

Description, classification and ordination of the dominant vegetation communities, Cathedral Peak, KwaZulu-Natal Drakensberg

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A survey of 13 vegetation communities which span the major topographic and successional differences in the KwaZulu-Natal Drakensberg was undertaken. A basic description of species present and their abundance was recorded. Furthermore, an analysis was performed to demonstrate the effectiveness of classification and ordination to delimit the representativeness of samples within particular vegetation communities and the relationship between chosen dominant communities based on homogeneity with regard to species composition and abundance. The analysis was performed using two-way indicator species analysis (TWINSPAN) and detrended correspondence analysis (DCA) to describe the distinctiveness or, in the case of the grassland communities, the close association between the various communities. Results are a record of the dominant vegetation communities within a region displaying a steep altitudinal, and hence environmental, gradient, the homogeneity of samples taken within a community and the distinctiveness and/or similarity between these communities.

Keywords: DCA, TWINSPAN, vegetation analysis.

Introduction

Environmental change may be manifested in the migration of vegetation communities along an altitudinal gradient, with each species reacting to environmental change on the basis of its ecological adaptability. The consequence of such changes is that many species that share a common sensitivity to the environmental conditions will occupy similar habitats. Any altitudinal shift of such communities is, therefore, an indication of changes in the environment that have taken place through time (van Zinderen Bakker & Coetzee 1988).

The KwaZulu-Natal Drakensberg, with its diverse topography and steep altitudinal gradients, is an ideal region in which to study possible vegetation changes or shifts as a consequence of palaeo-environmental changes. As environmental conditions change through time, vegetation communities will 'migrate' in accordance with the optimum conditions for that particular community. Although these shifts can be studied via palynology and dendrochronology, one can study modern analogues by observing the contemporary vegetation communities and their relation to the environmental conditions. This article describes, classifies and ordines the dominant vegetation communities, which to a greater or lesser extent would be affected, and hence migrate as a consequence of environmental change. Bearing in mind that this principle is often an oversimplification, it must be considered that although species will migrate with environmental change, whole communities will not necessarily follow suit, but the communities would be modified, in some way, by migration of some or all of the component species.

From an initial field survey, 13 vegetation communities were identified as being suitable in the context of the study's objectives. These communities either represented the dominant or climax communities within a particular altitudinal belt, were seral stages towards the climax community, or existed as a consequence of distinct topographical or geomorphological features. Therefore, if there has been or will be some form of environmental change it would be these communities which would be the most likely to be affected to an extent large enough to be recorded by palaeo-reconstruction techniques. Secondly, the chosen communities follow either a successional pathway or a distinct topographic or geomorphological feature within the altitudinal vegetation belt.

Study area

The research was carried out during 1990 in the environs of the Cathedral Peak Forestry Research Station, situated in the Bergville district of the KwaZulu-Natal Drakensberg at latitude 29°00'S and longitude 29°15'E (Figure 1). Ongoing research at this station is directed at examining the influence of various catchment management practices and water yield of the local mountain catchment area. This is being carried out on 15 small, gauged catchments, situated on the flat terrace known as the Little 'Berg or foothills, which occurs below the main Drakensberg Escarpment.

The vegetation of the Natal Drakensberg can be divided into altitudinal zones corresponding closely with the physiographic features. Killick (1963) identifies three such zones in the Drakensberg, namely:

- i) Montane belt (1 280–1 829 m),
- ii) Sub-alpine belt (1 830–2 865 m),
- iii) Alpine belt (2 866–3 353 m).

These belts coincide with the three terraces in the Drakensberg, namely the river valley system, the Little 'Berg or foothills

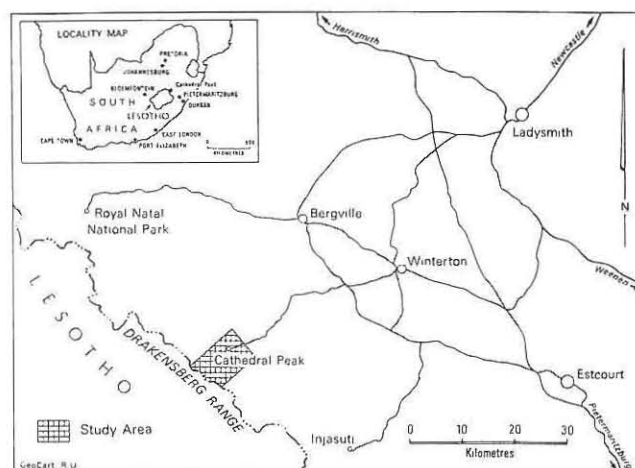


Figure 1 Situation of the Cathedral Peak Forestry Research Station, KwaZulu-Natal Drakensberg.

and the summit areas respectively. For the purpose of this research programme particular vegetation communities were selected from each of the three distinctive vegetation belts, namely:

- i) Montane belt:
 - Themeda*-dominated Highland Sourveld (Acocks number 44a) (Acocks 1988),
 - Protea* savanna or woodland,
 - Mountain *Podocarpus* forest.
- ii) Sub-alpine Belt:
 - Themeda*-*Festuca* sub-alpine grassland,
 - Leucosidea sericea* scrubland,
 - Sub-alpine fynbos,
 - Rendlia altera* grassland,
 - Hygrophilous herbaceous community (low-altitude vlei).
- iii) Alpine Belt:
 - Erica*-*Helichrysum* alpine fynbos,
 - Merxmuellera*-*Pentaschistis*-*Festuca* grassland,
 - Alpine sedge meadow (high-altitude vlei).

The *Themeda*-*Festuca* sub-alpine grassland is further subdivided into three communities, namely; *Themeda triandra*, 'Mixed' and *Festuca costata* grassland.

The situation of each of the sampled communities in relation to each other and to altitude is shown in Figure 2. The *Themeda*-dominated Highland Sourveld is not represented as it forms the dominant grassland community over extensive areas of the montane region and is observed in areas not demarcated by the list of vegetation communities above.

Montane belt

The *Themeda*-dominated Highland Sourveld, in common with other major moist grassland associations, is a relatively stable community which is prevented from successional development by recurrent grass fires. In Clementsian terms it constitutes a fire subclimax since the community is several stages inferior to the climatic climax *Podocarpus latifolius* forest. Where fire is either absent or reduced in effect by topography or other factors, there is a development towards *P. latifolius* forest, especially along the steep slopes of the Drakensberg.

The mountain *Podocarpus* forest community occurs in small

patches of from less than 1 ha to over 10 ha in extent, with occasional large stands of several hundred hectares. The generally small size of the forests means a high ratio of boundary area, and a corresponding large 'edge effect'. Therefore, only towards the centres of the larger forest patches are climax forest conditions found, and climax forest species commonly occur in addition to the dominant forest initials [van Zinderen Bakker (jun.) 1973].

On steeper, exposed slopes and ridges within the montane vegetation belt, *Protea* savanna communities exist. These communities are composed of scattered, evergreen, compact *Protea* trees (*Protea caffra* and *P. roupelliae*) from 1 to 4 m high. *P. caffra* and *P. roupelliae* savannas occur together although there is a segregation of the two communities on deeper and shallower soils respectively (Killick 1963). The grass stratum is principally that of the *Themeda*-dominated Highland Sourveld.

Sub-alpine belt

Within the sub-alpine belt the most extensive plant association is *Themeda*-*Festuca* sub-alpine grassland. Below 2 700 m, consociations of *Themeda triandra* and *Festuca costata* occur on warm, north-facing and on cool, south-facing slopes respectively. In the absence of burning, development of sub-alpine *Themeda*-*Festuca* grassland is towards *Leucosidea* scrubland in the lower sub-alpine belt, and towards sub-alpine fynbos in the upper sub-alpine belt. The *Leucosidea sericea* scrubland communities represent upward extensions into the sub-alpine belt of upland forest precursor communities, occurring locally along streams and slope talus. Although *Leucosidea* communities are commonly connected with plant succession along streams, the species also invades the lower sub-alpine grassland. *Leucosidea sericea* scrubland represents the principle climatic climax community in the zone of approximately 300 m between the mountain *Podocarpus* forest climax and the main sub-alpine fynbos climax above 2 300 m.

The principle climax community of the sub-alpine region is what Killick (1978) describes as the *Erica*-*Philippia*-*Passerina* fynbos community. This community is simply referred to as the sub-alpine fynbos in this study, since the nomenclature of *Philippia evansii* has been changed to *Erica evansii* (de Wet et al. 1989). The communities are best developed along streams, in

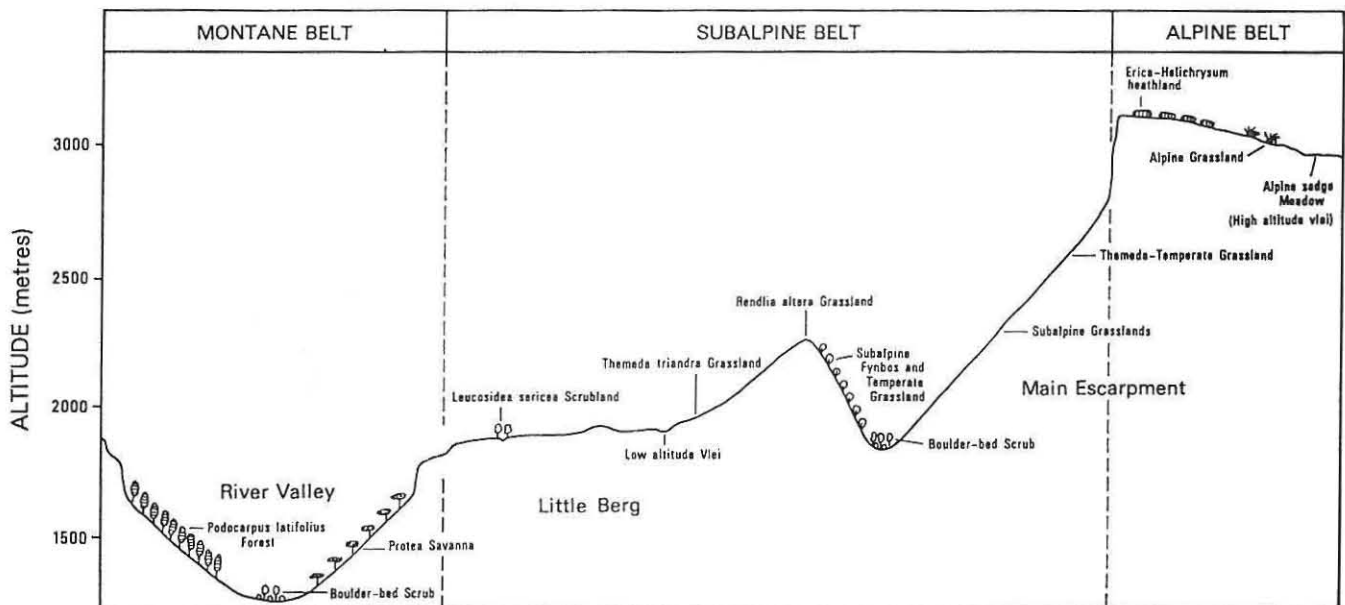


Figure 2 Schematic cross-section through the study site displaying the vegetation belts and dominant vegetation communities (From Killick 1963).

gullies and on rock outcrops, in situations where there is protection from fires. Sub-alpine fynbos is seral to forest at lower altitudes (Edwards 1967).

Two other vegetation communities from the sub-alpine belt that were included in the research are related more to topographical features rather than being seen as part of the successional pathway. The *Rendlia altera* grassland is found between 1 800 and 2 400 m on the ridges of the spurs bounding the catchment areas on the Little 'Berg. This grass is dominant and is mostly short and characteristic of early stages in the grassland succession.

A further study site was a hygrophilous herbaceous community (Edwards 1967) or low-altitude vlei. Most sub-alpine vleis are periodically burned, but owing to the moist nature of the soils, burning is usually limited to the upper portions of plants and fire damage is not severe. There is a close successional relationship between this community and grassland, the vleis forming the beginning of fire-deflected succession to grassland.

Alpine belt

This belt extends in a narrow strip along the summit area of the high Drakensberg. The principle plant communities are *Merxmuellera-Pentaschistis-Festuca* grassland and *Erica-Helichrysum* alpine fynbos or heathland (Killick 1979). On the summit areas of the Drakensberg Escarpment and stretching down into Lesotho are numerous headwater streams which form sponges or vleis. These communities are dominated by aquatic and hygrophilous vegetation which form alpine sedge meadows (Edwards 1967).

The climax community of the alpine belt is considered to be the *Erica-Helichrysum* alpine fynbos or heathland, the species occurring in associations or consociations. Alpine heathland communities are interpreted as local edaphic or post-climax communities (Killick 1963, 1979). Fires limit or deflect the alpine heathland plant succession, resulting in the development of *Merxmuellera-Pentaschistis-Festuca* alpine grassland.

Methods

Field techniques

Vegetation surveys were undertaken within each of the communities and species presence and the percentage canopy and basal cover were recorded. The type of sampling technique employed was decided upon after consultation with research personnel working within the research area (F. Smith, pers. commun. 1988), and related literature (Killick 1963; Edwards 1967; Westfall *et al.* 1983; Westfall & Panagos 1984; Everson & Clarke 1987). Everson and Clarke (1987) evaluated sampling techniques on the Highland Sourveld within the area using the quadrat, Levy bridge, step-point, wheel-point, metric belt transect and 't Mannetje and Haydock methods. They concluded that the quadrat and wheel-point techniques were most consistent. For the purpose of this study it was decided to use the quadrat method despite Everson and Clarke (1987) finding that the wheel-point method was the most suitable for determining grassland species composition. In this study, the wheel-point method was deemed to be unsuitable given the species composition and the abundance of the scrubland and forest vegetation. Therefore, for the sake of standardization and consistency, the quadrat sampling technique was employed.

The present study used 10 m × 10 m quadrats in the forest and scrubland communities. Similar vegetation studies conducted in the area have used 20 m × 5 m (Killick 1963), which proved to be representative. It was decided, in consultation with forestry staff, to use the same quadrat area (100 m²), but to use a 10 m × 10 m quadrat so as to reduce 'edge effects'. The grassland communities proved to be more of a problem since previous sampling strategies had employed either a Levy bridge or wheel-point method (Everson & Clarke 1987; Everson *et al.* 1989). For the sake of standardization and con-

sistency it was decided to also use quadrats within the grassland communities but to employ a 1 m × 1 m quadrat size.

The number of quadrats required was determined by drawing up a cumulative species versus quadrat number curve. This was undertaken in the field as samples were being collected and identified. It was evident that in some communities, for example *Hendlia altera* grassland, alpine sedge meadow and *Erica-Helichrysum* heathland that fewer quadrats would have been representative, whereas communities such as alpine grassland, sub-alpine fynbos and *Festuca costata* grassland still show increases in cumulative species number at a sample size of 15 to 20 quadrats. However as these increases are of the order of only one or two species over five quadrats, it was decided that 20 quadrats were sufficiently representative of the communities.

Analysis

The study used the computer programs two-way indicator species analysis (TWINSPAN) and detrended correspondence analysis (DCA) to classify and ordinate the data (Hill 1979a, b), thereby applying standardized sampling and the use of multivariate analysis or ordination to compare sites. TWINSPAN results may be displayed as a dendrogram showing the resultant sample hierarchy which uses sequences of divisions as integral levels or computes the levels as the average distances between samples in ordination space (Gauch & Whittaker 1981). TWINSPAN is recommended (Gauch 1982) for hierarchical classification because of its effectiveness and robustness as a consequence of being polythetic and divisive. The technique divides complete data sets into distinct groups on the basis of differences between the various samples or groups of samples. This 'grouping' of samples allows one to observe the homogeneity of the samples and how distinctive the samples are to a particular group, which in this case represents a vegetation community or a number of communities with similar species composition.

In classification studies the aim is to examine a set of 'objects' in order to establish whether there is any group structure in the data; for example, do the objects fall naturally into a number of distinct groups so that objects within a group are, in some sense, 'similar' to one another? In the present study, the object is a vegetation assemblage derived from a quadrat survey and it is of interest to know (i) whether the samples can be divided into a certain number of (initially unknown) 'homogeneous groups', and (ii) if such groups do exist, whether they correspond to the vegetation categories identified by this study as being homogeneous. This data set was examined by the ordination technique of DCA so as to group sample sites into communities according to common floristic and not environmental characteristics, which would have been the case if detrended canonical correspondence analysis (CANOCO) was applied. CANOCO (ter Braak 1987a, b) includes environmental factors directly into the ordination procedure (direct gradient analysis), whereas DCA ordines only the vegetative data (indirect gradient analysis). With DCA, environmental gradients are not studied directly but are inferred from species composition data (Taggart 1994). Despite DCA being criticized (van Groenewoud 1992), it has many advantages and this indirect gradient analysis '... is not circular reasoning, but rather a quite logical way to uncover factors determining community structure' (Palmer 1993, p. 2215).

According to Gauch (1982), results achieved by DCA are nearly ideal. DCA summarizes a two-dimensional data structure efficiently and clearly, thereby implying that the underlying model matches the data structure to a considerable degree. DCA is most useful in the analysis of difficult data sets, and axis length for DCA sample ordinations have been found to be accurate to within 10–20% (Gauch 1982), providing that the data set for DCA satisfies two assumptions. The first is that the data set to be analyzed consists of records of the abundance of a set of attributes in a set of individuals. With ecological data, the attributes are ordinarily species and the individuals are usually samples. The second assumption is that, at least in principle, the sample can be arranged along a gradient in such a way that species occupy only a limited extent of the gradient. In practice, the

length of a gradient available for study may not be sufficient for any species to be strictly confined to a particular part of it. In reality, the assumption is that if the gradient were longer, species would be confined to particular parts of it.

Results

Description

Montane belt

The *Themeda*-dominated Highland Sourveld is dominated by Poaceae (63%). The most conspicuous grasses are *Themeda triandra*, *Monocymbium cerasiiforme* and *Trachypogon spicatus*, although many other grass species are present in smaller numbers. *Pteridium aquilinum* (8%), *Helichrysum* and *Aster* (7%), *Acalypha* (6%), *Bulbostylis* and *Cyperus* (4%) and *Rhus* (4%) are the other main contributing taxa.

The *Protea* savanna community is sub-divided into two distinct vegetation strata. The upper stratum is dominated by the Proteaceae species *Protea caffra* and *P. roupelliae* (46%), and to a lesser extent *Diospyros austro-africana* (Ebenaceae), *Cussonia paniculata* (Araliaceae), *Haleria lucida* (Scrophulariaceae), *Rhus discolor*, *R. lucida* (Anacardiaceae) and *Myrica serrata* (Myricaceae). Although these latter species often covered 5–10% of a single quadrat, the species rarely occurred in more than one or two of the 20 sampled quadrats. Non-arboreal species covered approximately 90% of the aerial cover and were dominated by the grasses (64%), with *Themeda triandra*, *Digitaria flaccida*, *Tristachya leucothrix*, *Elionurus muticus*, *Panicum natalense* and *Monocymbium cerasiiforme* being the most dominant. Within the grassland stratum Cyperaceae, Pteridophyta, Asteraceae, Anacardiaceae, Rosaceae and Myricaceae occur with aerial cover values greater than 2% of the total.

The *Podocarpus* forest community was divided into five strata (adopted from Killick 1963), namely an upper, dominant, tree layer; a small tree layer; a shrub and herbaceous layer which included grasses and sedges; a ground and boulder layer; and an epiphytic and climber community. The arboreal spectrum was dominated by *Podocarpus latifolius* (Podocarpaceae – 34%), with Celastraceae, Flacourtiaceae, Sapindaceae, Apocynaceae, Rubiaceae, Rutaceae and Cornaceae representing the more abundant taxa. The non-arboreal spectrum comprised a large percentage of Pteridophyta (27%), mostly large ground ferns of the species *Polystichum setiferum* var. *fuscopaleaceum*, *P. lucidum*, *P. luctuosum*, *Pteris captoptera*, *P. dentata* and *Blenchum punctulatum* var. *punctulatum*. Poaceae (22%) was the second most dominant non-arboreal taxa dominated by *Festuca africana*, *Stipa dregeana* var. *elongata*, *Oplismenus hirtellus* and *Ehrharta erecta* var. *natalensis*. Other prominent non-arboreal taxa were Cyperaceae, Iridaceae and Rutaceae (herb and shrub forms of the family). This community displays a high species diversity with a complex community structure and the total percentage aerial cover exceeds 100% due to stratification of the vegetation.

Sub-alpine belt

The *Leucosidea sericea* scrubland has an aerial cover of approximately 60% in the arboreal stratum and up to 90% in the non-arboreal, ground stratum. The former stratum is dominated by *Leucosidea sericea* (Rosaceae) which constitutes \pm 45% of the spectrum. Other arboreal families include Ebenaceae (*Diospyros austro-africana* and *Euclea crispa*) and Rhamnaceae (*Rhamnus prinoides*). The species *Erica evansii* (Ericaceae), *Buddleja salviifolia* (Loganiaceae), *Lithospermum afroontanum* (Boraginaceae), *Rhus dentata*, *R. lucida* (Anacardiaceae) and *Myrsine africana* (Myrsinaceae) are some of the other arboreal species.

Poaceae (32%) and Pteridophyta (30%) are the dominant com-

ponents of the non-arboreal spectrum. The fern *Pteridium aquilinum* subsp. *aquilinum* was the only Pteridophyta observed, while the dominant grasses include *Themeda triandra*, *Digitaria flaccida*, *Diheteropogon filiformis*, *Panicum ecklonii*, *Tristachya leucothrix* and *Miscanthus capensis*. The families Anacardiaceae, Cyperaceae, Ericaceae, Asteraceae, Boraginaceae, Euphorbiaceae, Labiatae, Loganiaceae, Rubiaceae, Geraniaceae and Scrophulariaceae are represented in abundances greater than 1% of the non-arboreal spectrum.

The *Rendlia altera* grassland is dominated by the grass *Rendlia altera* (22%), while the grasses *Elionurus muticus*, *Allotopsis semialata*, *Eragrostis racemosa*, *Harpochloa faix*, *Stiburus alopecuroides* and *Themeda triandra* were also evident. The Poaceae taxa comprise 55% of the total spectrum, while a further 14% comes from Cyperaceae, predominantly *Bulbostylis schoenoides*, *B. humilis*, *Kyllinga pauciflora*, *Cyperus semitrifidus* and *C. obtusiflorus* var. *obtusiflorus*. The herbs *Helichrysum* and *Aster* (Asteraceae) and *Hypoxis* and *Rhodohypoxis* (Hypoxidaceae) constitute a further 6% and 0.7% respectively.

The temperate grasslands are sub-divided according to topographic differences. The *Themeda triandra* and the *Festuca costata* grassland communities have a high proportion of Poaceae elements present, 61% and 76% respectively. The *Themeda triandra* grassland is dominated by *Themeda triandra*, *Elionurus muticus*, *Allotopsis semialata*, *Tristachya leucothrix* and *Cymbopogon validus*. Genera of the Asteraceae family, *Helichrysum*, *Senecio*, *Vernonia* and *Aster* have a 15% cover, whereas shrub forms of Anacardiaceae (5%) and Ericaceae (5%) contribute significantly to the assemblage. The *Festuca costata* community is dominated (\pm 50%) by the grass *Festuca costata*, whereas a diverse array of herbs, predominantly of the Asteraceae family, form the remainder of the more abundant taxa within this community.

Between the two grasslands, on the small plateaux and in the valleys, is an ecotone with elements from both grasslands as well as a host of shrubs (predominantly *Rhus*) and tall herbs of the genera *Helichrysum*, *Senecio* and *Kniphofia*. This community, described as Brackenveld by Killick (1978) and as 'Mixed' grassland in this study, is dominated by grass elements (62%), the most abundant being *Themeda triandra*, *Elionurus muticus* and *Festuca costata*, Anacardiaceae (16%) and Asteraceae (10%).

The hygrophilous, herbaceous or low-altitude vlei community is dominated by Cyperaceae (45%), the hygrophilous stemless rhizomatous herb *Gunnera perpensa* (15%) and Poaceae (12%). Cyperaceae species diversity is high, the more dominant species being *Carex cognate*, *Cyperus schlechteri*, *C. semitrifidus* and *Pycnus macranthus*. The more abundant grasses are *Stiburus alopecuroides* and *Harpochloa faix*. Within the sedge-grass community are a number of herbs, predominantly of the Brassicaceae, Ranunculaceae, Boraginaceae, Asteraceae, Dipsacaceae, Scrophulariaceae and Rosaceae families.

The sub-alpine fynbos arboreal element is dominated by the plant families Rosaceae (21%), Thymelaeaceae (20%) and Ericaceae (18%). The family Rosaceae comprises the species *Cliffortia linearifolia* and *C. spathulata*, Thymelaeaceae comprises *Passerina filiformis* and *P. montana*, and Ericaceae *Erica evansii* and *E. ebracteata*. The families Ebenaceae, Proteaceae, Rhamnaceae, Myrsinaceae and Celastraceae are represented in the arboreal spectrum with an aerial cover greater than 1%. The non-arboreal element reflects the diversity of the community, with Poaceae (mostly *Cymbopogon validus*, *Themeda triandra* and *Festuca costata*) and Asteraceae (*Helichrysum*, *Senecio* and *Aster*) contributing the largest non-arboreal cover values at 27% and 13% respectively. Thirteen other families have abundance values in excess of 1%.

Alpine belt

The summit or alpine grassland of the KwaZulu-Natal Drakensberg escarpment is dominated by the xeromorphic grasses *Merxmuellera disticha*, *Festuca caprina* and *Pentaschistis oreodoxa*. Grass associates include *Merxmuellera drakensbergensis*, *Agrostis barbuligera*, *Koeleria capensis* and *Eragrostis caesia*. The grasses comprise 64% of the total community cover, while the sedges, in particular *Scirpus falsus*, *Scirpus ficinioides*, *Schoenoxiphium filiforme* and *Isolepis costata* contribute a further 16%. Asteraceae genera such as *Senecio*, *Berkheya* and *Helichrysum* contribute a further 11%, Ericaceae (2%) and Juncaceae (2%) make up the remaining families with an aerial cover value in excess of 1%.

The dominants of the *Erica-Helichrysum* heathland are *Erica dominans* and *Helichrysum trilineatum*. Ericaceae (32%) and Asteraceae (30%) constitute the two dominant taxa, with Thymelaeaceae, Poaceae, Santalaceae, Rosaceae, Cyperaceae, Crassulaceae and Scrophulariaceae being the other taxa which contribute an aerial cover of 1% or greater.

The high-altitude vlei community is dominated by the sedges *Carex killickii*, *C. monotropha*, *Isolepis fluitans*, *S. ficinioides*

and *Schoenoxiphium filiforme*, and the grasses *Agrostis barbuligera*, *Pentaschistis oreodoxa* and *Merxmuellera drakensbergensis*. *Eriocaulon dregei* (Eriocaulaceae – 16%) and species of the families Asteraceae, Juncaceae, Ericaceae, Iridaceae, Scrophulariaceae, Aizoaceae, Hypoxidaceae and Fabaceae represent 1% or more of the aerial cover.

Classification

The TWINSpan division process was stopped at the sixth group level as additional variance, explained by subsequent divisions, was low and caused the division of particular communities into meaningless groups. The results of TWINSpan are represented as a dendrogram (Figure 3). If a sample size or 'grouping' of five or greater was obtained, within a split into a particular group, then it is acknowledged in the dendrogram.

Ordination

The ordination programme detrended correspondence analysis was applied to complement the TWINSpan classification technique. The first two DCA axes are plotted against each other,

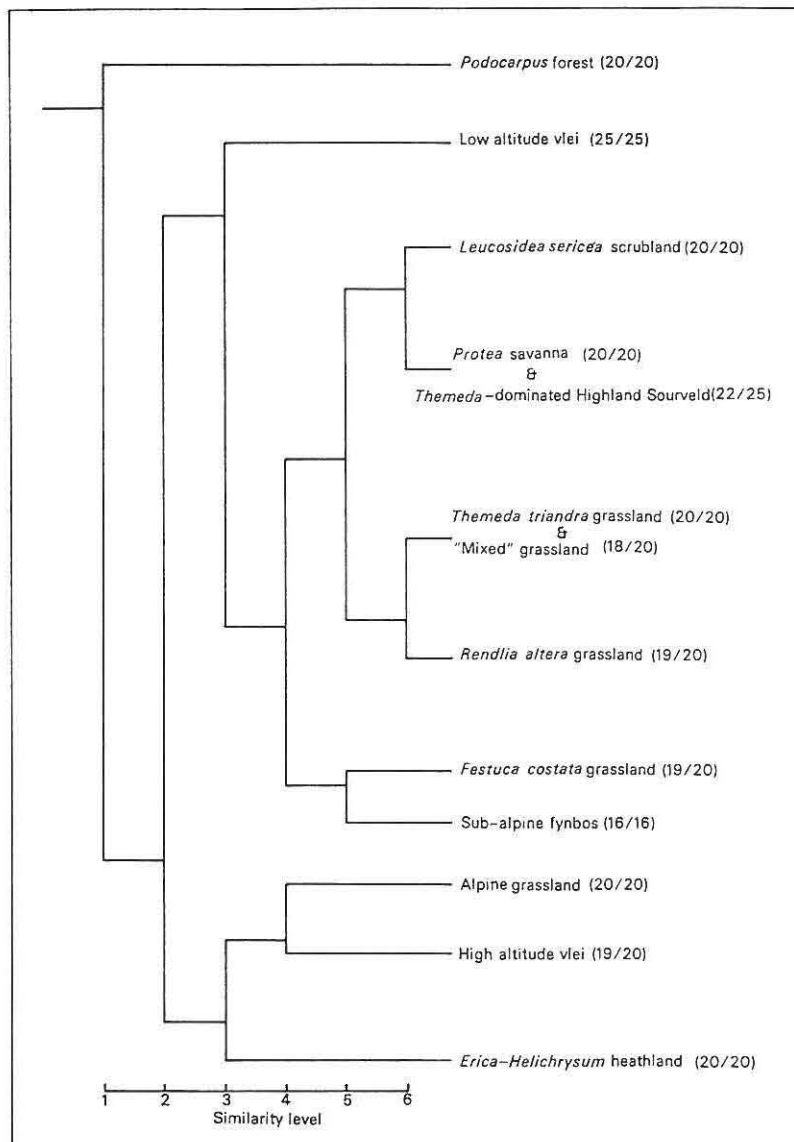


Figure 3 TWINSpan dendrogram of the vegetation data. The bracketed values represent the number of samples out of the total sample size which are classified together at level 6.

allowing for a visual comparison of the various samples and to permit observation of the resultant clustering of samples (Figure 4). Whereas the classification technique TWINSpan divided the samples according to differences, the ordination technique tends to group or cluster samples according to their similarities. Therefore a clustering of samples is indicative of a similarity between them which can be related to the initial vegetation community from which the samples were collected.

Discussion

Classification

As sampling was performed in distinctive vegetation communities, the final 'groups' should reflect this and a mixture of groups together at level six is indicative of communities with similar species composition. The TWINSpan dendrogram (Figure 3) reflects the homogeneity of the vegetation communities studied, with most quadrats from a community being representative of that community. The most heterogeneous community, based on TWINSpan output, is that of *Themeda*-dominated Highland Sourveld which is distinct in 22 of the 25 quadrats, while the remaining quadrats were dispersed between the groups of the other communities. The *Protea savanna* and *Themeda*-dominated Highland Sourveld remain grouped together after level 6. This is as a consequence of the understorey vegetation of the *Protea* community having a similar species composition as that

of the *Themeda*-dominated Highland Sourveld. A similar situation arises with the *Themeda triandra* and 'Mixed' grassland communities which have a number of species common to both.

The *Podocarpus* forest community divides off at level 1 of the vegetation analysis dendrogram as a consequence of its species, mostly arboreal taxa, not being represented in any of the other vegetation communities. Level 2 divides the three alpine communities from the remaining communities. The *Erica-Helichrysum* heathland is split at level 3 and high-altitude vlei and alpine grassland are divided at level 4. Of the remaining montane and sub-alpine communities, the low-altitude vlei is separated at level 3. Level 4 has the division of *Festuca costata* grassland and sub-alpine fynbos. These two communities are grouped together due to the species *Festuca costata* dominating the ground vegetation layer of both communities, albeit to a lesser extent in the fynbos. These two communities are divided at level 5 where the 'woody' *Protea* and *Leucosidea sericea* communities plus *Themeda*-dominated Highland Sourveld are split from the remaining sub-alpine grasslands. The *Leucosidea sericea* community is divided at level 6 from the *Protea* and *Themeda*-dominated Highland Sourveld communities. The *Rendlia altera* grassland is divided from *Themeda triandra* and 'Mixed' grasslands at level 6.

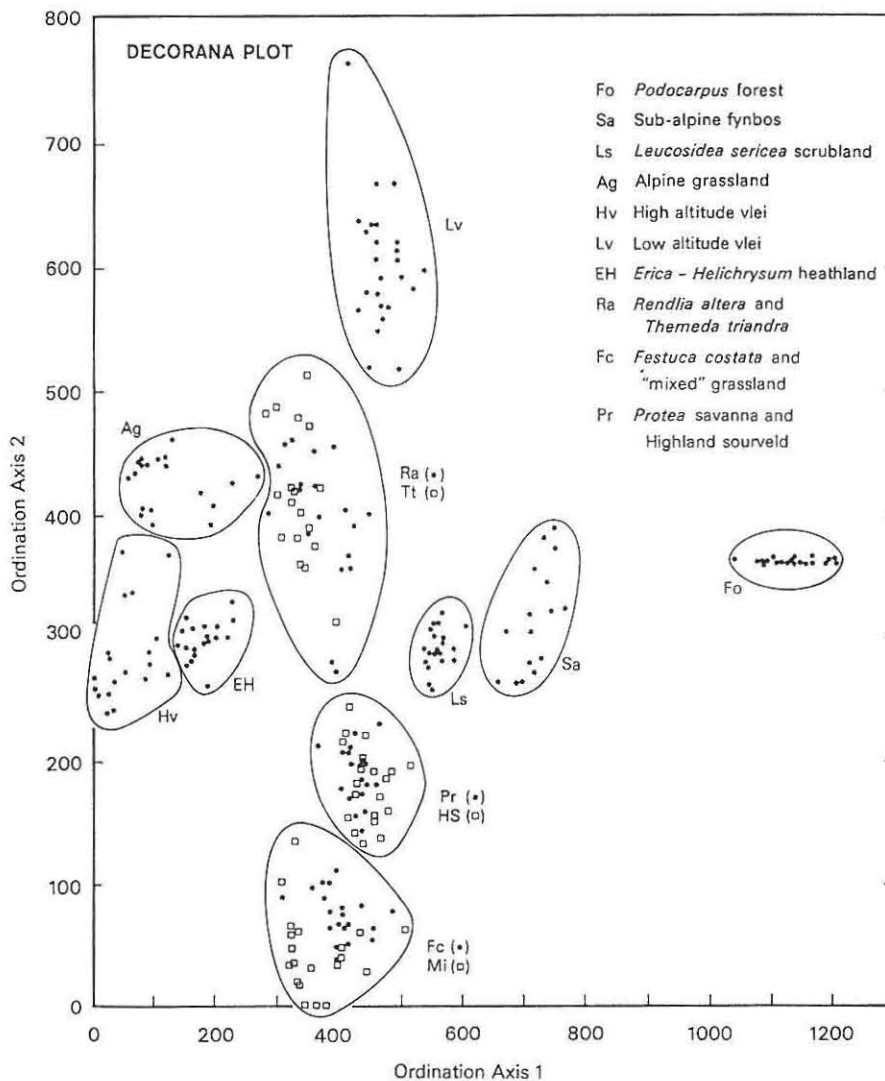


Figure 4 DCA plot of the vegetation data.

Ordination

The vegetation analysis plot displays distinct grouping of most of the vegetation communities studied, however, there is some overlap of the grassland-dominated communities (Figure 4). The three alpine communities form a separate group from the rest of the communities, as do the 'woody' components *Podocarpus* forest, sub-alpine fynbos and *Leucosidea sericea* scrubland. The low-altitude vlei community is also grouped as a separate entity. The communities which overlap and therefore have similar species compositions are the *Rendlia altera* grassland with *Themeda triandra* grassland, *Protea savanna* with *Themeda*-dominated Highland Sourveld, and *Festuca costata* grassland with 'Mixed' grassland. This grouping of communities does not reflect the same clustering pattern as the TWINSpan dendrogram. Whereas the TWINSpan dendrogram divides all the samples into units on the basis of distinct species, the DCA analysis combines samples depending on common species. Therefore, the three above-mentioned groups include two vegetation communities which are closely associated on the basis of taxa composition.

Conclusion

The TWINSpan dendrogram reflects the homogeneous assemblages as a consequence of the sampling strategy employed. Due to similar species composition, the *Protea savanna* and Highland Sourveld communities and the *Themeda triandra* and 'Mixed' grassland communities are grouped together. The dendrogram shows the distinctiveness of the individual communities, the fact that the communities can be separated as a consequence of their species composition and that the quadrats measured were representative of the particular community. The final grouping is of a number of samples which are closely associated with each other but distinct from the other groupings. This implies that all the samples within a group have a close affinity to each other, that they are distinct from the other groups of samples and that the samples are all representative of that particular group or, in this case, vegetation community.

DCA, although traditionally performed in conjunction with the classification technique of TWINSpan, does not produce similar results. Whereas TWINSpan divides the samples from an original group according to dissimilarities, DCA groups samples according to their similarities. The DCA vegetation plot forms distinctive sample concentrations for low-altitude vlei, *Podocarpus* forest, sub-alpine fynbos and *Leucosidea sericea* communities. The *Rendlia altera* and *Themeda triandra*, *Protea savanna* and Highland Sourveld, and *Festuca costata* and 'Mixed' grassland communities having similar species composition, are also grouped together. The three alpine communities form a separate grouping, and as they share some species, the concentration of samples of the individual communities is not as obvious. There is a tentative altitudinal gradient along the axis from the alpine communities through the sub-alpine grasslands and other sub-alpine communities to the *Leucosidea sericea* and sub-alpine fynbos communities, which are found predominantly in the river valleys, to the *Podocarpus* forest which is situated in the river gorges of the montane belt. From the DCA it is evident that a direct gradient-analysis approach, for example CCA, would prove to be a most worthwhile and pertinent next step in the vegetation analysis of the region.

In this study the vegetation community description is an inventory of species present within each of the recognized dominant communities. The study further notes, albeit indirectly, an obvious (as yet unmeasured, but possibly altitudinally related) environmental gradient. The classification and ordination analysis provides a good understanding of the representativeness of the samples within a particular vegetation community and the homogeneity, or in some instances similarity, between communities.

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