales, but not near REF, includes classifications of the vegetation of the western Transvaal (mapped at 1:250 000) (Van der Meulen 1979), the Loskop Dam Nature Reserve (mapped at 1:36 000) (Theron 1973) and at a more detailed scale, the Soutpan Experimental Farm (Grunow 1965).

Methods

Analysis

The study area was stratified using an aerial photographic mosaic at a scale of 1:8 000. Ten stratified units were identified for testing against the classification and for sampling unit distribution. Sampling unit location was based on equal area representation in which each sampling unit represents an approximately equal area of each stratified unit thus eliminating observer bias in sampling unit

location. A minimum of four sampling units were allocated to each stratified unit and 75 sampling units of 200 m^2 were positioned in this way (Figure 1).

The following floristic parameters were recorded: all plant taxa identifiable at the time of sampling, rooted in the stand; a growth form was assigned to each species recorded following Westfall *et al.* (1996); the mean canopy diameter for each species was recorded; and the projected canopy for each species recorded was sampled using the plant-number scale of Westfall and Panagos (1988).

Taxonomic nomenclature is according to the National Herbarium, Pretoria as described in Arnold and De Wet (1993).

Syntaxonomic nomenclature is according to the International Code of Syntaxonomical Nomenclature (Barkman *et al.* 1976, 1986) with the following provisions for local use: the suffix denoting rank is replaced with a structural epithet following Edwards (1983).

Environmental parameters recorded were the following: altitude - (m) along with the locality in degrees, minutes and seconds using a Global Positioning System (GPS) receiver; slope - measured in degrees using an inclinometer; aspect - measured in degrees using a compass; soil depth - measuring the depth of an augered hole (in the centre of the stand) with a tape measure to the nearest centimetre and soil form - determined by the diagnostic horizon combinations (removed from the augered hole) according to MacVicar *et al.* (1977).

Synthesis and verification

The floristic data set was analysed using the PHYTOTAB-PC program package (Westfall 1992; Westfall *et al.* 1996) which classifies relevés according to minimum entropy and species according to minimum noise. The uncoordinated occurrence of species in a matrix is termed noise (Gauch 1982).

The process of testing the validity of a classification can be termed the verification and the following verification methods were employed for this study (Westfall *et al.* 1996): classification

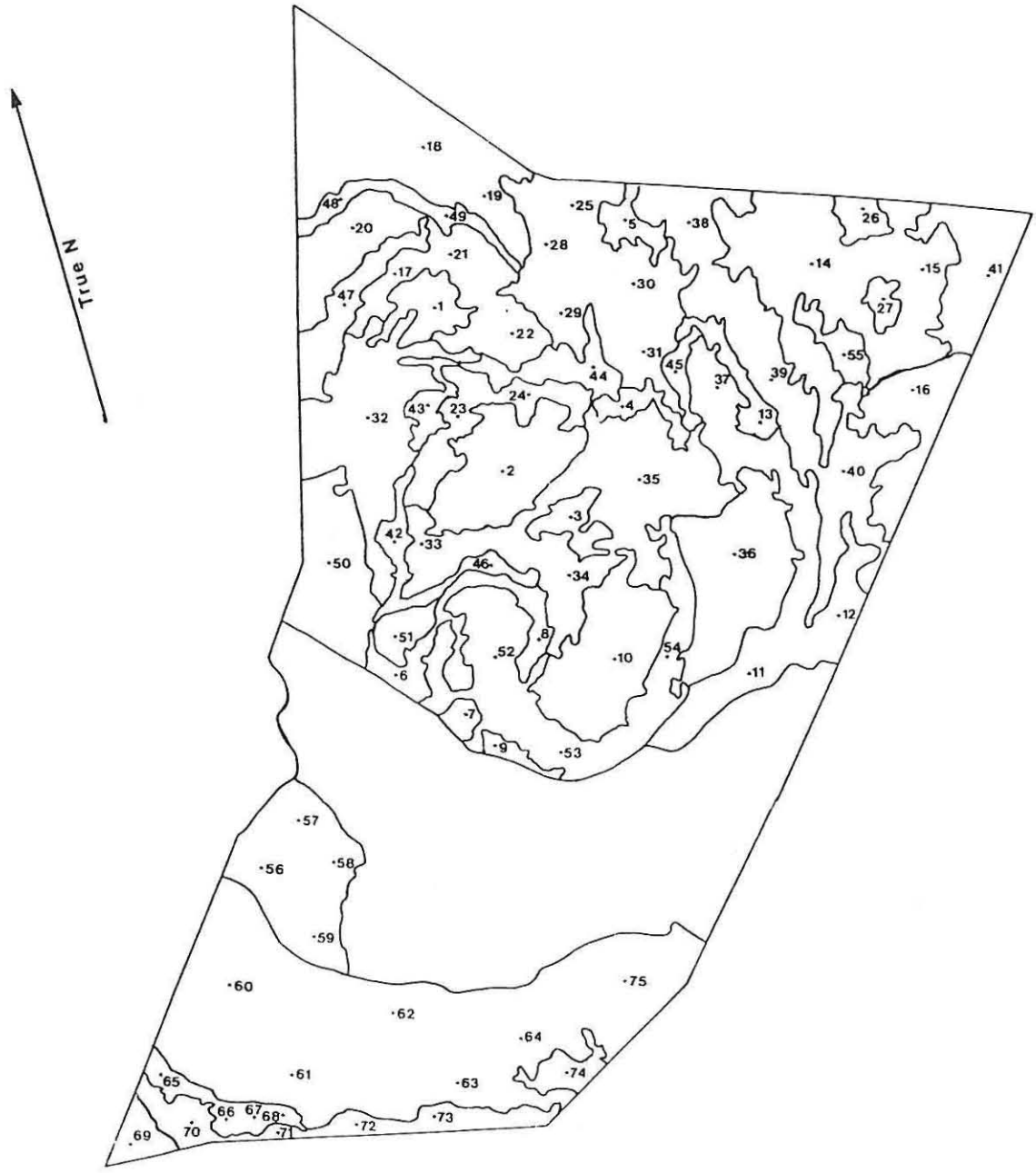


Figure 1 The stratified units of the Roodeplaat Experimental Farm study area numbered according to the initial air photo-based stratification.

efficiency; examination of the spatial integrity of the relevé-groups; floristic and habitat correlation; validity of the community composition analysis and ground truthing.

Classification efficiency

The classification efficiency of a classified matrix is the ratio of included gaps to all gaps in the classified matrix, expressed as a percentage (Westfall 1992; Westfall *et al.* 1996). A classification having an efficiency of 62% or higher is deemed robust since the removal of a number of species will not alter the relevé sequence significantly. With efficiencies of between 62% and 40%, a classification becomes increasingly less robust and a classification having an efficiency of less than 40% is the equivalent of a random relevé sequence.

Spatial integrity of relevé-groups

Spatial integrity is the degree to which relevés, grouped by a classification technique, form integral mapping units. The following methods were used to test for spatial integrity: a grouped number comparison method comparing the classified relevé sequence with relevés grouped according to the stratification and an overlay technique in which relevés grouped by the classification are superimposed on the stratification.

Habitat and floristic correlation

Two methods of correlation of the relevé-groups with the habitat were used in this study, namely: a hierarchical dendrogram in which the different habitat factors are associated with the classified plant communities and habitat gradients associated with an ordination of the synoptic relevés representative of each community using the CANOCO version of detrended correspondence analysis (ter Braak 1987).

Community composition analysis (CCA)

The CCA is a method of determining strong and weak competitor species for each growth form within a community according to canopy cover-to-frequency ratios. Because this method is dependent on an adequate classification, the strong competitors thus identified should correspond with field observations and quantitative cover and frequency data.

Ground-truthing

The following assessments were made visually in the field using the final classification and the vegetation map to test the degree to which: the relevés in each community are representative of the community; the diagnostic species for each community can be used for community identification; plant species selected for community names are characteristic of the community; the community habitat correlations are relevant and the mapped community boundaries correspond to what is observed in the field.

Floristic affinities

Background

Plant communities generally form integral mapping units as can be concluded from many published vegetation maps. The probability of finding a plant community which is completely included in a particular area that is identical in terms of species composition to another completely included plant community in another study area is low. Plant communities which are partially included in a study area cannot be compared with other plant communities partially included in other study areas because their floristic variation is unknown. Therefore, valid comparisons can only be made with completely included plant communities.

The degree of affinity between two plant communities is dependent on the number of plants common to both communities. However, the sampling unit sizes used in the field should be comparable. For example, in comparing a sampling unit in which 60 species were recorded with a sampling unit in which 300 species were recorded, the disparity in sampling unit size could lead to the assumption that little affinity exists. This however, may not be true because the smaller sampling unit could be a subset of the larger unit. Furthermore, it could be expected that most of the communities within a Veld Type would show some degree of floristic affinity with the species representing the Veld Type. It could also be expected that a generally lower degree of affinity exists between the communities of one Veld Type and those of an adjacent Veld Type than the communities within the Veld Type concerned. In such comparisons, other factors such as the diagnostic character, cover dominance and frequency of occurrence could be very relevant.

It appears however, that an arbitrary cut-off level of species in common is often used to indicate affinity. Van Rooyen (1983) lists 18 species in three plant communities out of a total of 394 species for the RNR, and deemed these species to show affinity with various other Sourish Mixed Bushveld, Sour Bushveld and Bankenveld studies. Of these 18 species only *Burkea africana, Dichapetalum cymosum, Fadogia monticola, Faurea saligna, Ochna pulchra, Setaria perennis* and *Strychnos pungens* were not recorded at REF. These species are indicative of the deeper sandy soils found on the RNR.

Affinity analysis for this study

Analysis of the data in this study is strictly quantitative. Consistancy, therefore, necessitates the treatment of floristic affinities in the same manner. Two approaches to making floristic comparisons were made, namely: comparing communities with communities and comparing each community with the entire data set. For this purpose the RNR (Van Rooyen 1983), Acocks' (1988) Sourish Mixed Bushveld (Veld Type 19) and Acocks' (1988) Sour Bushveld (Veld Type 20) were used by combining each of these data sets with the data for this study. The comparison of each community with another community is according to: the absolute common species; the proportion of common species to all species in each community and the proportion of common species to all species in both communities. The last mentioned comparison was also ranked according to the means for all communities. The comparison of each community with the combined data sets was according to commonality (Westfall 1992) where the total occurrence in the matrix of each species is determined for each community. Similarly, the total occurrence of all species occurring in the same communities as the species under consideration, is determined for each species. These comparisons can then be shown as a proportion of the total presences of the data set and ranked accordingly for convenience. These procedures were programmed and included in the PHYTOTAB-PC program package.

Results

Classification

A total of 350 plant specific and infra-specific taxa were recorded in five plant communities identified in the final phytosociological classification (Table 1). Species-groups are arranged to highlight the environmental gradients. The classification contains 15 species-groups, 178 diagnostic species (or a diagnostic proportion of *c.* 50%) and 172 non-diagnostic species. The spatial relations of the communities are presented in the form of a vegetation map (Figure 2).

Description of plant communities

1. The *Acacia tortilis* subsp. *heteracantha–Brachiaria nigropedata* - low open woodland (1)

The largest part of this community occurs in the central and

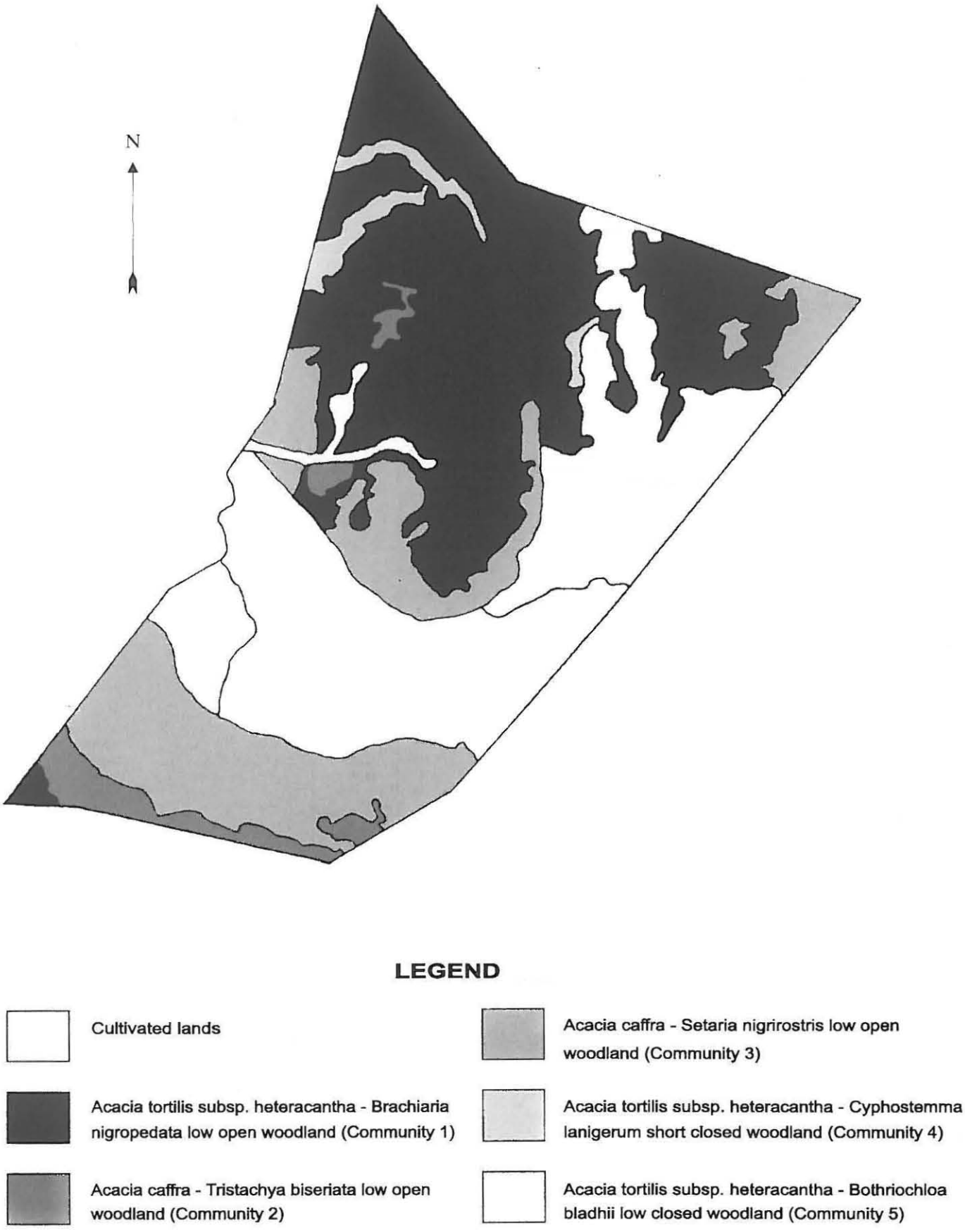
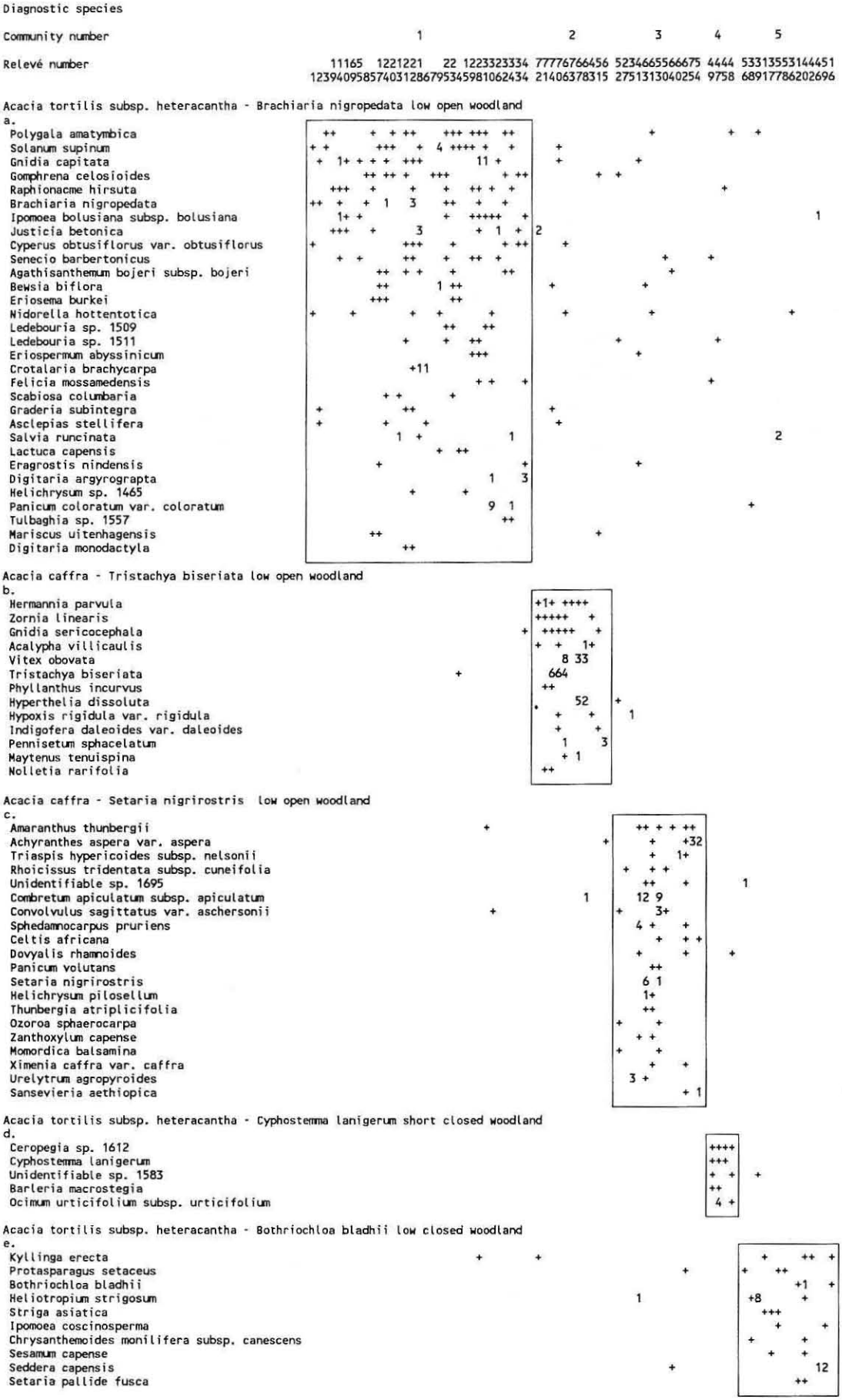


Figure 2 The plant communities of the Roodeplaat Experimental Farm study area.

Table 1 The phytosociological classification of the natural vegetation on Roodeplaat



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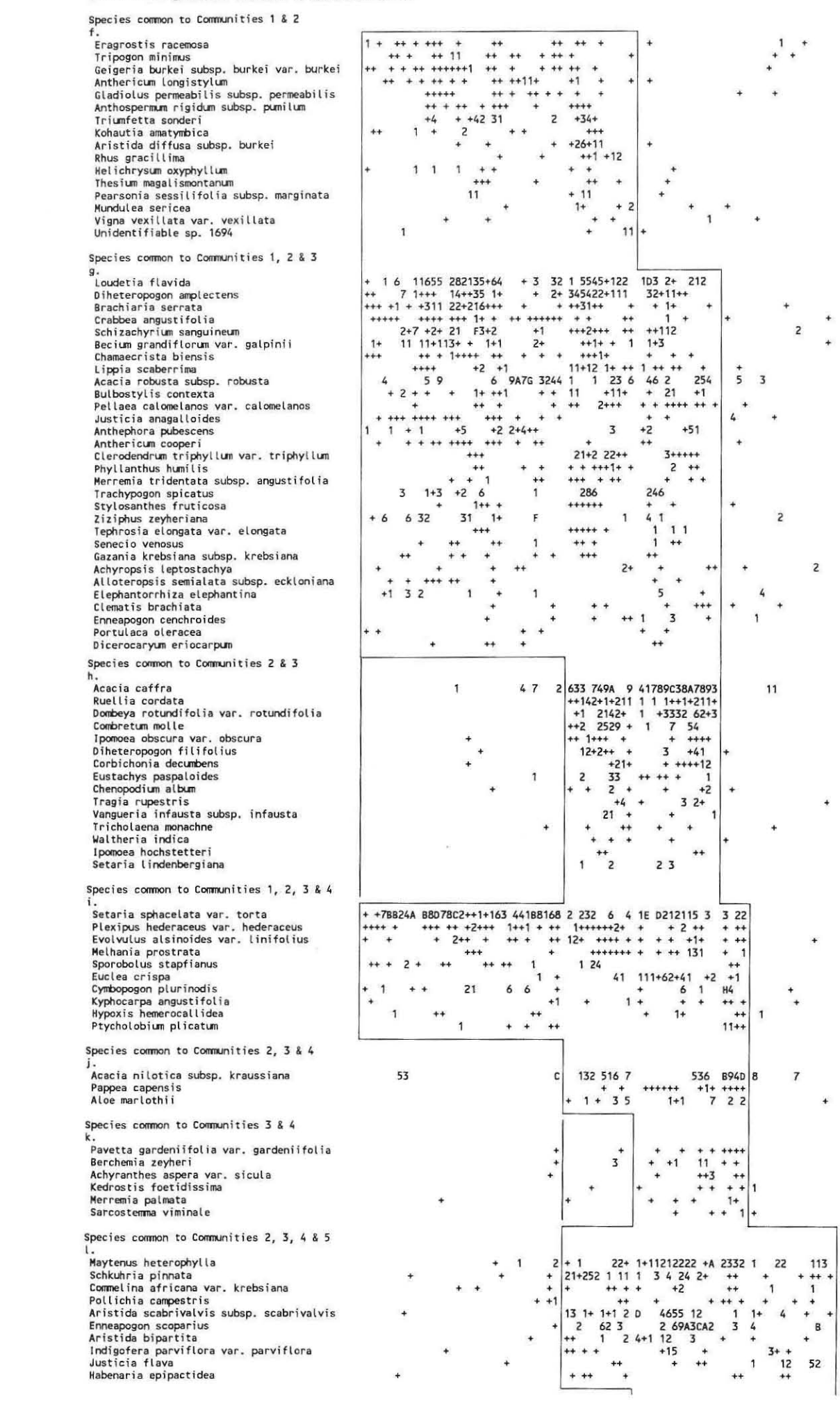

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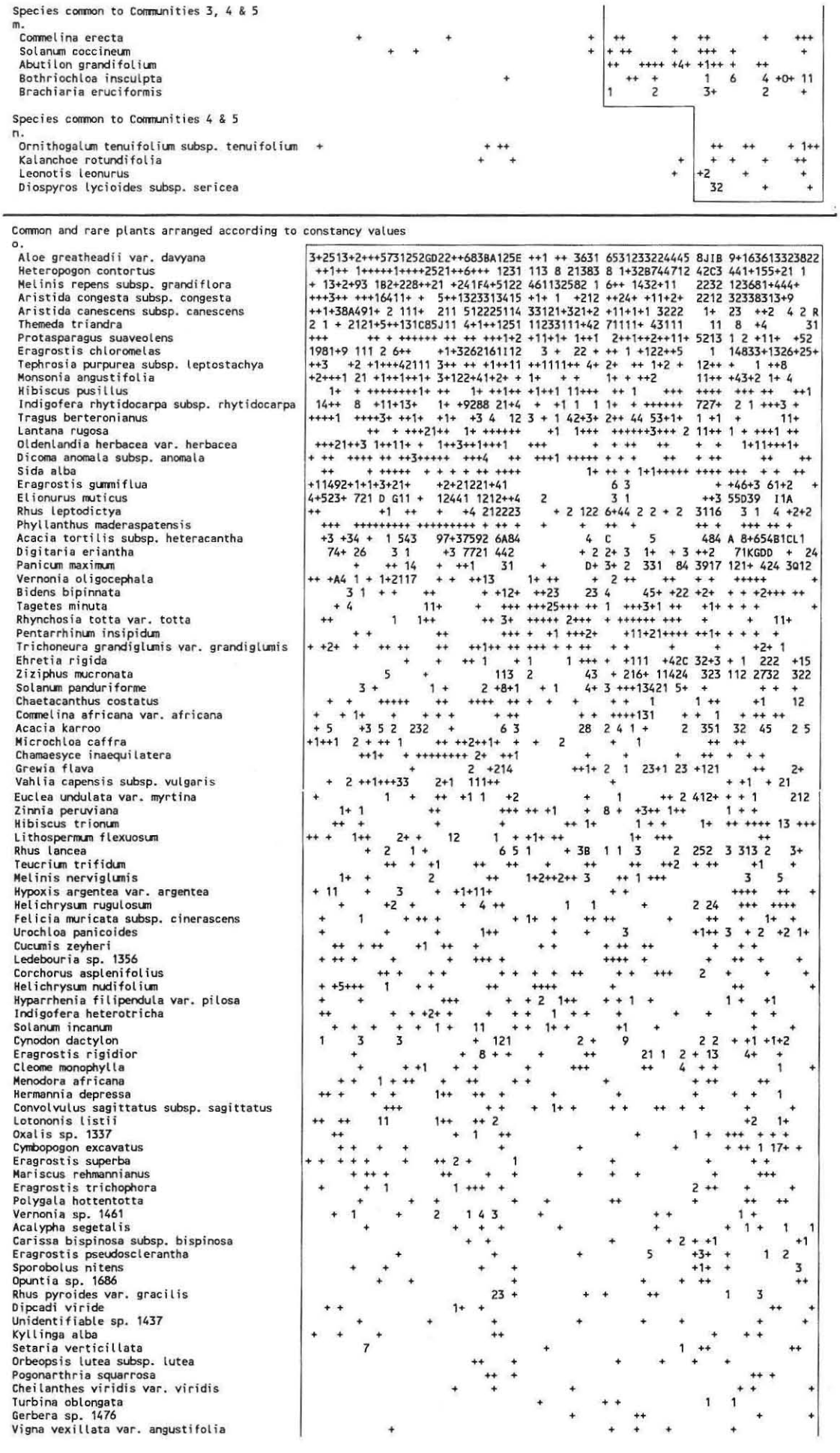

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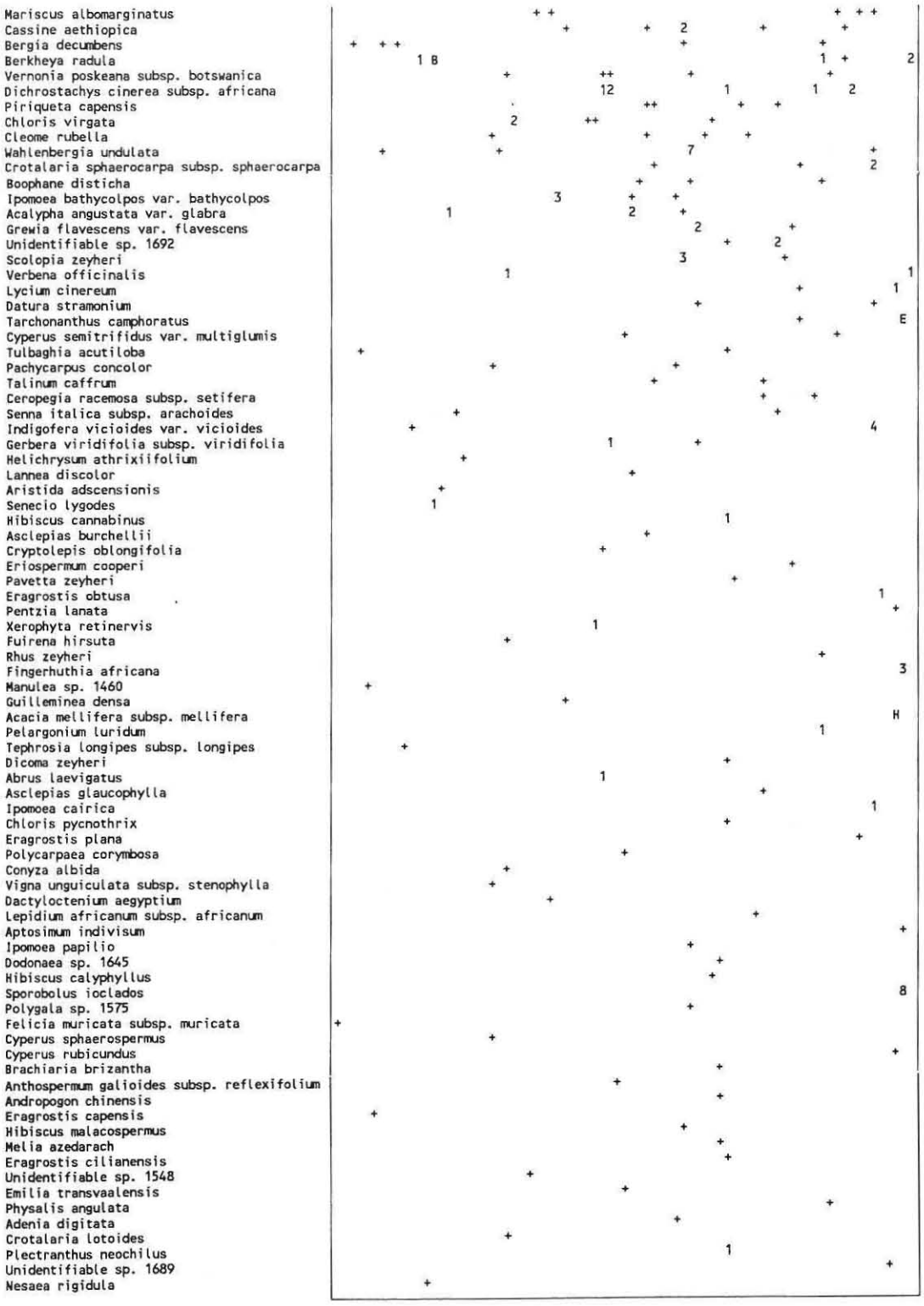

Table 2 Plant community statistics for the Roodeplaat Experimental Farm study area

Community number	1	2	3	4	5
Total diagnostic species	119	108	122	61	63
Diagnostic proportion	50.4%	53.7%	50.8%	43.9%	35.0%
Mean species per relevé	56	68	67	76	44
Community variation*	26.3%	33.8%	28.0%	4.9%	24.4%
Total species	236	201	240	139	180
Number of tree species	5	7	6	5	6
Number of shrub species	9	14	21	11	11
Number of dwarf shrub species	28	30	36	26	26
Number of grass species	57	44	54	30	44
Number of forb species	137	106	123	68	93
Number of relevés per community	33	11	13	4	14

* the proportion of species per relevé per community expressed as a percentage

northern portions of the farm with a small portion occurring in the south-western corner (Figure 2). It is characterized by: (a) shallow soils (median depth of 25 cm) which include Westleigh, Avalon and Mispah forms and (b) by bush clumping which occurs on termitaria interspersed in open grassland. It is differentiated from the other four communities on the basis that it has not previously been cultivated and it occurs on flats (median of 1°) overlying tuff and trachyte geological formations (Figures 3 and 4).

Species-group *a* (Table 1) is diagnostic for this low open woodland community in which a total of 236 species were recorded with a diagnostic proportion of 50% (Table 2). Although the forb stratum is only responsible for 3.5% canopy cover (Figure 5), this growth form comprises more than 50% of the 236 species recorded in the community (Table 2) . Dominant species (in terms of frequency and cover) include *Acacia robusta, Acacia tortilis, Aloe greatheadii, Setaria sphacelata, Themeda triandra, Elionurus muticus, Melinis repens, Eragrostis chloromelas, Aristida canescens* and *Indigofera rhytidocarpa* (Table 3). The total cover for the community is relatively low at 33.8% (Figure 5).

2. The *Acacia caffra - Tristachya biseriata* - low open woodland (2)

Community 2 (species-group *b*, Table 1) occurs on the crest of the Buffelsdrif Ridge in the south of the study area as well as on two koppies on the central plateau (Figure 2). Environmentally, the main differentiating factor for this community is physiography *i.e.* it is restricted to undulating crests (median slope of 3°) with shallow soils (Mispah form; median depth of 10 cm) overlying trachyte and tuff geological formations (Figures 3 and 4).

A total of 201 species were recorded in this low open woodland community of which 108 are diagnostic. In terms of species richness, the forb stratum comprised 106 of the 201 species (Table 2), although, similarly to Community 1, these plants have a low cover at 2.5% (Figure 5). Dominant species (in terms of frequency and cover) include *Acacia caffra, Acacia nilotica, Combretum molle, Rhus lancea, Panicum maximum, Heteropogon contortus*, and *Melinis repens* (Table 4). The total cover for the community is low (26.7%) (Figure 5).

3. The *Acacia caffra–Setaria nigrirostris* - low open woodland (3)

Community 3 is differentiated environmentally from the other communities since it is restricted to slopes (median of 4°) and it occurs on shallow Mispah soils (median of 10 cm) overlying tuff and trachyte geological formations (Figures 3 and 4). It occurs on the northern slopes of the Buffelsdrif Ridge, the southern slopes of the ridge just to the north of the Pienaars River and the slopes in the north-eastern corner of the REF (Figure 2).

As in Communities 1 and 2, this community has a high forb species richness (123 out of 240) and low cover (3.9%) (Table 2, Figure 5). Species-group *c* (Table 1) is diagnostic for this low open woodland community. Dominant species (in terms of frequency and cover) include *Acacia caffra, Acacia tortilis, Ehretia rigida, Aloe greatheadii, Setaria sphacelata, Enneapogon scoparius, Heteropogon contortus, Aristida scabrivalvis* and *Loudetia flavida* (Table 5). The total cover for the community is relatively high at 42.2% (Figure 5).

4. The *Acacia tortilis* subsp. *heteracantha–Cyphostemma lanigerum* - short closed woodland (4)

Community 4 forms dense belts of vegetation along the diabase

Table 3 Species and growth from relations in community 1

Species	Growth form	Competitor status	Canopy cover (%)	Crown diameter (m)	Individuals per ha	Caonpy to canopy gap (m)
Acacia robusta subsp. *robusta*	tree	strong	2.11	1.61	103	9.48
Acacia tortilis subsp. *heteracantha*	tree	normal	1.83	2.01	47	14.36
Aloe greatheadii var. *davyana*	dwarf shrub	strong	3.54	0.13	27550	0.55
Setaria sphacelata var. *torta*	grass	strong	4.25	0.08	93260	0.29
Eragrostis chrolomelas	grass	strong	2.12	0.07	49443	0.43
Themeda triandra	grass	strong	2.12	0.09	35559	0.51
Elionurus muticus	grass	strong	1.83	0.06	70947	0.37
Melinis repens subsp. *grandiflora*	grass	normal	1.84	0.07	45330	0.46
Aristida canescens subsp. *canescens*	grass	normal	1.12	0.07	30912	0.57
Indigophera rhytidocarpa subsp. *rhytidocarpa*	forb	strong	1.00	0.09	16285	0.80

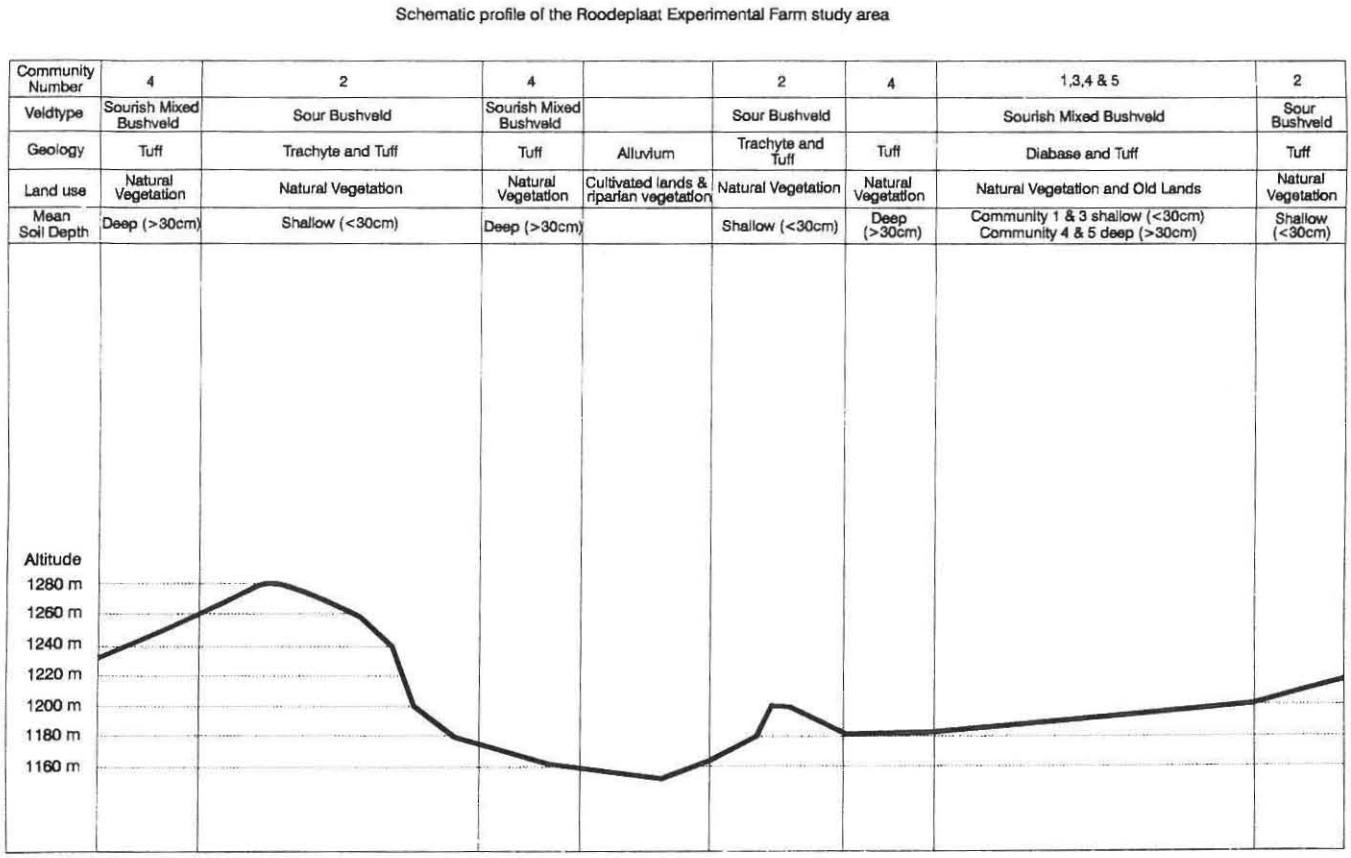

Figure 3 A schematic profile of the Roodeplaat Experimental Farm study area.

outcrops (which differentiates it from the other communities) present on the undulating (median slope of 1°) upland plateau in the central and northern portion of the REF (Figures 2, 3 and 4). The soils in this community are deeper than for the previous three communities (median of 35 cm) and Mispah and Avalon forms are present.

Species-group *d* (Table 1) is diagnostic for this short closed woodland comprising 139 species of which 61 are diagnostic (Table 2). Forbs, as for the three previous communities, comprised approximately half the species (68 out of 139) recorded in the community (Table 2). Dominant species (in terms of freqlency and cover) include *Acacia nilotica, Acacia tortilis, Aloe greatheadii, Rhus leptodictya, Cymbopogon plurinodis, Heteropogon contortus, Panicum maximum* and *Indigofera rhytidocarpa* (Table 6). The total cover for the community is high at 65.7% (Figure 5).

5. The *Acacia tortilis* subsp. *heteracantha–Bothriochloa bladhii* - low closed woodland (5)

The largest portion of this community occurs along the north-eastern boundary of the REF and a smaller portion is on the south-western boundary (Figure 2). Community 5 is differentiated environmentally from the other communities since it is restricted to flat (median of 1°), previously cultivated oldlands, occurring only on deep (median of 50 cm), well-drained soil forms such as Westleigh, Valsrivier, Shortlands, Avalon and Rensburg (Figures 3 and 4).

Species-group *e* (Table 1) is diagnostic for this short closed woodland. Forbs comprise 93 of the 180 species present in this community although, as for the other four communities, the cover is low at 2.5% (Table 2, Figure 5). Dominant species (in terms of frequency and cover) include *Acacia mellifera, Acacia*

Table 4 Species and growth from relations in Community 2

Species	Growth form	Competitor status	Canopy cover (%)	Crown diameter (m)	Individuals per ha	Canopy to canopy gap
Acacia caffra	tree	strong	3.49	1.44	130	8.46
Acacia nilotica subsp. *nilotica*	tree	normal	1.15	1.08	98	10.29
Combretum molle	tree	normal	1.08	1.84	38	16.45
Rhus lancea	shrub	strong	1.20	0.38	83	11.99
Panicum maximum	grass	strong	1.55	0.08	30328	0.57
Heteropogon contortus	grass	strong	1.48	0.06	54918	0.42
Melinis repens subsp. *grandiflora*	grass	strong	1.47	0.04	102012	0.31

Table 5 Species and growth form relations in Community 3

Species	Growth form	Competitor status	Canopy cover (%)	Crown diameter (m)	Individuals per ha	Canopy to canopy gap (m)
Acacia tortilis subsp. *heteracantha*	tree	strong	1.31	1.56	68	12.07
Acacia caffra	tree	normal	5.67	1.41	232	5.99
Ehretia rigida	shrub	strong	1.30	0.58	489	4.52
Aloe greatheadii var. *davyana*	dwarf shrub	strong	1.35	0.07	33190	0.55
Enneapogon scoparius	grass	strong	3.71	0.05	231787	0.19
Heteropogon contortus	grass	strong	2.59	0.07	62308	0.38
Setaria sphacelata var. *torta*	grass	strong	3.19	0.06	118107	0.27
Aristida scabrivalvis subsp. *scabrivalvis*	grass	strong	2.14	0.05	124055	0.27
Loudetia flavida	grass	normal	1.49	0.05	71803	0.37

tortilis, *Tarchonanthus camphoratus*, *Aloe greatheadii*, *Digitaria eriantha*, *Aristida canescens*, *Elionurus muticus*, *Bothriochloa insculpta*, *Panicum maximum*, *Aristida scabrivalvis*, *Eragrostis chloromelas* and *Melinis repens* (Table 7). The total cover for the community is relatively high at 55.5% (Figure 5).

Verification

Classification efficiency

The Roodeplaat classification had a relatively weak classification efficiency (53%) because the sampling scale of 1:8 000 was inappropriate (Panagos 1995). The sampling scale at which optimum community boundary definition is evident and at which the best correlation with stratification is obtained, on Sourish Mixed Bushveld farms, is 1:12 000 (Panagos 1995).

Spatial integrity of relevés

The grouped number comparison of the relevés as arranged in the stratified units, with the relevés grouped according to the final classification (Table 8) provided a low (31%) mean correspondence between the two groups.

Using the overlay method, it can be seen that in some cases a plant community covered more than one stratified unit and in these cases the neighbouring units were amalgamated (Figures 1 and 2). Having done this, 73 of the 75 relevés could be easily grouped and only two outliers were present *i.e.* a 97% correspondence.

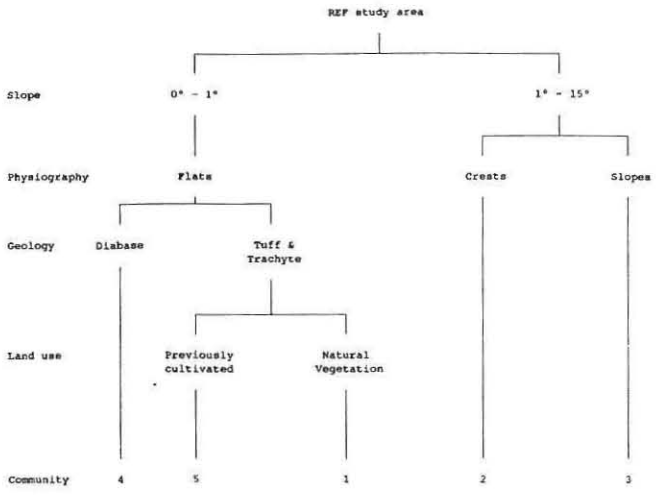

Figure 4 Dendrogram indicating the environmental parameters which differentiate the Roodeplaat Experimental Farm relevé-groups from each other.

Floristic and habitat correlation

The environmental parameters responsible for the differentiation of the relevé-groups are presented as a schematic profile of the study area (Figure 3) and as a dendrogram (Figure 4). Well defined environmental ranges are evident for the REF plant communities. For example, Communities 1, 4 and 5 are differentiated from Communities 2 and 3 on the basis of slope and physiography. Thereafter, each of the communities can be differentiated using one or more of the quantifiable habitat parameters recorded in the field or obtained from maps.

The positions of the five plant communities on the REF, ordinated using the CANOCO (ter Braak 1987) version of a DCA, are illustrated by means of a three dimensional ordination diagram (Figure 6). Axes 1 and 2 accounted for all the variation in the ordination.

Community composition analysis

The CCA output is summarized in Tables 3 to 7 in the plant community descriptions above. The key species, being the strong and weak competitor species on the REF, are presented in Table 9.

Ground- truthing

As a result of ground truthing, two small changes were made to the vegetation map (Figures 1 and 2). On the north-western side of the ridge, just north of the Pienaars River, Community 5 had its boundary extended to include a drainage area which had not been detected during stratification. Also, Community 3 had its boundary extended slighty to include a portion of the ridge which had been excluded in the stratification.

Floristic affinities

The comparison of the REF data set with the RNR data set for any floristic affinity indicates that the REF's Communities 2 and 3 have the highest affinity with the RNR's Community 3, although the percentage similarity is low at 23% and 20% respectively (Table 10). REF Community 4 and RNR Community 4 have the lowest floristic affinity at 7%.

The REF plant communities are, furthermore, less floristically unique than the RNR plant communities because the former, generally, have more species in common and the latter have fewer species in common (Table 11). For example, the REF Communities 1, 2, and 3 have commonality values ranging from 54% to 60% and the RNR plant Communities 1, 4, and 6 have

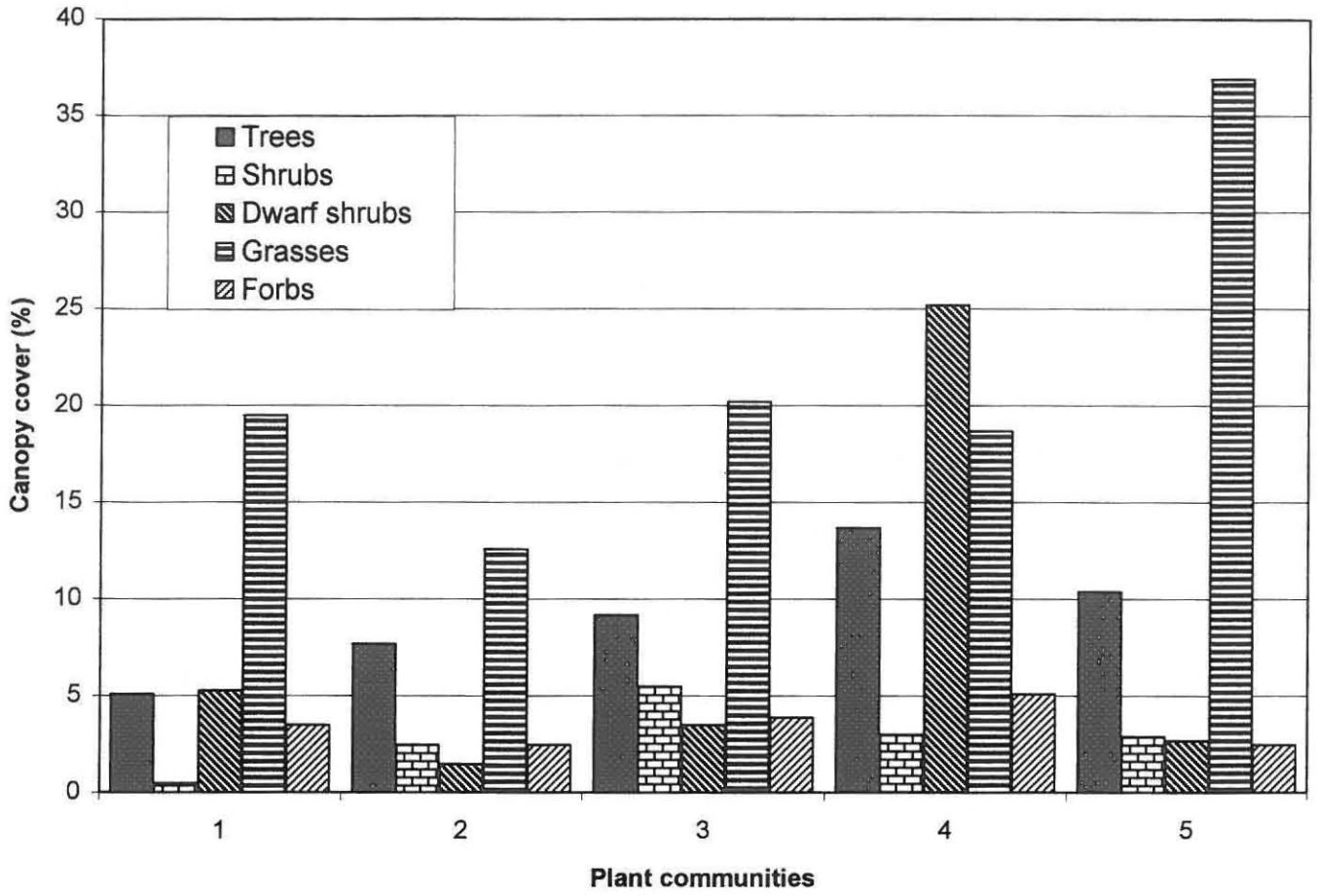

Figure 5 A histogram indicating the percentage canopy cover for the growth forms recorded in the five plant communities on Roodeplaat Experimental Farm.

commonality values ranging from 24% to 25%. Of the total number of species in the combined data sets, only two species, namely *Themeda triandra* and *Eragrostis chloromelas* have 100% commonality.

The comparison of the REF data set with the two Acocks' data sets (Veld Types 19 and 20) for any floristic affinity indicates that the REF's five communities have more affinity with each other, than with either of Acocks' Sourish Mixed and Sour Bushveld data sets. The Sourish Mixed Bushveld data set has a marginally higher mean proportional co-occurrence value (8%) than the Sour Bushveld data set (6%) (Table 12 a and b).

The REF Community 3 had the highest affinity with both Acocks' (1988) Sourish Mixed and Sour Bushveld data sets (53% and 44% respectively), whereas REF Community 4 had the lowest affinity with Acocks' data sets (37% and 30%) (Table 13 a and b). Also, in the comparison of the REF data set (350 species) with the Sourish Mixed Bushveld (930 species) and the Sour Bushveld (1 312 species) data sets, only 34 and 41 species respectively, have 100% commonality.

Discussion and Conclusions

Verification

Classification efficiency

Table 6 Species and growth form relations in Community 4

Species	Growth form	Competitor status	Canopy cover (%)	Crown diameter (m)	Individuals per ha	Canopy to canopy gap (m)
Acacia nilotica subsp. *kraussiana*	tree	strong	9.76	2.53	194	5.57
Acacia tortilis subsp. *heteracantha*	tree	strong	2.42	1.93	82	10.48
Rhus leptodictya	tree	normal	1.19	1.93	39	15.99
Aloe greatheadii var. *davyana*	dwarf shrub	strong	21.92	0.08	467685	0.09
Cymbopogon plurinodis	grass	strong	7.68	0.14	50627	0.36
Heteropogon contortus	grass	strong	4.36	0.07	123594	0.25
Panicum maximum	grass	strong	3.53	0.08	75369	0.33
Indigophera rhytidocarpa subsp. *rhytidocarpa*	forb	strong	2.57	0.07	64975	0.37

Table 7 Species and growth form relations in Community 5

Species	Growth form	Competitor status	Canopy cover (%)	Crown diameter (m)	Individuals per ha	Canopy to canopy gap (m)
Acacia mellifera subsp. *mellifera*	tree	strong	2.08	3.13	27	18.57
Acacia tortilis subsp. *heteracantha*	tree	normal	6.83	1.82	221	5.76
Tarchonanthus camphoratus	shrub	strong	1.41	0.74	328	5.49
Aloe greatheadii var. *davyana*	dwarf shrub	strong	1.92	0.11	19115	0.70
Digitaria eriantha	grass	strong	7.66	0.07	226923	0.17
Aristida canescens subsp. *canescens*	grass	strong	5.51	0.09	81625	0.30
Elionurus muticus	grass	strong	5.28	0.06	170894	0.21
Bothriochloa insculpta	grass	strong	4.54	0.06	168365	0.22
Panicum maximum	grass	strong	5.27	0.09	86101	0.30
Aristida congesta subsp. *congesta*	grass	normal	1.41	0.05	75815	0.36
Eragrostis chloromelas	grass	weak	1.28	0.06	44861	0.47
Melinis repens subsp. *grandiflora*	grass	weak	1.17	0.05	66649	0.39

The classification efficiency for this study would have been higher had a sampling scale of 1:12 000 been used (Panagos 1995). However, the value of 53% does not necessarily invalidate the classification because of corroboration by some of the other verification methods. The classification efficiency value indicates, in this case, an inadequate sampling scale.

Spatial integrity of relevés

Although the grouped number comparison gave a low correspondence (31%) between the stratification and plant communities, the stratified units generally formed subsets of the plant communities (Table 8). This indicates a far too detailed stratification (1:8 000) for the vegetation concerned and corroborates the conclusion obtained with the classification efficiency. Overlaying the stratification (Figure 1) on the classified vegetation map (Figure 2) confirms this conclusion.

Floristic and habitat correlation

The plant communities on the REF are differentiated primarily by physiography with Community 2 representing crests, Community 3 representing slopes and Communities 1, 4 and 5 representing flats. The flats communities are differentiated by geology and land-use (Figures 3 and 4). These differentiating factors are supported by a soil depth gradient where the crests (Community 2) and slopes (Community 3) have the shallowest soils and the flats (Communities 1, 4 and 5) have the deepest soils (Figure 4).

Finding a correlation between habitat and plant communities does not necessarily validate a classification because with all the habitat factors available it should be possible to find some or other correlation with any group of plants. Of importance, however, is that habitat factors shown to correlate with the plant communities, should form some sort of environmental gradient. In this study, physiography, geology and land-use correlated with and differentiated the plant communities and also indicated the existence of a soil depth gradient. This confirms the classification.

The arrangement of the communities by the DCA ordination on axis 2 (Figure 6) follows the PHYTOTAB-PC classification's arrangement of communities thus confirming the environmental

Table 8 The percentage correspondence between the stratified unit relevé sequence (Set A) and the Roodeplaat Experimental Farm classified relevé sequence (Set B)

		Set A (strat. sequence)										Total percentage correspondence
		1	2	3	4	5	6	7	8	9	10	
Set B (Roodeplaat)	1	53*	48*	21*	13	4	0	0	0	0	5	144
	2	0	0	0	0	10	12	0	0	53*	58*	133
	3	0	8	0	17	0	44*	0	63*	0	0	132
	4	0	0	0	0	66*	0	0	0	0	0	66
	5	20	0	0	41*	18	0	44*	0	0	0	123
Total percentage correspondence		73	56	21	71	98	56	44	63	53	63	

* the Roodeplaat Experimental Farm relevé-groups having the highest percentage correspondence with the stratified unit relevé-groups

Table 9 Listing of strong and weak competitor species (key species) for each vegetation unit, according to growth forms on Roodeplaat Experimental Farm (where 3 = strong competitors; 1 = weak competitors, * = normal competitors; and - = not recorded)

	Vegetation unit number						
Growth forms & species	1	2	3	4	5	% Strong	% Weak
Trees							
Acacia robusta subsp. *robusta*	3	*	*	*	*	20	0
Acacia tortilis subsp. *heteracantha*	*	*	3	*	*	20	0
Acacia caffra	*	3	*	-	*	20	0
Acacia karroo	1	*	1	*	1	0	60
Acacia mellifera subsp. *mellifera*	-	-	-	-	3	20	0
Shrubs							
Rhus lancea	3	3	*	3	*	60	0
Pavetta gardeniifolia var. *gardeniifolia*	*	*	*	1	-	0	20
Euclea crispa	*	*	1	*	-	0	20
Grewia flava	*	*	1	1	*	0	40
Ehretia rigida	1	*	3	*	*	20	20
Combretum apiculatum subsp. *apiculatum*	-	*	3	-	-	20	0
Tarchonanthus camphoratus	-	-	-	*	3	20	0
Dwarf shrubs							
Aloe greatheadii var. *davyana*	3	3	3	3	3	100	0
Ziziphus zeyheriana	3	*	*	-	*	20	0
Melhania prostrate	*	1	*	*	-	0	20
Solanum panduriforme	*	3	*	*	*	20	0
Triumfetta sonderi	*	3	-	-	-	20	0
Euclea undulate var. *myrtina*	*	*	*	*	1	0	20
Rhus leptodictya	*	*	3	*	*	20	0
Polygala amatymbica	1	-	*	*	*	0	20
Lantana rugosa	1	*	1	*	1	0	60
Protasparagus suaveolens	1	1	1	*	1	0	80
Pappea capensis	-	*	1	*	-	0	20
Grasses							
Setaria sphacelata var. *torte*	3	*	3	*	-	40	0
Eragrostis chloromelas	3	*	1	*	1	20	40
Themeda triandra	3	*	*	*	*	20	0
Elionurus muticus	3	*	*	*	3	40	0
Melinis repens subsp. *grandiflora*	*	3	*	*	1	20	20
Schizachyrium sanguineum	*	1	*	-	*	0	20
Digitaria eriantha	*	*	*	*	3	20	0
Enneapogon scoparius	*	*	3	*	*	20	0
Aristida scabrivalvis subsp. *scabrivalvis*	*	*	3	*	*	20	0
Bothriochloa insculpta	*	-	*	*	3	20	0
Tristachya hiseriata	*	3	-	-	-	20	0
Loudetia flavida	*	3	*	-	-	20	0
Cymbopogon plurinodis	*	-	*	3	*	20	0
Trachypogon spicatus	*	3	*	-	-	20	0
Cynodon dactylon	*	*	*	*	1	0	20
Aristida canescens subsp. *canescens*	*	*	1	*	3	20	20
Panicum maximum	*	3	*	3	3	60	0

Table 9 Continued

Growth forms and species	Vegetation unit number 1	2	3	4	5	% Strong	% weak
Brachiaria serrata	1	*	*	-	*	0	20
Trichoneura grandiglumis var. *grandiglumis*	1	1	*	*	*	0	40
Eragrostis gummiflua	1	-	*	*	1	0	40
Aristida congesta subsp. *congesta*	1	*	1	*	*	0	40
Microchloa caffra	1	*	*	*	*	0	20
Tragus berteronianus	1	*	*	*	*	0	20
Heteropogon contortus	1	3	3	3	1	60	40
Forbs							
Indigofera rhytidocarpa subsp. *rhytidocarpa*	3	*	1	3	*	40	20
Vernonia oligocephala	3	*	*	*	*	20	0
Berkheya radula	3	-	-	-	*	20	0
Helichrysum rugulosum	*	*	*	3	*	20	0
Tagetes minuta	*	3	*	*	*	20	0
Tephrosia purpurea subsp. *leptostachya*	*	3	*	*	3	40	0
Gnidia sericocephala	*	1	-	-	-	0	20
Justicia flava	*	*	*	-	3	20	0
Indigofera vicioides var. *vicioides*	*	-	-	-	3	20	0
Indigofera parviflora var. *parviflora*	*	*	3	-	*	20	0
Ipomoea obscura var. *obscura*	*	1	*	-	-	0	20
Monsonia angustifolia	*	*	*	*	3	20	0
Wahlenbergia undulata	*	-	3	-	*	20	0
Bidens bipinnata	*	3	3	*	*	40	0
Schkuhria pinnata	*	3	3	*	*	40	0
Tephrosia elongata var. *elongata*	*	1	*	-	-	0	20
Clerodendrum triphyllum var. *triphyllum*	*	3	*	-	-	20	0
Phyllanthus humilis	*	1	*	-	-	0	20
Rhynchosia totta var. *totta*	*	1	1	*	*	0	40
Merremia tridentata subsp. *angustifolia*	*	1	*	-	-	0	20
Stylosanthes fruticosa	*	1	*	*	-	0	20
Pellaea calomelanos var. *calomelanos*	*	*	1	*	-	0	20
Cleome monophylla	*	*	3	*	*	20	0
Zinnia peruviana	*	*	3	-	*	20	0
Dicoma anomala subsp. *anomala*	*	1	*	*	*	0	20
Justicia anagalloides	*	-	*	3	*	20	0
Sida alba	*	*	1	*	*	0	20
Hibiscus pusillus	*	1	*	*	*	0	20
Crabbea angustifolia	1	*	*	*	*	0	20
Phyllanthus maderaspatensis	1	*	*	*	*	0	20
Tragia rupestris	-	3	*	-	*	20	0
Ruellia cordata	-	3	*	-	-	20	0
Zornia linearis	-	1	-	-	-	0	20
Hermannia parvula	-	1	-	-	-	0	20
Heliotropium strigosum	-	-	*	-	3	20	0
Ocimum urticifolium subsp. *urticifolium*	-	-	-	3	-	20	0

Total strong and weak competitors : 83

Table 10 Affinity matrix showing the proportion of co-occuring species as a percentage of the total species for each two relevés/ communities where 01 represents the Roodeplaat Experimental Farm's data set and 02 represents the Roodeplaat Nature Reserve's data set. The values following these digits are the community numbers for each study

	01 001	01 002	01 003	01 004	01 005	02 001	01 002	02 003	02 004	02 005	02 006	Means
01 001	0	56	56	43	49	8	18	19	9	17	13	28
01 002	56	0	57	39	42	11	17	23	11	17	9	28
01 003	56	57	0	44	47	12	18	20	9	14	9	28
01 004	43	39	44	0	48	13	18	16	7	10	13	25
01 005	49	42	47	48	0	9	19	16	8	13	13	26
02 001	8	11	12	13	9	0	20	20	10	6	8	11
02 002	18	17	18	18	19	20	0	43	19	33	28	23
02 003	19	23	20	16	16	20	43	0	32	44	22	25
02 004	9	11	9	7	8	10	19	32	0	29	14	14
02 005	17	17	14	10	13	6	33	44	29	0	27	21
02 006	13	9	9	13	13	8	28	22	14	27	0	15

gradients. The DCA ordination, however, shows Community 3 (slopes) to be distinctly different from the other communities on axis 1 (Figure 6). This community has the highest floristic affinity with both the Sour Bushveld (Acocks 1988) and the Sourish Mixed Bushveld (Acocks 1988) which could explain it's position on this axis.

Community composition analysis

Field observations indicated that *Aloe greatheadii* var. *davyana* had high frequencies and cover throughout the study area and that *Heteropogon contortus* had high frequencies and cover on the ridges and crests. These observations were confirmed by the CCA. Furthermore, *Aloe greatheadii* var. *davyana*, [a plant which when occurring at high frequencies is extremely competitive with and replaces grass (Wells *et al.* 1986)] had a higher density than any of the woody plants in the communities in which it occurred (Tables 3 to 7). This confirms the classification.

Table 11 Ranked relevé/community commonality, where commonality refers to presences throughout the matrix or data set for species present in each relevé/community. The figure 01 represents the Roodeplaat Experimental Farm's data set and 02 represents the Roodeplaat Nature Reserve's data set. The values following these digits are the community numbers for each study

Community Number	Commonality Index	Species in community	Percentage presences
02 006	465	91	24.81
02 001	466	127	24.87
02 004	485	107	25.88
02 005	761	172	40.61
01 004	784	139	41.84
02 002	832	173	44.40
01 005	915	180	48.83
02 003	969	208	51.71
01 002	1023	201	54.59
01 001	1124	236	59.98
01 003	1130	240	60.30

Matrix dimensions (presences): 1874

Ground-truthing

Ground-truthing showed that the relevés in each community were representative of the communities in which they occurred. Most of the diagnostic species are forbs (Table 1, species-groups *a* to *e*) which indicates the degraded condition of the vegetation. The frequency of occurrence of most of the diagnostic species and the number of diagnostic species for each community facilitates community recognition even if only a few of these species are used for diagnosis. The species used for plant community names are physiognomically dominant in the case of woody species and widespread in the case of grasses, facilitating community identification. The environmental gradient responsible for community differentiation appeared to be valid for each entire

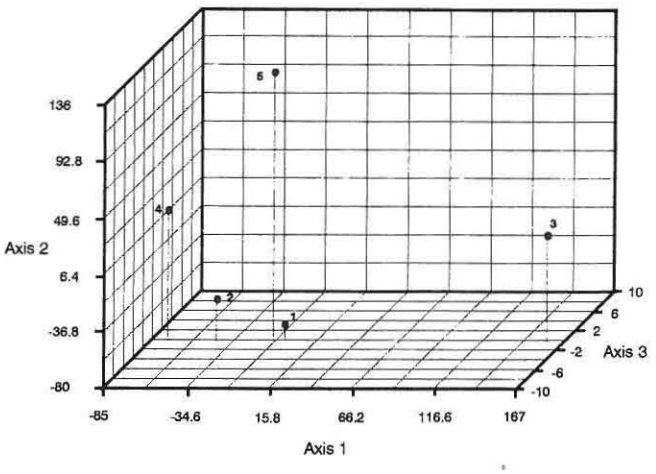

Figure 6 A three-dimensional detrended correspondence analysis (DCA) diagram of the five plant communities on Roodeplaat Experimental Farm (the axes indicate eigenvalues).

Table 12a and b Affinity matrix showing the proportion of co-occurring species as a percentage of the total species for each two relevés/communities where 01 represents the Roodeplaat Experimental Farm's data set and 02 represents **a**. Acocks' (1988) Sourish Mixed Bushveld and **b**. Acocks' (1988) Sour Bushveld data sets. The values following these digits are the community numbers for each study

a

	01 001	01 002	01 003	01 004	01 005	02 001	Means
01 001	0	56	56	43	49	9	42
01 002	56	0	57	39	42	8	40
01 003	56	57	0	44	47	8	42
01 004	43	39	44	0	48	7	36
01 005	49	42	47	48	0	8	38
02 001	9	8	8	7	8	0	8

Lowest value: 7 for 01 004 with 02 001
Highest value: 57 for 01 002 with 01 003

b

	01 001	01 002	01 003	01 004	01 005	02 001	Means
01 001	0	56	56	43	49	7	42
01 002	56	0	57	39	42	6	40
01 003	56	57	0	44	47	7	42
01 004	43	39	44	0	48	4	35
01 005	49	42	47	48	0	6	38
02 001	7	6	7	4	6	0	6

Lowest value: 4 for 01 004 with 02 001
Highest value: 57 for 01 002 with 01 003

community thus differentiated from ground-truthing. Mapped community borders are for the most part easily identifiable on the ground. However, Community 5 (Figure 2) does not form distinct borders because of wide ecotones present. The ground-truthing exercise confirms the validity of the classification.

Floristic affinities

The low floristic affinity of the REF and the RNR could be due to past management practices, namely nature conservation as opposed to agricultural experimentation. For example, the RNR has more unique plant communities than the REF because, ecologically, the former's communities have been managed better. The degraded range condition on the REF is evidenced by the high proportion of forbs and the low grass cover, as well as the high frequency and cover of the dwarf shrub *Aloe greatheadii* var. *davyana*. *Aloe greatheadii* var. *davyana* is not one of 34 species listed as having 100% commonality in the affinity analysis of the REF and Acocks' (1988) Sourish Mixed Bushveld (it's commonality value is 58%) thus indicating it's undesirable dominance in the study area.

It is not intended in this article to criticize specific authors on the validity or otherwise of their classifications. However, all classifications should be validated because of the permutations involved in relevé sequencing.

Recommendations

This study has shown that it is essential for classifications to be validated by more than one criterion. Recommendations relating to the management of the REF are based on the degraded condition of the vegetation where forbs comprise 50% of the species composition, a generally low grass cover (18%) of which 70% are categorized as Increaser I and Increaser II species and the invasion by *Acacia tortilis* in Community 5. The recommendations are: the reduction of the dwarf shrub *Aloe greatheadii* var. *davyana* which is a strong competitor in all five plant communities; the limitation of browsers especially in Community 5 which could exacerbate woody densification through seed dispersion; the application of very conservative stocking rates and sheep should not be grazed on their own; and cultivation should be restricted to the areas currently in use and not the described plant communities.

The uniqueness and atypical, for Sourish Mixed Bushveld, geological formation on which the REF is situated (*i.e.* the Roodeplaat volcano), and its proximity to the large metropolitan areas of Pretoria and Johannesburg favour the development of ecotourism as well as an educational centre. However, this uniqueness could preclude the extrapolatability of research results.

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Table 13a and b Ranked relevé/community commonality where commonality refers to presences throughout the matrix or data set for species present in each relevé/community. The figure 01 represents the Roodeplaat Experimental Farm's data set and 02 represents **a.** Acocks' (1988) Sourish Mixed Bushveld and **b.** Acocks' (1988) Sour Bushveld data sets. The values following these digits are the community numbers for each study

a

Community number	Commonality Index	Species in community	Percentage presences
01 004	631	139	37.29
01 005	745	180	44.03
01 002	811	201	47.93
01 001	906	236	53.55
01 003	910	240	53.78
02 001	1065	696	62.94

Matrix dimensions (presences): 1692

b

Community number	Commonality Index	Species in community	Percentage presences
01 004	639	139	30.56
01 005	750	180	35.87
01 002	818	201	39.12
01 001	917	236	43.85
01 003	926	240	44.29
02 006	1511	1095	72.26

Matrix dimensions (presences): 2091

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