Rangeland condition in the Ceres Karoo- the importance of long-term studies

Craig M^c^Kune
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Department of Botany, University of Cape Town, Rondebosch, 7700

Abstract

The impact of the small stock industry on Succulent Karoo vegetation has long been acknowledged, and there is a need for researchers and managers to better understand the dynamics and processes leading to vegetation degradation and recovery. Despite the fact that these arid systems tend to hold high demographic inertia, as well as being prone to sudden and unpredictable events, there are few data-sets that are long enough (>50 yrs) to adequately distinguish 'noise' from true changes. This study examines an extensive data set of plant % cover, recorded using a rapid transect step-point technique, for the period between 1971 and 2002 throughout the Ceres Karoo. Correspondence analysis (CA) ordinations were used to show plant community changes from year to year at two sites: one that has been rested for many decades, and one that has used the Group Camp system since 1970. CA ordinations were also used to depict changes between 1992 and 2002 on three farms using different grazing systems. Results are discussed against the backdrop of the Stock Reduction Scheme initiated in the 1970's. Of the two farms examined from 1971 to 2002, the one using the group camp approach has shown an initial lag-period of about 10 years, and a subsequently steady and directional turnover of plant communities, increasing in cover of desirable species, until 2002. The rested farm showed no identifiable change. Of the farms studied between 1992 and 2002, a clear separation was found between the one using the Group Camp system and the others that are only grazed in winter. The former farm appeared to be showing the greatest amount of change. These results challenge the opinion that rested arid region veld is unlikely to recover. On the contrary, there has been a move toward more desirable veld since the 1970's in land that has not even been rested, but has had relatively reduced stock numbers. The more rested lands appear to be healthier than those that have been more frequently grazed, but they are not showing clear signs of change, supporting theories that arid region vegetation dynamics are characterised by a state and transition type of model. An important pattern to note is that changes from a degraded to a more desirable veld are characterised by a long lag period of more than 10 years, with subsequent changes occurring throughout a 20-year period. Thus the importance of allowing rangelands sufficient time to recover is highlighted, as is the importance of establishing, and continuing existing, long-term data sets.

Introduction

In the Ceres Karoo agricultural sub-region of the winter-rainfall region of South Africa, rangelands are currently the single most important economic resource. As it is a region of low rainfall with skeletal and saline soils, this area is suitable only for extensive pastoral use (Mackay and Zietsman, 1996). Utilization of arid shrublands globally, such as the Karoo, by domestic livestock, has resulted in changes in plant species composition that reduce the carrying capacity for these animals (Dean and Macdonald, 1994). The impacts of the small stock industry on Karoo vegetation have long been acknowledged (Roux and Vorster, 1983, Stokes, 1994), and predictions have been made about this leading to the expansion of Karoo vegetation (Acocks, 1975). As these arid areas have a low economic significance, relatively little attention was paid to their management until the 1930's. As human population size increases, however, there is an increasing pressure on these marginal resources, and efforts have increased that seek to improve and sustain production in these areas (Stokes, 1994). Since 1934 the Department of Agricultural Extension services has encouraged research and sustainable land use practices in these regions.

There is a need to understand the dynamics and processes leading to vegetation degradation, in order that these arid rangelands can be sustainably managed, and the state of the vegetation successfully improved. A theoretical understanding of vegetation dynamics as influenced by grazing and climate is needed, along with practical procedures in order to evaluate this theory. Little progress, however, has been made toward quantifying and understanding these processes in the Succulent Karoo, particularly when compared with other southern African rangelands. This problem is exacerbated by a lack of adequate farm management records, making it difficult to relate current vegetation composition to land use history (Stokes, 1994).

The Succulent Karoo (Fig. 1), forming the southwestern border of the Karoo, although arid, receives predictable moisture from winter rainfall and supports a rich succulent flora. The Ceres Karoo region occupies the valley of the Tanqua and Doorn rivers. It is flat country that ranges between 200 and 750 m above sea leavel, but mostly from 300 to 450 m (Acocks, 1975). The Roggeveld mountains to the east, and the Kouebokkeveld and Cedarberg mountains to the west cut the Ceres Karoo off from rainfall, and the whole region experiences only 150 mm of yearly rainfall, mainly in winter (Acocks, 1975). The most prominent succulents in the Ceres Karoo are the subfamilies Mesembryanthemoideae and

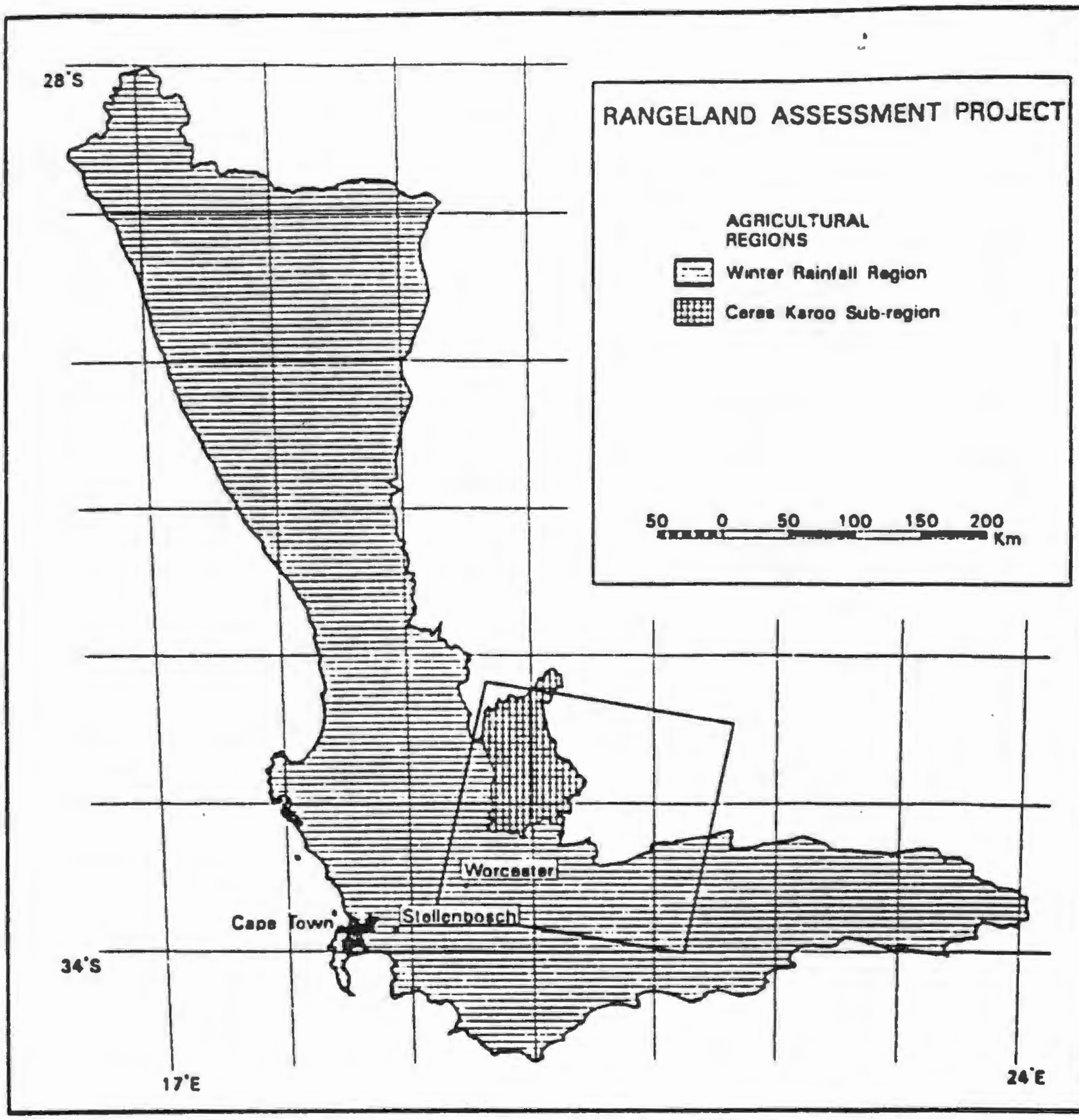

Figure 1. Location of the Ceres Karoo, Western Cape, South Africa (modified from Mackay and Zietsman, 1996).

Ruschioideae within the Aizoaceae. These, together with small woody shrubs, many of which are within the family Asteraceae, form apparently homogenous dwarf shrublands (Mackay and Zietsman, 1996; Stokes, 1994). Grasses such as *Stipagrostis obtusa* occur after good rains. Annuals and geophytes are numerous, but rarely seen. This region is poorly conserved and severely overgrazed and trampled, being eroded to bare shale in places (Acocks, 1975; Dean and Macdonald, 1994).

Current theories regarding arid to semi-arid rangeland vegetation change

In order that sustained animal production and species conservation can be effectively managed, it is important that an understanding of the dynamic behaviour of arid shrubland communities be grasped. Because research has been lagging in arid and semi-arid rangelands, other theoretical generalisations regarding rangeland dynamics have often been applied to these areas, often leading to inappropriate management practices.

Clements' work on succession as an important principle in rangeland dynamics described predictable, deterministic plant communities that successively replace each other by 'relay floristics' following a disturbance event such as grazing or drought (Luken, 1990; Stokes, 1994). The disturbance event was explained as bringing about vegetation changes that are the reverse of those associated with succession to a climax vegetation (Westoby *et al*, 1989a). This model, thus emphasizes the role of biotic forces in determining a plant community. The implication of this theory regarding rangeland dynamics is that degraded vegetation will be restored to its original healthy state once it has been rested. Karoo vegetative communities, however, display high demographic inertia, and the withdrawal of grazing pressure has frequently failed to show an improvement in veld condition, leading to much criticism of this model (Omar, 1991; Westoby, 1989a; Wiegand and Milton, 1996). Arid and semi-arid zones have been found to experience intense and unpredictable environmental stresses, and more recent reviews of the succession model have taken into account the stability and irreversibility of some vegetation conditions, as well as acknowledging the ability of successional pathways to be altered by environmental influence (Stokes, 1994).

Another common model is the state and transition model. This model suggests that the rare, episodic or event-driven changes that often characterise arid areas lead to a species composition that is 'stable' between events. The unpredictability of events tends to lead to rapid, discontinuous and unpredictable vegetation changes (Westoby *et al*, 1989a, Westoby *et al*, 1989b, Lockwood and Lockwood, 1993). This model emphasizes the importance of biotic and abiotic disturbance processes, the frequency or severity of which may be big enough to prevent vegetative recovery through successional forces. Demographic inertia and lag effects, whereby an established cohort of unpalatable species persists for a long time, may inhibit rehabilitation. This model thus emphasizes a non-equilibrial system of quasi-stable states. The state and transition model is more appropriate than the succession principle in arid systems, but the concepts of a stable 'state' and a completely transient 'transition' are not realistic, and are merely useful for the purposes of study (Stokes, 1994). Thus this model only suggests probable responses of a state to a transition factor, risking becoming merely a descriptive catalogue of vegetation change.

Roux and Vorster (1983), noting the instability and the state and transition nature of Karoo vegetation, identified five broad overlapping, but recognisable, phases of vegetation change, or desertification, that can be ascribed to the agricultural activities of humans over the past few centuries, particularly grazing by sheep. Phase 1, primary degradation, was characterised by the thinning out of valuable, productive and soil protecting species. This phase of vegetation, which would have initially developed in the mid 19th century, would rarely be found today, except in well conserved veld. Phase 2, primary denudation, would have been the time lag phase occurring as palatable and valuable vegetation was removed at a high rate that could not be compensated for soon enough by the slower increase in less palatable, grazing resistant and pioneer species. The result of this lag phase was a sparse vegetation cover that encouraged increased run-off and high rates of erosion. These effects massively decreased the rangeland grazing capacity. During Phase 3, named re-vegetation, bare, denuded patches of land were re-vegetated by species known to be unpalatable, invaders, Karoo pioneers and undesirable species. The general rangeland canopy cover thickened through this phase, and the vegetation appeared to reach a state of stability. Phase 3 is the current scenario of much of the Karoo vegetation, a phase offering an opportunity to manage the veld correctly, resting it and potentially moving back toward a Phase 1 type of vegetation. It is debatable, however, whether a reversal to Phase 1 is possible as much valuable soil potential to support the original vegetation was lost during the denudation phase. In addition to this, the stability or demographic inertia of Phase 3 vegetation may be difficult or impossible to reverse. Conversely, when the veld is further mismanaged and overgrazed, Phase 4 is reached, labeled as secondary degradation. This phase is characterised by a more or less permanent stable cover, dominated by one or two unpalatable or undesirable species. Ephemeral and annual herbaceous species typically characterise the floor cover, their density and development being strongly dependant on rainfall. Run-off and erosion rates are usually high and the grazing capacity of the land is typically low. The final phase of degradation, Phase 5, desertified phase, appears as high stocking rates and increased levels of soil loss destroy remaining vegetative cover.

Transformations between vegetative 'states' in arid systems may occur over long time spans that could well exceed that of a human life-span (Wiegand and Milton, 1996). Data bases assessing vegetative change, however, are not usually longer than a few years, and thus little is known about the long term dynamics of arid or semi-arid systems. In order to understand some of these long term processes and mechanisms, Wiegand and Milton (1996) developed a spatially explicit individual based model that simulates changes in a typical Karoo shrub community over time. The model is based on life-history attributes of five typical dominant plant species within a Karoo community, following the fate of each individual plant within the community, and exploring the effect of a realistic range of rainfall patterns on the ability of these species to compete, survive, grow and reproduce. Five scenarios were simulated over a 60 year period, showing that the time scale for changes of the dynamic state of the system are long compared with human life-spans, and that short-term community dynamics and community species compositions depend strongly on the short-term sequence of rainfall events. Simulations of the resting of ungrazed healthy rangeland indicated that the final state of the vegetation was unpredictable, varying by more than 37% after a 60-year period. Overgrazed rangelands were indicated to only show 7% improvement after a 60-year resting period, whilst heavily overgrazed lands were unlikely to recover at all. Active management, such as clearing of unpalatable shrubs resulted in only a 66% probability that the degraded land would be in good condition after 60 years. Simulated heavy grazing of a rangeland in good initial condition indicated that damage, or degradation would only become evident after 40-50 years, and that the land would reach a degraded state after 70 years. This model indicates the strong demographic inertia that determines the dynamics and vegetation composition of arid or semi-arid rangelands where plants are long-lived.

The importance of monitoring

Despite the fact that pastoral practices have been widely recognised as causing vegetation changes in South Africa, and especially the Karoo, there are very few data sets illustrating these changes that are robust enough to stand up to rigorous scrutiny (Mentis, 1989). It is difficult to produce data and analyses that unequivocally show that vegetation has changed, but identifying the cause of this change is an even more daunting task. Ecosystems must be accepted as being dynamic, with large short-term fluctuations hindering the identification of long-term patterns. This is particularly problematic in the Karoo where vegetation changes are driven by sudden and unpredictable events. The results of Wiegand and Milton's (1996) long-term modeling experiment indicated that research of Karoo rangeland vegetation change is of little use unless it spans time-scales that are generally greater than the life-span of a human.

The assessment of rangeland conditions and trends is a controversial subject, with much disagreement occurring among researchers and managers about adequate techniques and data interpretation (Friedel, 1991). Appropriate data gathering and interpretation methodologies must be developed in order to obtain site assessments to meet survey and monitoring objectives. Many indices of rangeland condition, or the 'state of health' of the vegetation (Tainton, in Stokes, 1994), have been developed over the past 50 years, where plants are categorised according to their responses to management, weightings are assigned to each category and an index is calculated from the abundances of plants in each category (Stokes, 1994). This score is generally compared to a standard, or 'ideal', vegetation according to management objectives. Examples of this approach are the ecological index method (Vorster, in Stokes, 1994), the benchmark method (Foran *et al*, in Stokes, 1994), the weighted palatability method (Barnes *et al*, in Stokes, 1994), the key species method (Hardy and Hurt, in Stokes, 1994), and the weighted key species method (Heard *et al*, in Stokes, 1994). Little progress has been made, however, toward objective measurement of Succulent Karoo degradation, due to the diverse flora with localized and patchy species distributions, and poor farm management records (Stokes, 1994).

Many researchers have used ordination techniques as a means of indirect gradient analysis of rangeland vegetation composition (Stokes, 1994). This method is indirect in that it seeks a gradient of an environmental variable from survey data alone, without the analysis requiring any reference to the environmental variable being considered. Thus it is crucial that the environmental factor being tested for is in fact the major contributor to variation in the data set. This method can be efficiently applied to a gradient of time, characterised by changes in land use history. The time gradient must be long enough, however, to detect true patterns of change, and not merely short-term vegetation changes. For instance, the long-term model described by Wiegand and Milton (1996), indicated that time scales of more than 50 years are necessary to observe changes occurring in Succulent Karoo vegetation. It is virtually impossible, however, for a researcher to devote enough time to a long-term study to make it truly useful in the context of the Karoo. In addition to this, a lack of adequate long-term land-use records of farms makes it difficult to successfully apply long-term research (Stokes, 1994). Another challenge in this field is to find a method of data collection that is adequate, easily applicable by different generations of researchers, and cost effective in that a given effort will yield results of adequate precision (Mentis, 1989).

It is clearly necessary for a long-term research effort to be established in the Karoo that is well organised enough and sufficiently funded and supported to continue over a time-span of more than 50 years. This effort needs to include the inputs of local farmers as to their requirements from the land, as well as their knowledge of past and current land-use practices. A clear, efficient and easy to follow method of data collection also needs to be established that is not confounded by individual bias and excessive sampling error. Plotless vegetation sampling techniques have been most popular due to their flexibility and practical efficiency in terms of time, manpower and equipment (Stokes, 1994). Two categories of plotless sampling techniques can generally be defined: intercept methods and plant distance methods. In the former, cover is estimated from the proportion of sampling units, such as points, out of the total that intercept vegetation (Cormack *et al*, in Stokes, 1994). Distance methods involve sampling the distance from either random points, or random plants, to the nearest neighbouring plants. Coupled with measurements of plant sizes, distance techniques can be used to estimate cover and size distributions. The use of distance methods is not, however, useful in the Karoo as the assumption of randomly distributed plants is usually invalid, and the advantages of plotless sampling become outweighed by the extra effort required (Stokes, 1994). Line and point based techniques have thus been favoured in the Karoo, despite the drawback that they generate only cover values.

Extensive data sets, recording % cover per species have been collected by the Department of Agriculture from 600 sites throughout the Succulent Karoo between 1966 and 1994. These data were collected using plotless intercept methods, and provide a good opportunity for a long-term analysis of rangeland vegetation change in the area. Rangeland vegetation changes can be related to the Stock Reduction Scheme (1969 to 1978) where farmers were encouraged to reduce their stock numbers greatly. For instance, in an interview with Mr. Theunissen, the current farmer at the 2330 ha farm Kareekolk in the Ceres Karoo, it was revealed that merino sheep numbers were reduced from about 700 to 75 animals in 1970. In return, the farmer was paid R500 per month. By 1980 the farmers were handed back the responsibility of maintaining their veld, and stock numbers once again increased, but generally were not as high as previously. Kareekolk, for instance, at present, keeps between 200 and 300 sheep on the farm at a given time, at Mr. Theunissen believes that the veld at Kareekolk is rapidly recovering.

Aims

The present analysis has extended the data set of a number of sites occurring in the Ceres Karoo by replicating the surveys in August 2002. This study aims to describe changes that have occurred in the vegetation at Kareekolk and at some surrounding farms using ordination techniques, demonstrating whether the 1970's Stock Reduction Scheme had any positive effect on the state of the state of the veld. After 30 years of reduced stock numbers and theoretically more sustainable farming practices, such as the group camp system, it is expected, in the light of succession theory, that the degraded vegetation will be moving toward a restored healthy state (Luken, 1990). The veld at Kareekolk has not, however, been given any extended rest. Furthermore, in the light of the high demographic inertia and unpredictability, as well as predictions that even rest is not sufficient to promote recovery, in Succulent Karoo vegetation (Omar, 1991; Westoby, 1989a; Wiegand and Milton, 1996), it is not expected that the results of this study will show any improvement in the vegetation at Kareekolk. At the Inverdoorn survey, where the vegetation has been ungrazed for a number of decades, and at Drooge Laagte and Groot-fontein, where the veld has been rested for large parts of every year since 1970, it is expected that the vegetation will show comparatively larger degrees of recovery.

This study is intended as a preliminary, or pilot study that can highlight the issues involved in an attempt to successfully and efficiently continue and reestablish the long-term survey of the state of the vegetation of the Ceres Karoo.

Methods

Study area

This study was conducted in the Ceres Karoo (Fig. 1), for which extensive rangeland survey data sets were available for comparison. The rangelands of the Ceres Karoo are considered to be relatively homogenous, compared to neighbouring vegetation types, however areas separated by fenceline boundaries tend to exhibit various stages of degradation, depending their history of use (Mackay and Zietsman, 1996)

The farm Kareekolk is located on the Ceres to Sutherland road, approximately 71 kilometers northeast of Ceres, and a few kilometers southeast of the confluence of the Grootrivier and the Doringrivier. Ten survey sites were chosen from the data sets on the farm Kareekolk, and the adjacently positioned Drooge Laagte and Groot-fontein farms (Table 1, Fig. 2). These sites were chosen in order to compare the effects of the different grazing systems used on Drooge Laagte and Groot-fontein, as opposed to those of Kareekolk, over the short time period between 1992 and 2002. Mr. Theunissen, the farm owner of Kareekolk, indicated that the Drooge Laagte and Groot-fontein lands have only been grazed by sheep in the winter months since 1970, and the land has been rested for the remainder of the year. Kareekolk has used the more intensive group camp system, whereby the farm has four camps, three of which are grazed at different times throughout the year, and the remaining camp is rested. Using this method, each camp is grazed at a different time every year.

Two more sites, IV1 and KK1, were chosen to be used for a long-term rangeland condition analysis (Table 1, Fig. 2) at the respective farms Inverdoorn and Kareekolk. These sites were chosen due to their having experienced differing grazing impacts since the early 1970's, the effects of which could thus be compared. According to staff at Inverdoorn, the land at IV1 has not been grazed over the past few decades due to a lack of water supply in the area.

Sites have been labeled as in the original data, with an abbreviation to denote the name of the farm and a number representing each site on that farm, for example: KK8 is the eighth site that was originally sampled at Kareekolk.

Raw data files contain precise details of each site, and are kept in the care of Anneline Swanepoel at the Elsenberg Agricultural College Pasture Research section.

Sampling technique

A rapid step-point technique of data collection was use by the Department of Agriculture in 1992 at the short-term sites KK8-KK11, DL1, DL2, and GF1-4, and was again replicated for this study from 20-22 August 2002. This technique involves walking a transect of paces of regulated size and number across the veld, recording the presence of any plant species that are present in the canopy above or below the samplers big toe. Care was taken to replicate the 1992 transects as accurately as possible, initiating them at the same points as in 1992,

Table 1. Survey site locations and time period covered by relevant analyses. Grid references indicate the starting and end points of the survey transects. Map number referes to the relevant 1:50 000 South Africa Topographical Series sheet. Detailed descriptions of each survey can be found in original data files (Elsenberg Agricultural College, Pasture Research Section, Anneline Swanepoel).

Survey site name	Farm	Time period	Starting-point grid reference	End-point grid reference	Map number	Location description
IV1	Inverdoorn	1971-2002	33^0 06' 53.7" S 19^0 49' 59.8" E	33^0 06' 52.0" S 19^0 50' 24.8" E	3319BB INVERDOORN	13 km south of Karrekolk southern boundary, to the east of Ceres to Sutherland road.
KK1	Kareekolk	1972-2002	32^0 58' 02.9" S 19^0 53' 26.6" E	32^0 57' 54.4" S 19^0 53' 27.2" E	3219DD KAREEKOLK	To the north of Kareekolk farmhouse road, approx. 2000 m from Ceres to Sutherland road gate.
KK8	Kareekolk	1992-2002	32^0 57' 26.1" S 19^0 55' 28.1" E	32^0 57' 11.1" S 19^0 55' 19.0" E	3219DD KAREEKOLK	To the south-east of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline, parallel and opposite to GF1, and adjacent to KK9.
KK9	Kareekolk	1992-2002	32^0 57' 51.2" S 19^0 55' 43.2" E	32^0 57' 36.3" S 19^0 55' 34.3" E	3219DD KAREEKOLK	To the south-east of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline, parallel and opposite to GF2, and adjacent to KK8.
KK10	Kareekolk	1992-2002	32^0 56' 45.8" S 19^0 55' 03.7" E	32^0 56' 31.0" S 19^0 54' 54.8" E	3219DD KAREEKOLK	Approx. 1500 m to the north-west of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline between Drooge Laagte and Kareekolk, parallel and opposite to DL1, and adjacent to KK11.
KK11	Kareekolk	1992-2002	32^0 56' 30.4" S 19^0 54' 51.2" E	32^0 56' 29.7" S 19^0 54' 31.1" E	3219DD KAREEKOLK	Approx. 1500 m to the north-west of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline between Groot-fontein and Kareekolk, parallel and opposite to GF3, and adjacent to KK10.
DL1	Drooge Laagte	1992-2002	32^0 56' 29.4" S 19^0 54' 31.3" E	32^0 56' 30.0" S 19^0 54' 50.4" E	3219DD KAREEKOLK	Approx. 1500 m to the north-west of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline between Drooge Laagte and Kareekolk, parallel and opposite to KK10, and adjacent to DL2.
DL2	Drooge Laagte	1992-2002	32^0 56' 28.6" S 19^0 54' 55.2" E	32^0 56' 13.1" S 19^0 55' 01.5" E	3219DD KAREEKOLK	Approx. 1500 m to the north-west of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline between Drooge Laagte and Groot-fontein, parallel and opposite to GF4, and adjacent to DL1.
GF1	Groot-fontein	1992-2002	32^0 57' 10.2" S 19^0 55' 18.9" E	32^0 57' 25.7" S 19^0 55' 28.5" E	3219DD KAREEKOLK	To the south-east of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline, parallel and opposite to KK8, and adjacent to GF2.
GF2	Groot-fontein	1992-2002	32^0 57' 36.2" S 19^0 55' 34.4" E	32^0 57' 51.4" S 19^0 55' 43.7" E	3219DD KAREEKOLK	To the south-east of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline, parallel and opposite to KK9, and adjacent to GF1.
GF3	Groot-fontein	1992-2002	32^0 56' 31.4" S 19^0 54' 55.3" E	32^0 56' 45.9" S 19^0 55' 03.8" E	3219DD KAREEKOLK	Approx. 1500 m to the north-west of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline between Groot-fontein and Kareekolk, parallel and opposite to KK11, and adjacent to GF4
GF4	Groot-fontein	1992-2002	32^0 56' 13.1" S 19^0 55' 02.0" E	32^0 56' 28.7" S 19^0 54' 55.6" E	3219DD KAREEKOLK	Approx. 1500 m to the north-west of Ceres to Sutherland road at north-east fenceline boundary between Kareekolk and Groot-fontein. Runs parallel to fenceline between Drooge Laagte and Groot-fontein, parallel and opposite to DL2, and adjacent to GF3.

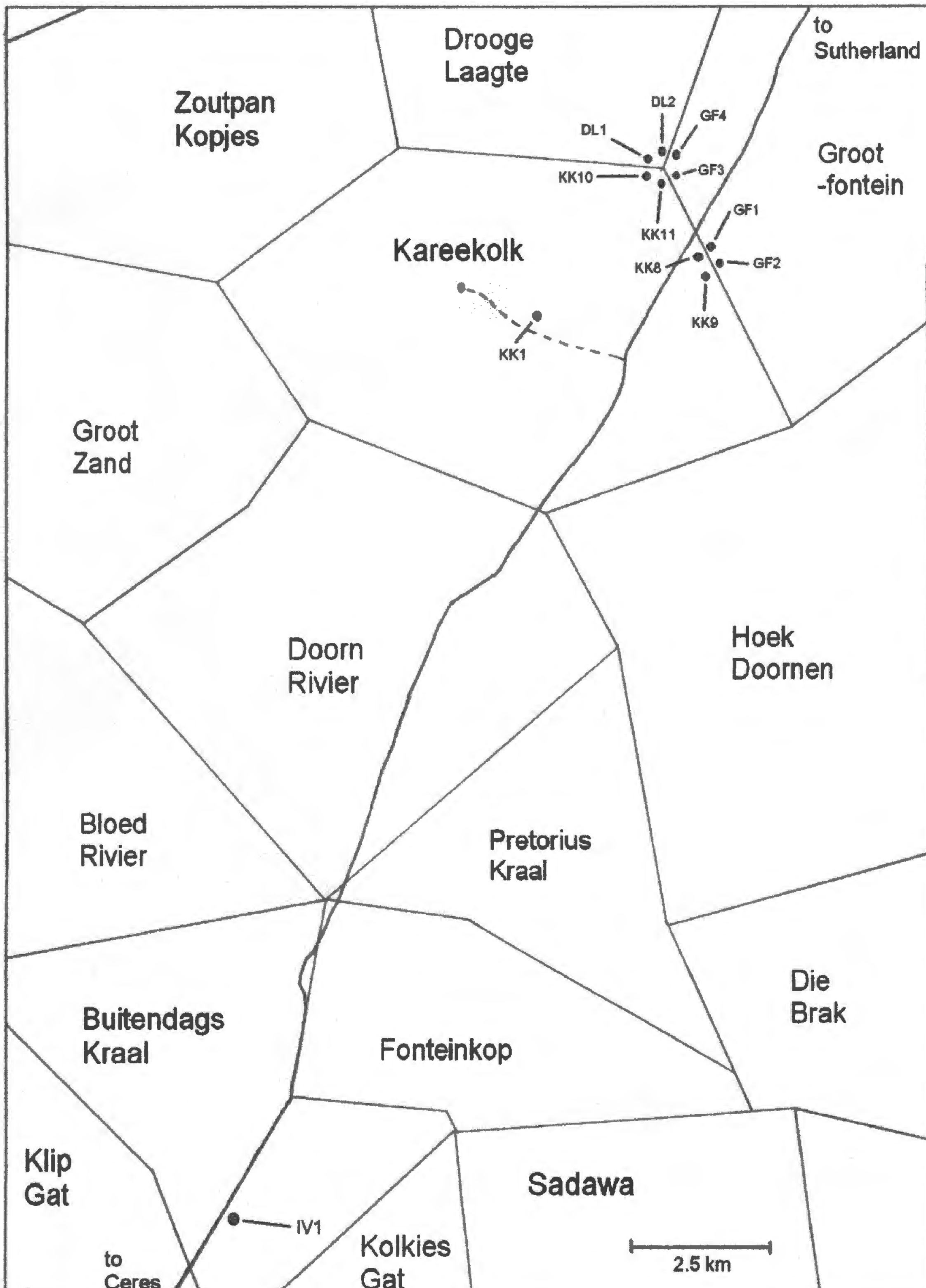

Figure 2. Locations of the Kareekolk (KK), Groot-fontein (GF), Drooge Laagte (DL) and Inverdoorn (IV) surveys and surrounding farms.

running parallel to the fence at the same distance of five paces. For these sites a transect length of 630 paces was used to yield a representative sample of the veld.

The two long term sites KK1 and IV1 were originally sampled in 1972 and 1971 respectively, and then each year throughout the remainder of the 1970's, early 1980's, mid-1980's (Inverdoorn only), and in 1989 (Inverdoorn only), 1990 and 1992. The sampling was then replicated again for the purposes of this study. Earlier sampling was undertaken using a fixed-point survey where a chain was used to mark each meter along a transect and a dropper was used to mark a point on the ground from which the presence or absence of any plant species was recorded. More recent surveys since 1989, including the 2002 replication, have used the more rapid step-point method as described above. The transects at these two sites are each 1000 metres in length, variation in pace length, however, has caused this to be an approximate measurement. The 2002 IV1 survey was thus 1167 paces long, and the KK1 survey was 1036 paces long.

Analysis

For the purposes of the analysis, *Atriplex lindleyi* and *A. semibaccata* have been grouped together as *Atriplex* spp. as they are difficult to distinguish from one another and their separation may falsely skew the analysis. Similarly, records for *Delosperma pageanum* have been incorporated into *Delosperma* sp., and *Galenia secunda* has been grouped with *G. fruticosa*.

The numbers of scores for each species were converted into percentage cover of the total amount of paces. Ordinations for all the short-term sites, KK1 and IV1 were performed using species percentage cover data. For each of the three ordinations, species data was only used if the species occurred at an average of more than one strike for all samples, as rare species skewed the ordination results.

For the short-term analysis, the results of KK9 were excluded due to uncertainty as to the accuracy of the 2002 transect replication. Three transects for 1992 and 2002 respectively were thus used from Kareekolk, and of the adjacent farms two transects were used from Drooge Laagte and four from Groot-fontein. 18 samples and 12 species were thus used in the short-term ordination.

Bray-Curtis % similarity values for each of the nine short-term sites between 1992 and

2002 were calculated, using a fourth-root transformation. High % similarity values indicated a lack of change in the floristic community and low values conversely indicated high levels of community change. A Student's t-test was performed at a 0.05 probability level to test the null-hypothesis that there is no significant difference between the % similarity values of Kareekolk and those of its adjacent farms, Groot-fontein and Drooge Laagte.

Sphalmanthus usitatus was excluded from the KK1 analysis as it had a disproportionate affect on the ordination. For this analysis 13 samples (one per sample year) and 11 species were used.

Ruschia sp. was excluded from the IV1 analysis because it was unlikely that other researchers have recognised it as a separate *Ruschia* species, and it had a distorting effect on the ordination, as did *Sphalmanthus usitatus* and *Drosanthemum lique*, which were also both excluded. For this analysis 19 samples (one per sample year) and 19 species were used.

For the ordination the FORTRAN program CANOCO (Ter Braak, 1988) was used. For all three datasets a correspondence analysis (CA) was performed. A CA is an indirect gradient analysis technique that searches for major gradients in the species data, irrespective of environmental variables, which are later used to interpret the species data (Ter Braak, 1988). CANOCO assigns eigenvalues to the first four axes of variation. Eigenvalues indicate the strength of each axis, thus an axis with an eigenvalue of 1 explains 100% of the variation in that direction (Ter Braak, 1988).

A regression analysis was used to test the null-hypothesis that there is no relationship between the % crown covers at the Kareekolk and Inverdoorn long-term sites.

Two similarity matrices were created, using the Bray-Curtis technique and fourth-root transformations, to show similarities between sample years at both KK1 and at IV1 respectively.

Results

Short-term analysis

Table 2 (Appendix) shows the percentage cover of all 28 species recorded at all 10 short-term sites, as well as the total percentage crown cover for each sample.

Figures 3 and 4 show the results of the short-term ordination. The eigenvalues for axes-1 and 2 are 0.37 and 0.08 respectively (Fig's 2 and 3), indicating a weak site separation along these axes. The sites have been separated along axis-1 into two essential groups: one, to the left, contains all of the Kareekolk (KK) samples, and the other, to the right, contains all samples from the adjacent farms (GF+DL). Of the KK samples, KK8 and KK10 show relatively large changes in the same direction along axis-2, but KK11 shows barely any change. Of the GF+DL samples, there was a similar directional change along axis-2 for GF1, GF4 and DL2. The latter samples, however, show a comparatively small change, and the directionality of the change is not as obvious as at KK. GF2 and GF3 do not share the previously mentioned directionality, and neither does DL1, which has barely changed at all.

Table 3 shows the mean percentage cover, and standard deviations, per dominant species on Kareekolk and on Groot-fontein and Drooge Laagte, the latter two farms being grouped together due to their similar grazing systems. KK showed a total decrease in crown cover of 11%, whilst GF+DL only showed a decrease of 2%. The mean total % crown covers at GF+DL were higher in both years at 45.8% and 44.0% in 1992 and 2002 respectively versus 37.7% and 30.3% at KK. On all farms there was a 100% increase, or an appearance, of *Delosperma* sp. and *Zygophyllum microphyllum*, and a 100% decrease, or a disappearance, of *Ruschia* cf. *muricata* between 1992 and 2002. This result is evident in the ordination (Fig's 3 and 4) where it can be seen that these three species play an important role in spreading the sites along axis-2, which, in the case of KK8, KK10, GF1, GF4 and DL2, means that these sites' communities have changed substantially from 1992 to 2002. The ordination (Fig's. 3 and 4) shows *Aridaria* sp. to be important in separating sites along axis-2, however it's percentage cover in 2002 was low enough to show no mean presence, as shown in Table 3. *Aridaria noctiflora*, *Drosanthemum ebemeum* and *Ruschia spinosa* are shown in the ordination (Fig's. 3 and 4), to be important in separating the samples along axis-1. *A. noctiflora* had a higher mean percentage cover of 7.3% and 7.8% in 1992 and 2002 respectively at KK than at GF+DL, which had respective covers of 2.5% and 1.5%. In addition to this the change in cover was a 3% increase at KK and a 25% decrease at GF+DL. *D. ebemeum* was present at a higher % cover at KK (0.5% and 0.4%) than at GF+DL (0.1% and 0.1%) in both 1992 and 2002 respectively, however it did show a small relative decrease in cover over time. *R. spinosa* had a stable % cover over time, however it was substantially more common at GF+DL (23.8% and 24.8%) than at KK (0.1% and 0.1%)

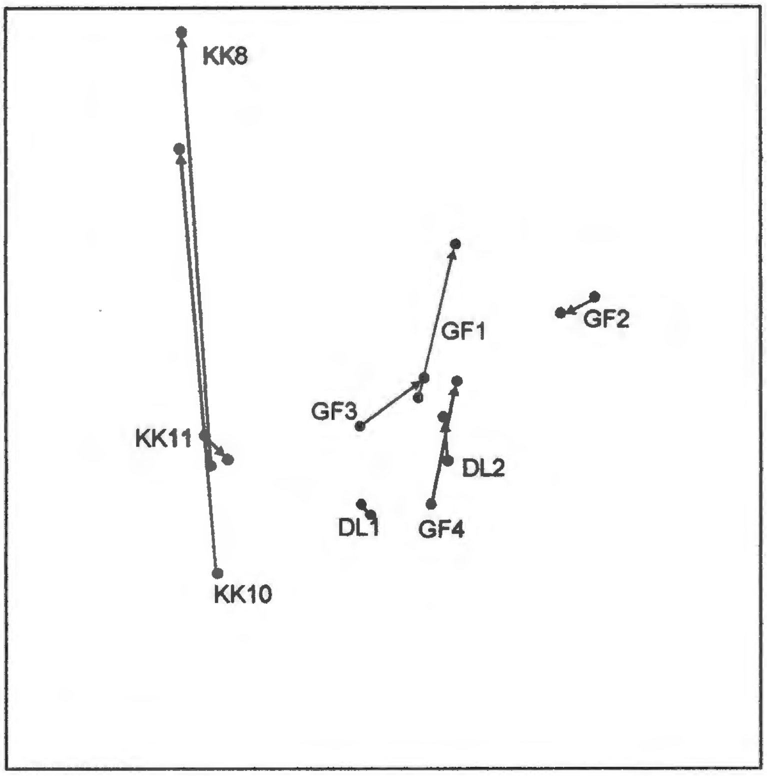

Figure 3. CA ordination showing the plant community separation of short-term sample surveys according to % cover. Eigenvalues for axes 1 and 2: 0.37 and 0.08 respectively. Arrows indicate direction of change per survey from 1992 to 2002.

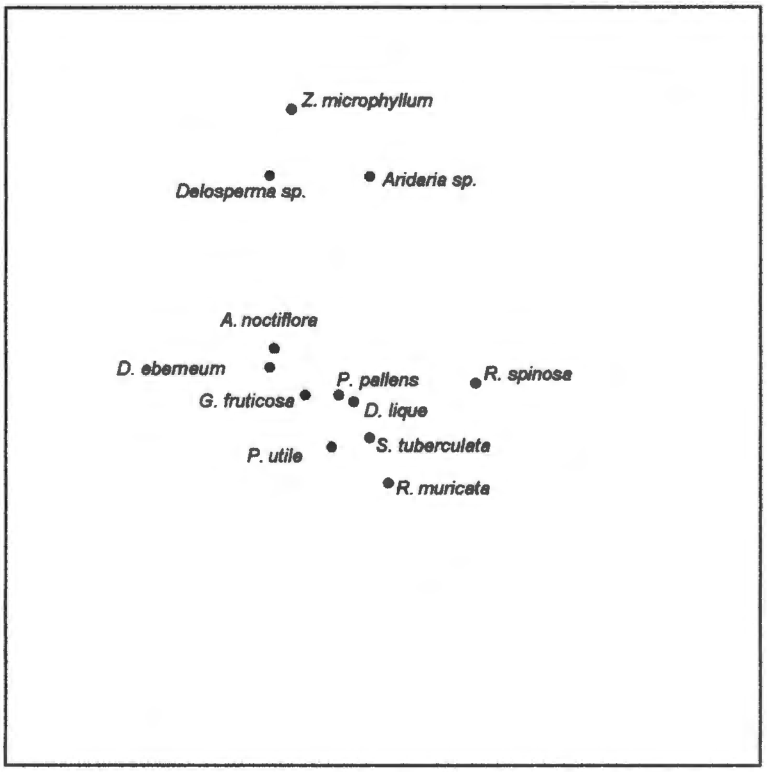

Figure 4. CA ordination as in Figure 3, using identical axes, showing spread of species (as in Table 3) occurring at an average percentage cover of more than 1% for both 1992 and 2002.

Table 3. Mean % cover of non-rare (see text for explanation) species in 1992 and 2002 at Kareekolk (KK) and the adjacent farms, Groot-fontein (GF) and Drooger Laagte (DL). Crown cover is also shown, as this the percentage increase (+) or decrease (-) in cover.

Species	Kareekolk (n=3)					Groot-fontein & Drooge Laagte (n=6)				
	1992		2002		%	1992		2002		%
	Mean	S.D.	Mean	S.D.	change	Mean	S.D.	Mean	S.D.	change
Aridaria noctiflora	7.3	+/- 1.8	7.8	+/- 5	3	2.5	+/- 1.9	1.5	+/- 0.7	-25
Aridaria sp.	0.0	0	0.0	+/- 0.1	0	0.0	0	0.0	+/- 0.1	0
Delosperma sp.	0.0	0	1.4	+/- 1.7	100	0.0	0	0.3	+/- 0.4	100
Drosanthemum eberneum	0.5	+/- 0.5	0.4	+/- 0.4	-11	0.1	+/- 0.1	0.1	+/- 0.1	0
Drosanthemum lique	1.3	+/- 1	0.4	+/- 0.8	-53	0.6	+/- 0.5	0.7	+/- 0.8	8
Galenia fruticosa	1.7	+/- 1	1.2	+/- 0.2	-17	0.4	+/- 0.3	0.8	+/- 0.4	33
Psilocaulon utile	9.7	+/- 3.6	3.7	+/- 2.5	-45	6.2	+/- 3.4	3.6	+/- 2.8	-27
Pteronia pallens	15.7	+/- 2.6	13.6	+/- 0.9	-7	10.7	+/- 4.9	10.8	+/- 3.1	0
Ruschia cf. *muricata*	0.2	+/- 0.3	0.0	0	-100	0.6	+/- 0.7	0.0	0	-100
Ruschia spinosa	0.1	+/- 0.1	0.1	+/- 0.1	0	23.8	+/- 10	24.8	+/- 11.3	2
Salsola tuberculata	0.5	+/- 0.4	0.4	+/- 0.4	-11	0.8	+/- 0.6	0.5	+/- 0.5	-23
Zygophyllum microphyllum	0	0	0.5	+/- 0.8	100	0.0	+/- 0.1	0.1	+/- 0.2	100
Total crown cover	**37.7**	**+/- 2.9**	**30.3**	**+/- 10.5**	**-11**	**45.8**	**+/- 2.9**	**44.0**	**+/- 6.8**	**-2**

Table 4. % Similarity between 1992 and 2002 surveys at Kareekolk (KK) and the adjacent farms, Groot-fontein (GF) and Drooger Laagte (DL).

Plot no.	% Similarity between 1992 and 2002 surveys
Kareekolk	
KK8	55.3
KK10	73.8
KK11	81.7
mean	**70.3**
Adjacent farms	
GF1	65
GF2	69
GF3	86.6
GF4	78.1
DL1	88.6
DL2	81.8
mean	**78.2**

in 1992 and 2002 respectively. *Pteronia pallens* appeared to be stable on both farms, only decreasing by 7% at KK. It was, however, present at slightly higher % covers in both years at KK (15.7% and 13.6%) than at GF+DL (10.7% and 10.8%). *Drosanthemum lique*, although present at similar % covers on both farms, has decreased by 53% at KK, whilst it has increased by 8% at GF+DL. *Galenia fruticosa* has decreased in % cover by 17% at KK, but increased by 33% at GF+DL. *Psilocaulon utile* decreased from 1992 to 2002 by 45% at KK and by 27% at GF+DL. *Salsola tuberculata* was present at similar % covers on both farms, decreasing by 11% and 23% at KK and GF+DL respectively.

The results of the Students T-test were t=-1.04 and p=0.45, which is insignificant at the 0.05 probability level. Thus the null-hypothesis was accepted that there was no significant difference between the % similarity values of KK and GF+DL shown in Table 4. This result reveals that although the KK samples appeared, in the ordination (Figs. 3 and 4), to have changed more than those of GF+DL, these changes in floral community composition were not significantly different.

Long-term analyses

Table 5 (Appendix) shows the percentage cover of all 25 species recorded from all 13 sample years between 1972 and 2002 for each sample at the Kareekolk long-term survey site (KK1).

The KK1 ordination diagram is shown in Figure's 5 and 6. The eigenvalue for axis-1 is 0.25, and for axis-2 is 0.03, indicating a weak site separation along these axes. The primary site separation along axis-1 indicates that the floral community at KK1 has been changing since 1980. Species that characterize the earlier samples between 1972 and 1981, as can be seen in Figure 7, Table 6 and in the ordination species spread (Fig. 5 and 6), include *Delosperma* sp. and *Psilocaulon utile*. *Delosperma* sp. peaked at 10.1% cover in 1975 and then dropped to 1.2% and 1.3% in 1992 and 2002. *P. utile* peaked in 1977 at 8.7% cover, dropped to 1.9% in 1981, and increased again by 2002 to 5.4%. Species that have increased in % cover in the later samples from 1990 to 2002 include *Aridaria noctiflora*, *Galenia fruticosa* and *Pteronia pallens* (Fig's. 6 and 7, Table 6), as well as *Salsola tuberculata*, *Brownanthus ciliatus* and *Ruschia spinosa*. *A. noctiflora* was absent in all samples previous to 1992, where it was present at 4.9% and then at 2.3% in 2002, *G. fruticosa* peaked in 2002 at 2.5% cover, and *P. pallens*, although consistently present between 4.1% and 6.9%, peaked in 1992 and 2002 at 14.4% and 14% respectively. *S. tuberculata*, *B. ciliatus* and *R. spinosa* were either

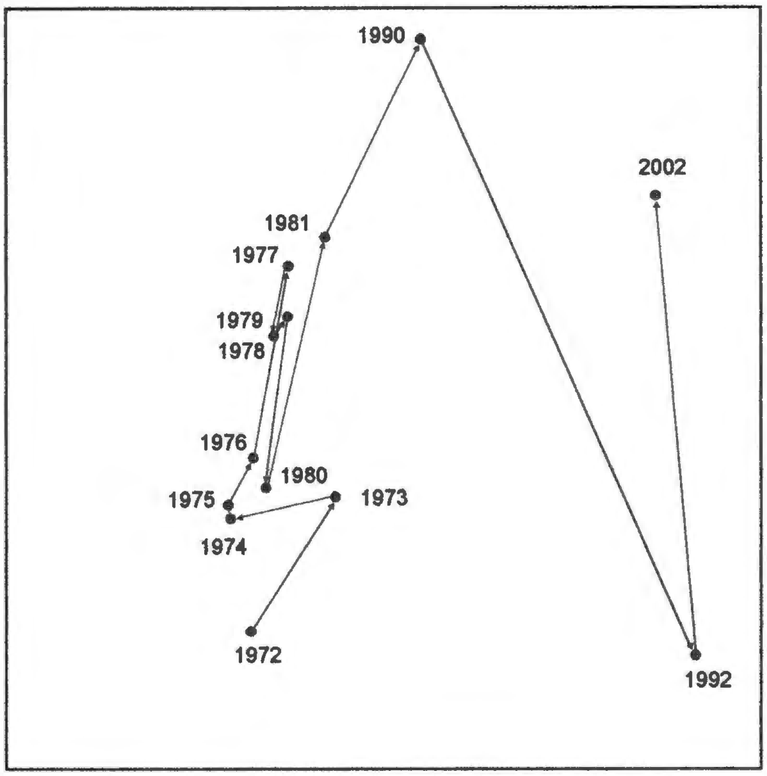

Figure 5. CA ordination showing changes in the plant community at KK1, according to % cover. Eigenvalues for axes 1 and 2: 0.25 and 0.03 respectively. Arrows indicate the relative direction of change from 1972 to 2002.

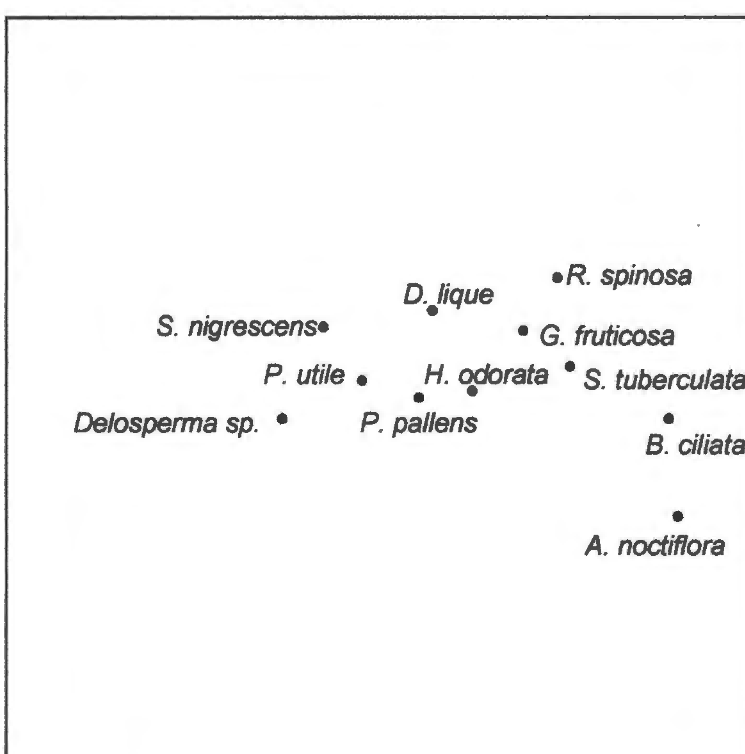

Figure 6. CA ordination as in Figure 5, using identical axes, showing spread of species (as in Table 4) occurring at an average percentage cover of more than 1% for all years.

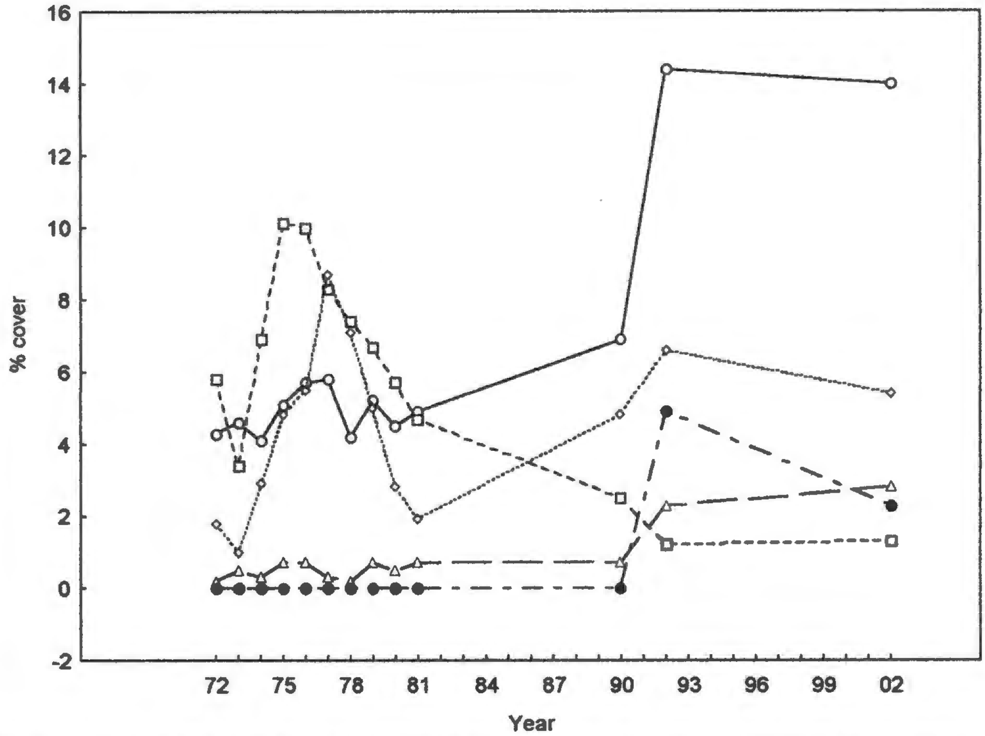

Figure 7. Fluctuations in % cover of *Pteronia pallens* (solid, circles), *Delosperma* sp. (Dashed, squares), *Psilocaulon utile* (dotted, diamonds), *Hereroa odorata* (dashed, triangles) and *Aridaria noctiflora* (dashed, filled circles) at Kareekolk (KK1) from 1972 (72) to 2002 (02) .

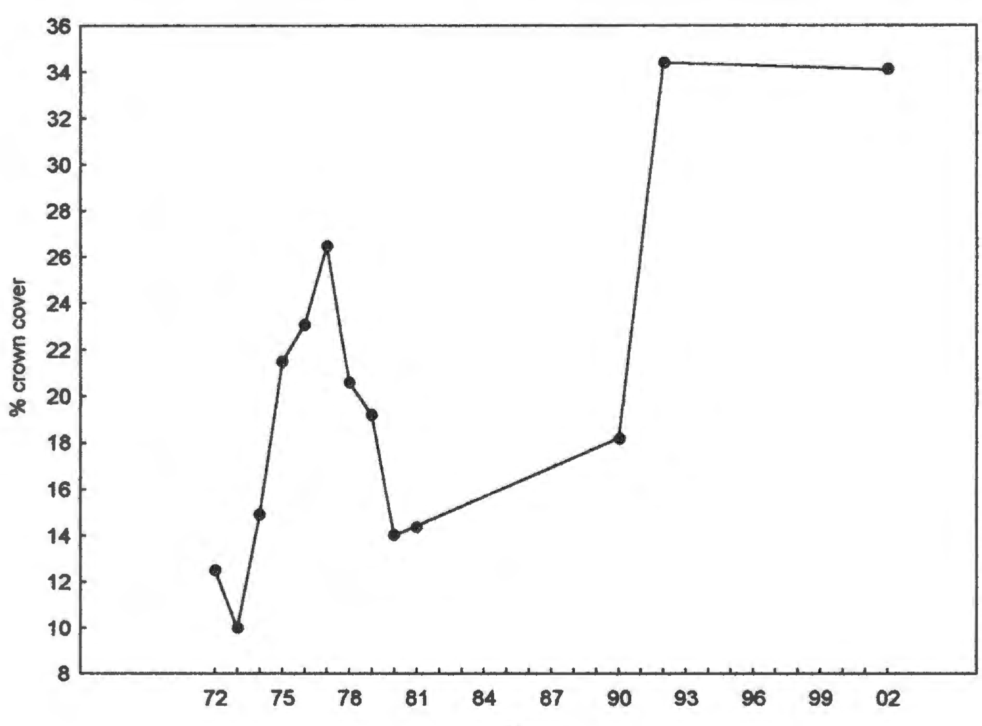

Figure 8. Fluctuations in % crown cover at Kareekolk (KK1) from 1972 (72) to 2002 (02) .

Table 6. % cover of non-rare (see text for explanation) species as sampled at Kareekolk (KK1) from 1972 to 2002.

Species	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1990	1992	2002
Aridaria noctiflora	0	0	0	0	0	0	0	0	0	0	0	4.9	2.3
Brownanthus ciliatus	0	0	0	0	0	0	0	0	0	0	0	0.8	0.9
Delosperma sp.	5.8	3.4	6.9	10.1	10	8.3	7.4	6.7	5.7	4.7	2.5	1.2	1.3
Drosanthemum lique	0	0.3	0.1	0	0.5	0.8	0.3	0.5	0.1	0.7	1.1	0.9	1.2
Galenia fruticosa	0	0	0	0.1	0.2	0.7	0.5	0.2	0	0.4	0.4	1.4	2.5
Heroroa odorata	0.2	0.5	0.3	0.7	0.7	0.3	0.2	0.7	0.5	0.7	0.7	2.3	2.8
Psilocaulon utile	1.8	1	2.9	4.8	5.5	8.7	7.1	5	2.8	1.9	4.8	6.6	5.4
Pteronia pallens	4.3	4.6	4.1	5.1	5.7	5.8	4.2	5.2	4.5	4.9	6.9	14.4	14
Ruschia sp.	0	0	0	0.1	0.1	0	0	0.1	0	0	0.2	0.2	1
Salsola nigrescens	0	0	0.6	0.5	0.2	0.5	0.3	0.7	0.4	0.9	0.5	0	0.5
Salsola tuberculata	0.1	0	0	0	0	0.1	0.3	0	0	0	0.3	0.9	1.1
Sphalmanthus usitatus	0	0	0	0	0	1	0	0	0	0	0.6	0	0
Total crown cover	**12.5**	**10**	**14.9**	**21.5**	**23.1**	**26.5**	**20.6**	**19.2**	**14**	**14.4**	**18.2**	**34.4**	**34.1**

Table 8. % cover of non-rare (see text for explanation) species at Inverdoorn (IV1) as sampled from 1971 to 2002.

Species	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1987	1989	1990	1992	2002
Antimima hantamensis	1.5	1.6	1.6	1.7	2.1	2.3	2.1	1.8	1.8	1.7	1.6	1.4	1.5	1.5	1.5	1.5	1.8	2.3	0
Cladoraphis spinescens	0	0	0	0	0.2	0.3	0.1	0.2	0.1	0.2	0.3	0	0.3	0.2	0.3	0.1	0.1	0.5	0
Delosperma sp.	2.6	3	2.6	2.5	2.5	5.9	4.7	3.1	4.5	1.8	1.5	0.7	0.6	4.5	6.8	1.4	2.2	0	2.5
Drosanthemum calycinum	0	0	0.1	0.2	0.4	0	0.2	0	0.2	0	0.1	0	0.2	0.2	0.7	0.4	0.4	0	0
Drosanthemum lique	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.8
Eriocephalus ericoides	0	0.1	0	0	0.2	0	0	0	0.1	0	0.2	0.2	0	0.1	0.1	0.2	0.1	0.3	0.4
Eriocephalus spinescens	0.2	0.1	0	0.1	0.1	0.3	0.4	0.1	0.2	0.5	0	0	0.3	0.2	0.2	0.1	0.1	0.7	0.4
Galenia africana	0.3	0.5	0.7	0.2	1.1	0.7	0.9	1.1	0.8	0.9	1.8	1.5	2.5	1.3	1.3	2	2.5	2.5	0.6
Galenia fruticosa	0.4	1.5	0.4	1	0.8	2.6	1.6	1	1	0.8	2.7	3.7	3.4	3.2	2.2	1.1	1.4	2.6	3
Leipoldtia jacobseniana	3.1	3.4	3.3	3.6	4.5	4.9	4.4	3.9	3.8	3.5	3.5	3	3.2	3.3	3.2	3.3	3.9	5.5	6.6
Lycium arenicolum	0.7	0.2	0.7	0.2	0.3	0.1	0.4	0.1	0.3	0.4	0.5	0.8	1	0.8	0.7	1	0.7	0.3	0.8
Phyllobolus spinuliferus	0.1	0.3	0.1	0.3	0.2	0.4	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.5	0.3	0.3	0.2	0.4	0.1
Psilocaulon utile	0.8	0.7	0.3	0.2	0.8	1.2	1.5	1.5	0.8	0.9	0.4	0.5	0.8	0.7	0.5	0.5	1	0.9	0.4
Pteronia pallens	0	0.8	1.3	0.8	0.8	1.3	1.4	1.6	1.5	0.5	1.3	0.9	0.1	1.1	1.1	1.8	0.9	0.7	1
Rhinephyllum macradenium	0.4	1.2	0.1	0.4	0.2	0.3	0.4	0	0.1	0.4	0.1	0.3	0.2	0.8	0.7	0.5	0.3	0.6	0.6
Ruschia sp.	1.2	0	0.1	0	0.2	0.1	0.2	0.4	0	0	0.2	0.2	0.1	0	0.1	0	0	5.8	0.3
Ruschia spinosa	19.2	21.4	20.8	22.6	27.9	30.4	27.6	24.2	23.6	22.1	21.8	19	20	20.4	20.3	20.4	24.1	24.8	34.7
Salsola nigrescens	0.2	0.1	0.1	0	0.2	0.4	0	0.1	0.1	0.1	0.3	0.2	0.3	0	0.3	0.3	0.1	0	0
Sphalmanthus usitatus	0	0	0	0	0.4	0	0	0	0	0	0	1	3.1	0	0	0	0.1	0	0
Tetragonia fruticosa	1.2	0.3	0.5	1	1	1	0.8	0.9	0.7	0.4	1	1	1.6	1	0.4	0.7	0.4	1	1.2
Tripteris sinuatum	0	0.1	0.1	0.3	0.8	0.7	0.1	0.1	0.2	0	0.2	0.4	0.7	0.5	0.1	0.1	0.4	0.7	1.5
Zygophyllum microphyllum	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.2	0.3	0.4	0.2	0.4	0.2	0.3	0.2	0.1	0.1	0.2
Total crown cover	**33**	**36**	**34**	**36**	**46**	**54**	**48**	**41**	**41**	**35**	**38**	**35**	**41**	**41**	**42**	**36**	**41**	**55.3**	**58**

absent or present at low % covers between 1972 and 1981, however their abundances had increased to 1.1%, 0.9% and 1% respectively in 2002. Site separation in the plane of axis-2 was unlikely to be important due to the low eigenvalue associated with that axis.

Total % crown cover increased from 1972 to 2002, with peaks of 26.5% in 1977 and 34.4% in 1992 (Table 6, Fig. 8).

Table 7 (Appendix) shows the percentage cover of all 49 species recorded from all 19 sample years between 1971 and 2002 for each sample at the Inverdoorn long-term survey site (IV1).

The IV1 ordination diagram is shown in Figure's 9 and 10. The eigenvalue for axis-1 is 0.04, and for axis-2 is 0.02, indicating an extremely weak site separation along these axes. The samples did not change predictably, with no obvious association to any species abundances. The most abundant species was *Ruschia spinosa*, which displayed two peaks in its abundance (Figure 11), one of 30.4% in 1976, and another of 34.7% in 2002 (Table 8). Other dominant species, including *Delosperma* sp., Galenia *fruticosa*, *Antimima hantamensis* and *Pteronia pallens* showed no obvious trends in abundance (Figure 12)

Total % crown cover at IV1 increased from 1971 to 2002, with peaks of 53.8% in 1977 and 57.8% in 2002 (Table 8, Fig. 13). A regression analysis of the relationship between respective % crown covers at KK1 and IV1 yielded an R-value of 1.0 and a p-statistic of less than 0.000001. This result is significant at the 0.01 probability level, and the null-hypothesis, that there is no relationship between % crown covers at the two sites, was strongly rejected.

The % similarity matrices for KK1 and IV1 are shown respectively in Table's 9 and 10. In these tables a high similarity value between years indicates a small amount of change. The total similarity between 1972 and 2002, and between 1971 and 2002 at KK1 and IV1 respectively was 45.8% and 64.9%. This indicates that the veld community has changed more at KK1 than at IV1 since the early 1970's. Since 1975, when the Stock Reduction Scheme was ended in the area, according to Mr. Theunissen, the change in the veld communities was highest at KK1 (60.4%) than at IV1 (70.1%). At KK1 the highest successive sample change occurred between 1990 and 1992 at 64.9% similarity, and then between 1972 and 1973 at 68%. At IV1 the highest successive sample change occurred between 1990 and 1992, at 70.5%, the same period as at KK1, but a smaller change.

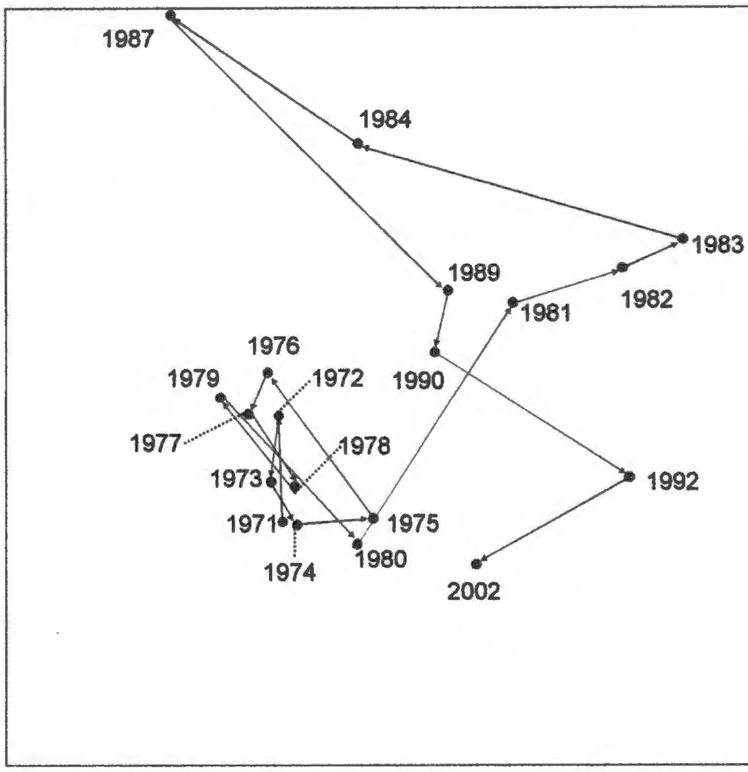

Figure 9. CA ordination showing changes in the plant community at IV1, according to % cover. Eigenvalues for axes 1 and 2: 0.04 and 0.02 respectively. Arrows indicate the relative direction of change from 1971 to 2002.

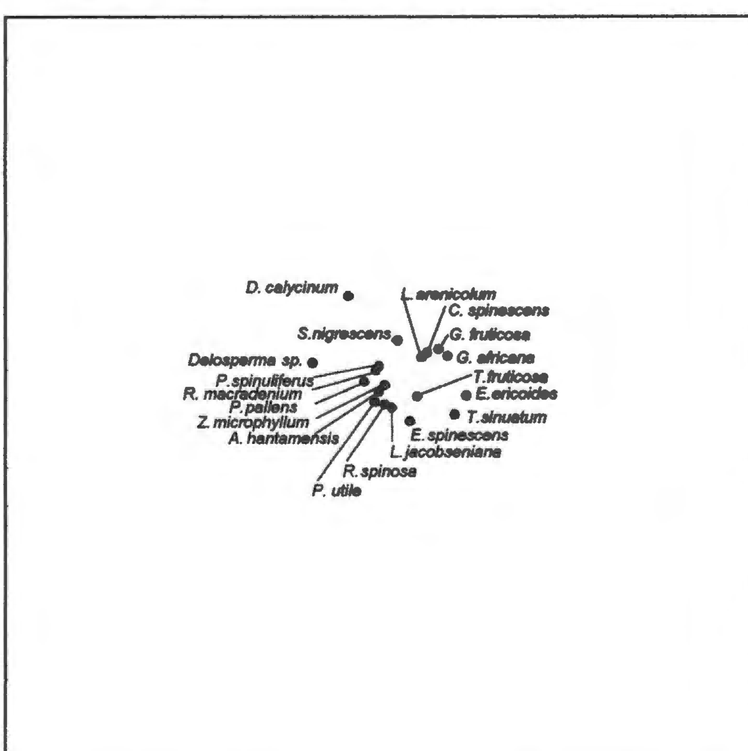

Figure 10. CA ordination as in Figure 9, using identical axes, showing spread of species (as in Table 8) occurring at an average percentage cover of more than 1% for all years.

Table 9. Matrix of Bray-Curtis % similarity scores between years at Kareekolk (KK1).

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1990	1992	2002
1972													
1973	68.0												
1974	73.1	77.8											
1975	65.0	70.9	80.5										
1976	61.0	76.0	80.5	92.4									
1977	65.1	58.3	71.4	68.7	73.8								
1978	76.5	66.2	80.4	75.1	80.1	84.7							
1979	68.6	69.2	83.5	86.5	90.6	79.7	86.7						
1980	73.4	80.1	97.6	80.7	81.3	70.4	79.6	83.4					
1981	68.5	70.2	81.3	75.6	80.1	72.4	77.8	83.3	82.1				
1990	65.8	60.9	70.4	74.6	79.1	85.3	84.9	86.5	71.4	74.8			
1992	46.2	48.4	48.3	53.5	60.1	56.3	59.7	59.7	49.5	54.2	64.9		
2002	45.8	48.0	55.8	60.4	65.1	61.7	64.8	66.3	56.6	60.9	71.4	79.4	

Table 10. Matrix of Bray-Curtis % similarity scores between years at Inverdoorn (IV1).

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1987	1989	1990	1990	2002
1971																			
1972	76.4																		
1973	76.2	78.3																	
1974	75.6	83.5	83.5																
1975	74.5	80.1	78.0	80.2															
1976	73.0	80.7	76.9	79.3	83.2														
1977	76.1	75.4	76.6	79.9	85.1	82.0													
1978	77.3	80.3	78.9	81.5	84.9	82.1	83.6												
1979	74.2	84.9	77.1	80.7	85.6	83.0	81.5	80.3											
1980	82.5	86.3	76.2	79.8	79.3	81.8	77.9	82.3	86.5										
1981	75.0	81.2	80.4	76.9	83.8	80.8	80.0	80.7	83.4	80.4									
1982	74.2	82.5	77.9	75.0	83.0	77.8	72.2	76.5	77.1	77.3	85.6								
1983	73.0	78.0	73.8	74.2	82.8	79.5	75.4	76.5	80.3	78.8	82.1	83.6							
1984	72.6	82.8	76.6	84.4	82.9	79.3	81.7	78.4	86.8	80.1	81.8	78.1	81.5						
1987	78.3	82.8	76.5	76.4	84.5	84.2	83.9	78.1	88.5	83.6	84.8	79.2	80.2	83.7					
1989	72.4	85.8	80.6	80.9	83.3	78.8	80.1	78.7	86.3	83.7	86.3	81.4	80.7	84.9	86.1				
1990	69.6	83.6	78.0	79.0	90.5	80.6	81.5	80.1	87.8	82.1	82.3	81.3	81.3	82.9	85.1	89.6			
1992	60.5	65.0	59.0	61.2	70.5	67.8	68.6	66.3	66.7	67.4	67.3	65.8	65.3	67.5	68.5	70.7	70.5		
2002	64.9	66.5	62.6	65.8	70.1	65.6	68.1	67.0	65.6	64.6	65.1	67.2	62.0	68.8	66.9	64.0	65.4	74.4	

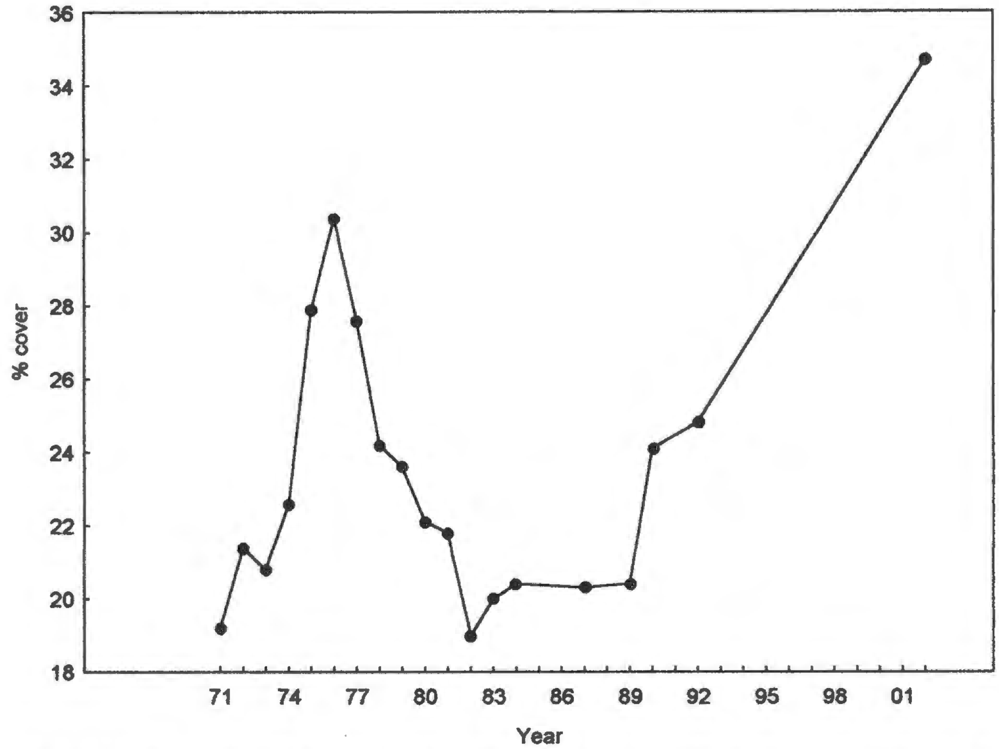

Figure 11. Fluctuations in % cover of *Ruschia spinosa* at Inverdoorn (IV1) from 1971 (71) to 2002 (02) .

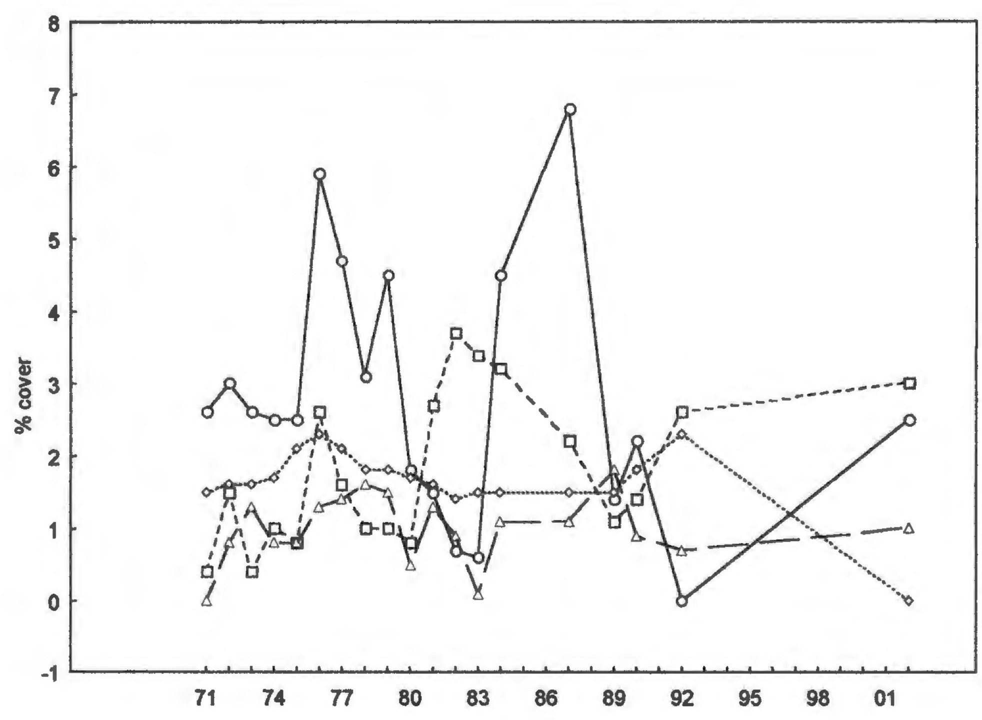

Figure 12. Fluctuations in % cover of *Delosperma* sp. (solid, circles), *Galenia fruticosa* (Dashed, squares), *Antimima hantamensis* (dotted, diamonds) and *Pteronia pallens* (dashed, triangles) at Inverdoorn (IV1) from 1971 (71) to 2002 (02) .

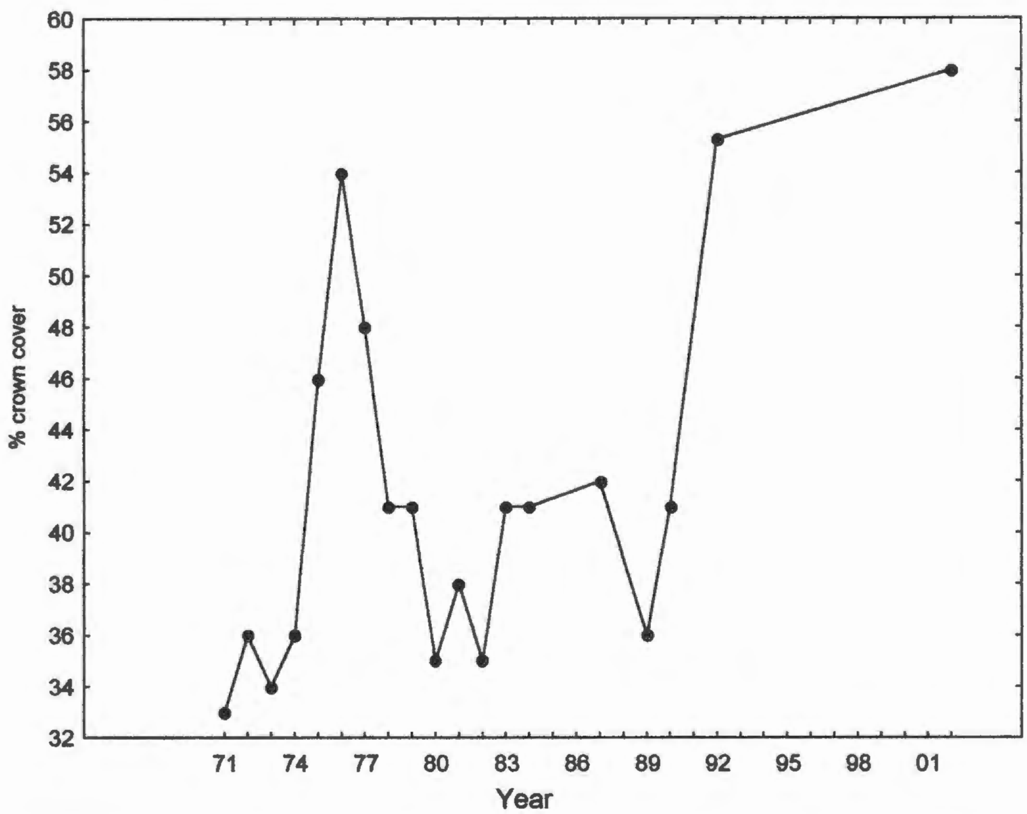

Figure 13. Fluctuations in % crown cover at Inverdoorn (IV1) from 1971 (71) to 2002 (02) .

Discussion

Species indicators of rangeland condition

Variations within the data of this study are attributed solely to differences in species compositions of different samples. Thus in order to explain variations, reference has to be made to the plant species characterizing different samples. Rangelands of different states or phases (Roux and Vorster; 1983, Stokes, 1994) of degradation tend to be characterised by different species or groups of species, and conversely the presence of certain species tends to indicate the ecological condition of the land. Authors have thus applied ratings to different species according to their grazer palatability's, their desirability by the farmers, or their general plant value (eg. le Roux *et al*, 1994; van Breda and Barnard, 1991). A plant is considered to be generally useful, or desirable, if it is highly palatable, and thus eaten readily by stock animals. Veld consisting of generally palatable plants will be able to support a healthier herd of animals, and is also indicative of land that has not been severely overgrazed. Information is limited as many species found in this study have not been assigned a rank and have not been associated with a phase of land degradation by any authors, nor did the researchers have any knowledge of the general value of certain plants. Information is, however, available for many species, and information from the following authors was assimilated subjectively to give an overall rating (R) of increasing general usefulness from 1-5 for each of these species (Table 11, Appendix). le Roux *et al* (1994) provided a rating of increasing palatability from 1-10, as well as a 1-5 star rating of general plant value for each species. van Breda (1991) provided a 1-4 star rating according to each species' palatability. Roux and Vorster (1983) associated certain species with five different phases of land degradation. Stokes (1994) produced ordinations of data collected along a gradient of increasingly degraded land. A separate species was shown per ordination, and was subjectively assigned a rating of increasing value from 1-5 for the purposes of this study. Personal knowledge of the present author was also considered in the final rating.

Patterns found in the short-term analysis

The most obvious pattern found in this data was a separation of sites into two groups, one from KK and the other from GF+DL. This separation is most likely to be explained by the fact that the KK plant community has been subjected to different grazing systems than GF+DL since the 1970's. Whilst GF+DL has been rested during summers and then grazed relatively lightly in winters, KK has been subjected to a group camp approach. Nevertheless, stock numbers were reduced at both farms during and after the Stock Reduction Scheme of the

1970's. Thus it is expected that the veld at both farms should have improved in both cover and abundance of palatable plants since 1970, but due to less rigorous grazing, the improvement would have been greater at GF+DL. *A. noctiflora* and *Z. microphyllum*, both assigned a final rating (R) of 4, show increases on both sides of the fence, and *R. spinosa* (R=4) has maintained a stable population, indicating a healthy, and improved veld on all farms. *Delosperma* sp. (R=2), however also shows an increase on both sides of the fence, and *P. pallens* (R=2) does not show any indication of decreasing in cover, indicating more degraded veld.

It appears as if the amount of vegetation change is more at KK than at GF+DL, this was, however, shown to not be significantly so. A comparison between within-sample and between-sample variation would have been a useful tool here that could have been used to more adequately quantify the amount of change that occurs on each site (Mentis, 1989; Stokes, 1994). Future long-term studies of this nature should certainly include this technique. In addition to this, the directionality of change appeared to be different between sites, even those that are situated in close proximity, such as KK10 and KK11. These inconsistencies highlight the importance of spatial heterogeneity in these environments, and thus the importance of conducting sufficient numbers of sample replications.

These results display the importance of different grazing systems in effecting the rate and direction of recovery of vegetative communities. Farms subjected to the different grazing systems have developed different species assemblages, or they are showing plant communities at different 'state' or 'transition' phases.

Patterns found in the long-term analyses

At KK1, there was little obvious change in the plant community between 1972 and 1980, but from 1980 to 2002 there was a marked change from the original community. This change appeared to be closely correlated to an increase in desirable species such as *A. noctiflora*, *S. tuberculata*, *R. spinosa* and *H. odorata* (all R=4), and a decrease in *Delosperma* sp. (R=2). There was, however, also a slight increase in cover of *P. pallens* (R=2), but it did not appear to be of crucial importance in the ordination result. These results clearly show a positive recovery in the veld condition since the initiation of Stock Reduction Scheme of the 1970's. It is crucial for management purposes to observe, however, that there was a long lag period from 1972 to 1980, where no recovery was evident, but after that the changes are obvious. This explanation is consistent with the idea that Succulent Karoo communities hold a high demographic inertia, as presented by Wiegand and Milton's (1996) model. It is also plausible that the veld at this site is changing along a successive pathway, whereby it was originally (previous to 1972) overgrazed to a pioneer community, and is now being replaced by successive communities, moving toward a climax community, also analogous to Roux and Vorster's (1983) Phase 1 or 2 situations.

There were no obvious trends in plant community composition at IV1 from 1971 to 2002. As IV1 consists of veld that has not been grazed in a long time, it would be expected that the veld would not be moving toward an improved, nor a degraded state. Succession theory would predict that IV1 has reached a healthy, desirable climax state. State and transition theory would predict that either the community is fluctuating between unpredictable states, driven by certain events, possibly climatic; or that it is currently maintaining a 'stable' state, exhibiting the demographic inertia that is typical of this flora. The latter is more plausible, as changes in the ordination diagram are not supported by strong ordination axes. Roux and Vorster's (1983) theory of phases of degradation would predict that this veld has recovered slightly, having previously moved from a Phase 3 state to a Phase 2 state, in which it is now stable. It does seem plausible that this site is existing as a 'stable' state, of whatever sort, as most species do not show any clear patterns of increase or decrease, and the weak axes in the ordination do not indicate changes to be significant. *P. pallens* (R=2) has maintained a stable population since 1971, despite the theory that this is recovered veld, indicating it's typical nature of persisting once veld has been overgrazed and it has been allowed to establish. *R. spinosa* (R=4) has shown a more recent increase in cover, possibly indicating further veld recovery, but the fact that there was also a peak in % cover between 1975 and 1977 indicates that it may merely be a 'boom and bust' population, responding to rainfall.

The close relation between the changes in total % crown-cover at KK1 and IV1 is most likely to be explained by changes in annual rainfall, or some other climatic variable that is not fenceline specific. This result indicates that the effect of changing or fluctuating climatic conditions is very important in the Succulent Karoo. It is crucial that this be considered in the future continuation of long-term studies such as this one.

The Bray-Curtis % similarity values at KK1 and IV1 indicate that the KK1 plant community has changed more than at IV1 since the early 1970's. This is so for the overall percentage change for all sample years, for the years following the end of the Stock Reduction Scheme, and for the respective years of highest change. The higher levels of change at

Kareekolk, which are toward a more palatable vegetation cover than at Inverdoorn, indicate a scenario whereby the initial (in 1970) veld condition at Kareekolk was overgrazed, and was then more lightly grazed in the following years, leading to a slow, but persistent recovery of the vegetation. This has occurred despite predictions and observations that the vegetation of arid regions won't, or didn't, recover over a short period of 30 years, despite rest (Omar, 1991; Westoby, 1989a; Wiegand and Milton, 1996). At IV1, however, the initial condition was one of veld that had already been rested, and has now reached an improved condition that is stable, to certain degree.

Future studies

Future long-term research efforts need to focus on honing sampling and analysis techniques so that data can be as clear and predictive as possible.

An initial difficulty was revealed during attempts at accurately re-sampling certain sites, where written descriptions of sites by previous samplers were unclear, untidy and difficult to follow. Due to uncertainty, two sites were excluded from the study, thus reducing the sample size. A lack of enough sample repetitions can confound data through the effects of special heterogeneity. The major emphasis of this study is on the usefulness of using long-term data in analysing the state of degraded rangelands, understanding the biotic and abiotic processes involved in influencing changes, and developing predictive capabilities so that the veld can be properly managed. As long-term analyses are likely to span the lives of more than one researcher, personal communication will not always be possible between researchers. It is thus crucial that every time a researcher collects data that will contribute to a long-term data set, rigorous, accurate and clear notes are taken as to the exact methods used and the exact localities of sites. The Global Positioning System resource is invaluable, and must be used in determining the positions of sites. Average step length should be measured in the case of this study where the step-point method was used, thus subsequent researchers will be more able to accurately repeat samples. Rock cairns, or similar simple markers, should be built along the length of transects to note points of importance, such as direction changes, middle point and ends of a transect. Photographs should be taken of sites to aid future researchers in finding them. Photographs will also be useful as a remote sensing comparative technique. Care was taken during this study to use all of the above-mentioned practices. Average step length, however, was not recorded. The researchers felt confident that samples were repeated with sufficient accuracy.

Long-term studies, spanning the lives of more than one researcher need to always consider the effects of sampler bias. Samplers may use different step lengths, as well as record species cover in varying area sizes over the big toe. If care is taken to establish adequate communication means between successive samplers, however, this problem can be greatly alleviated. Sites that were sampled previous to 1989 were sampled using a different method, the fixed-point method, as opposed to the current step-point method. The use of differing methods in a long-term analysis may introduce false variation within the data, and should be avoided. The current researchers, however, are confident that this variation, although not optimal, is minor. It is also crucial that samplers take care to accurately identify species. If previous samplers grouped certain species as one due to identification difficulties, such as the present grouping of *Atriplex lindleyi* and *A. semibaccata*, it must be made clear within written communication. When there is uncertainty as to the identity of a plant, researchers should collect, press and accurately identify the plant as soon as possible by consulting herbarium material, specialists of that particular genus, or previous samplers.

Conclusions

It is debatable whether rest alone can aid the recovery of degraded Karoo veld. This study, however, has shown that veld recovery in a highly degraded region is possible, not only with rest, but also with mere reductions in stock numbers and better grazing systems. This indicates that the Stock Reduction Scheme of the 1970's, although expensive (Roux and Vorster, 1983), has played an important role in aiding the recovery of, at least, parts of the Succulent Karoo. An important message evident in this study is the need to allow the veld a long period before any recovery can become evident.

Patterns of change have been revealed in this study of a small portion of the Ceres Karoo vegetation that would have been invisible at smaller time scales. For instance the time-lag that occurred between 1972 and 1980, before the Kareekolk sites began to show evidence of change, would not have been evident without the last 20 years' worth of samples. This indicates how it is important that similar studies to this one be applied across the Succulent Karoo, using the existing extensive data sets collected by the Department of Agriculture between 1966 and 1994. These long-term studies will be able to aid researchers greatly toward a better understanding of the dynamics that control the state of arid to semi-arid rangelands, and existing theories such as succession theory, state and transition theory, and Roux and Vorster's (1983) five phases of development theory, can be further developed and refined.

Future techniques of long-term rangeland analysis can, and must, be further sharpened and enhanced, and this is entirely possible. This long-term analysis could provide a shining example to researchers and managers involved in studies of other arid to semi-arid rangelands throughout the world.

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Appendix

Table 2. % cover of all species recorded at Kareekolk (KK) and the adjacent farms, Groot-fontein (GF) and Drooger Laagte (DL) in 1992 and 2002.

	KK8		KK9		KK10		KK11		DL2		DL1		GF1		GF2		GF3		GF4	
Species	**1992**	**2002**	**1992**	**2002**	**1992**	**2002**	**1992**	**2002**	**1992**	**2002**	**1992**	**2002**	**1992**	**2002**	**1992**	**2002**	**1992**	**2002**	**1992**	**2002**
Antimima hantamensis	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0
Aridaria noctiflora	6.5	8.4	5.2	2.9	6	12.4	9.4	2.5	1.4	1.9	2.5	1.6	3.5	1.1	0.3	0.5	5.6	2.5	1.4	1.1
Aridaria sp.	0	0.1	0	3.4	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
Atriplex spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0
Augea capensis	0	0.2	0	1	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0
Brownanthus ciliatus	0.3	0	0.6	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crassula muscosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0
Crassula subaphylla	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Delosperma sp.	0	1	0	4.8	0	3.3	0	0	0	0	0	0	0	1	0	0.2	0	0	0	0.6
Drosanthemum eberneum	1	0.3	1	2.7	0.5	0.8	0	0	0	0.2	0.3	0.2	0	0	0	0.3	0	0	0	0
Drosanthemum lique	0.3	0	3.5	0.3	2.2	1.3	1.4	0	0.2	0.5	1	1	0.3	2.1	1.1	0.2	0	0	0.8	0.2
Eriocephalus spinescens	0	0.2	0.2	0	0	0	0	0	0	0	0	0	0.2	1	0.2	0.2	0	0	0	0
Galenia fruticosa	0.6	1.3	1	0.2	2.5	1	2.1	1.4	0.5	0.8	0.6	0.3	0.2	1	0	0.2	0.6	1.4	0.2	0.8
Heroroa odorata	0	0	0	0	0	0	0	0	0.3	0	0	0	0.3	0.5	0	0	0	0	0.3	0.2
Hirpicium integrifolium	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycium arenicolum	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0.2	0
Malephora luteola	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
Phyllobolus spinuliferus	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protasparagus capensis	0	0.3	0.2	0.2	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0
Psilocaulon utile	8.3	1.7	1	1.1	13.8	6.5	7.1	3	7	4.8	10	7.9	4.1	0.3	0.6	1.1	7	3	8.4	4.3
Pteronia cf. *membranaceae*	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0
Pteronia pallens	18.7	14.4	4.1	0.5	14.4	13.8	14.1	12.7	9.7	8.7	13.8	13.5	14.1	14.1	1.3	6.3	12.7	12.7	12.5	9.7
Ruschia cf. *muricata*	0	0	0	0	0.2	0	0.5	0	0.3	0	0.5	0	0.6	0	0	0	0.2	0	1.9	0
Ruschia crassa	0	0	0	0	0	0.6	0	0	0	1.3	0	0.5	0	0	0	0	0	0	0	0.3
Ruschia spinosa	0	0	0	0	0	0.2	0.2	0.2	23.8	21	15.9	11.7	21.3	27.1	42.5	45.2	14.9	19.8	24.1	24
Salsola tuberculata	0	0	0	0.6	0.6	0.8	0.8	0.3	1.3	0.8	1.4	0.5	0.3	0	0	0	0.8	0.3	1	1.4
Tetragonia fruticosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
Tripteris sinuatum	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zygophyllum microphyllum	0	1.4	1.7	0	0	0	0	0	0	0	0	0	0	0.5	0.2	0	0	0	0	0
Total crown cover	**35.7**	**30.2**	**18.9**	**17.7**	**40.7**	**40.9**	**35.6**	**20.1**	**44.5**	**40**	**46**	**37.2**	**45.4**	**49.4**	**46.4**	**54.6**	**42**	**39.7**	**51**	**42.6**

Table 5. % cover of all species recorded at Kareekolk (KK1) from 1972 to 2002.

Species	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1990	1992	2002
Aridaria noctiflora	0	0	0	0	0	0	0	0	0	0	0	4.9	2.3
Aridaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	1
Augea capensis	0	0	0	0	0	0	0	0	0	0	0	0	0.1
Brownanthus ciliatus	0	0	0	0	0	0	0	0	0	0	0	0.8	0.9
Crassula deltoidea	0	0	0	0	0	0	0	0	0	0	0	0.1	0
Delosperma sp.	5.8	3.4	6.9	10.1	10	8.3	7.4	6.7	5.7	4.7	2.5	1.2	1.3
Drosanthemum eberneum	0	0	0	0	0	0	0	0	0	0	0	0.5	0
Drosanthemum lique	0	0.3	0.1	0	0.5	0.8	0.3	0.5	0.1	0.7	1.1	0.9	1.2
Euphorbia gentilis	0	0	0	0	0	0	0	0	0	0	0	0.1	0
Euphorbia karroensis	0	0.1	0	0.1	0.2	0	0	0	0	0	0	0	0
Galenia fruticosa	0	0	0	0.1	0.2	0.7	0.5	0.2	0	0.4	0.4	1.4	2.5
Heroroa odorata	0.2	0.5	0.3	0.7	0.7	0.3	0.2	0.7	0.5	0.7	0.7	2.3	2.8
Lessertia pauciflora	0	0	0	0	0	0.1	0	0	0	0	0	0	0
Malephora luteola	0	0.1	0	0	0	0	0	0	0	0	0	0	0
Mesembryanthemum crystallinum	0	0	0	0	0	0	0	0	0	0.1	0	0	0
Protasparagus capensis	0	0	0	0	0	0	0	0	0	0	0	0.1	0
Psilocaulon utile	1.8	1	2.9	4.8	5.5	8.7	7.1	5	2.8	1.9	4.8	6.6	5.4
Pteronia glabrata	0	0	0	0	0	0.1	0	0	0	0	0	0	0
Pteronia pallens	4.3	4.6	4.1	5.1	5.7	5.8	4.2	5.2	4.5	4.9	6.9	14.4	14
Pteronia punctata	0.1	0	0	0	0	0	0	0	0	0.1	0	0	0
Ruschia spinosa	0	0	0	0.1	0.1	0	0	0.1	0	0	0.2	0.2	1
Salsola glabrescens	0.2	0	0	0	0	0.1	0.3	0.1	0	0	0.2	0	0
Salsola nigrescens	0	0	0.6	0.5	0.2	0.5	0.3	0.7	0.4	0.9	0.5	0	0.5
Salsola tuberculata	0.1	0	0	0	0	0.1	0.3	0	0	0	0.3	0.9	1.1
Sphalmanthus usitatus	0	0	0	0	0	1	0	0	0	0	0.6	0	0
Total crown cover	**12.5**	**10**	**14.9**	**21.5**	**23.1**	**26.5**	**20.6**	**19.2**	**14**	**14.4**	**18.2**	**34.4**	**34.1**

Table 7. % cover of all species recorded at Inverdoorn (KK1) from 1971 to 2002.

Species	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1987	1989	1990	1990	2002
Antimima hantamensis	1.5	1.6	1.6	1.7	2.1	2.3	2.1	1.8	1.8	1.7	1.6	1.4	1.5	1.5	1.5	1.5	1.8	2.3	0
Aridaria noctiflora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0.4
Aridaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3
Atriplex spp.	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0
Cephallophyllum curtophyllum	0	0	0	0	0.2	0.3	0.1	0.2	0.1	0.2	0.3	0	0.3	0.2	0.3	0.1	0.1	0.5	0
Crassula atropurpurea	0	0.1	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0
Crassula deltoidea	0	0	0	0.1	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0
Crassula muscosa	0.1	0	0	0	0	0	0	0	0.1	0.1	0	0	0	0	0.2	0	0	0.2	0.1
Crassula subaphylla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1
Delosperma sp.	2.6	3	2.6	2.5	2.5	5.9	4.7	3.1	4.5	1.8	1.5	0.7	0.6	4.5	6.8	1.4	2.2	0	2.5
Drosanthemum calycinum	0	0	0.1	0.2	0.4	0	0.2	0	0.2	0	0.1	0	0.2	0.2	0.7	0.4	0.4	0	0
Drosanthemum eberneum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
Drosanthemum lique	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.8
Eriocephalus ericoides	0	0.1	0	0	0.2	0	0	0	0.1	0	0.2	0.2	0	0.1	0.1	0.2	0.1	0.3	0.4
Eriocephalus spinescens	0.2	0.1	0	0.1	0.1	0.3	0.4	0.1	0.2	0.5	0	0	0.3	0.2	0.2	0.1	0.1	0.7	0.4
Euphorbia erectoramus	0.2	0	0.2	0.2	0.1	0	0.3	0.1	0	0	0	0	0	0.3	0	0	0	0	0.1
Euphorbia multiceps	0	0	0	0	0	0	0.1	0	0	0	0.1	0	0	0	0	0	0	0	0
Felicia filifolia	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galenia africana	0.3	0.5	0.7	0.2	1.1	0.7	0.9	1.1	0.8	0.9	1.8	1.5	2.5	1.3	1.3	2	2.5	2.5	0.6
Galenia fruticosa	0.4	1.5	0.4	1	0.8	2.6	1.6	1	1	0.8	2.7	3.7	3.4	3.2	2.2	1.1	1.4	2.6	3
Gazania krebsiana	0	0	0	0	0.1	0.4	0.3	0	0.1	0	0	0	0	0	0.2	0	0.1	0	0
Heroroa odorata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
Indigofera sp.	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Leipoldtia jacobseniana	3.1	3.4	3.3	3.6	4.5	4.9	4.4	3.9	3.8	3.5	3.5	3	3.2	3.3	3.2	3.3	3.9	5.5	6.6
Lessertia pauciflora	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0
Lycium arenicolum	0.7	0.2	0.7	0.2	0.3	0.1	0.4	0.1	0.3	0.4	0.5	0.8	1	0.8	0.7	1	0.7	0.3	0.8
Malephora luteola	0.1	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0.3	0	0	0	0
Osteospermum scariosum	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Othonna silenifolia	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.2	0
Pentzia incana	0	0	0.1	0.1	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllobolus spinuliferus	0.1	0.3	0.1	0.3	0.2	0.4	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.5	0.3	0.3	0.2	0.4	0.1
Protasparagus capensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0
Psilocaulon utile	0.8	0.7	0.3	0.2	0.8	1.2	1.5	1.5	0.8	0.9	0.4	0.5	0.8	0.7	0.5	0.5	1	0.9	0.4
Pteronia pallens	0	0.8	1.3	0.8	0.8	1.3	1.4	1.6	1.5	0.5	1.3	0.9	0.1	1.1	1.1	1.8	0.9	0.7	1
Pteronia paniculata	0	0	0	0	0.4	0	0.1	0.1	0	0	0	0	0	0	0	0	0.1	0.7	0.1
Pteronia punctata	0	0	0	0	0	0	0	0	0.4	0	0	0	0.1	0.1	0	0	0	0	0
Rhinephyllum macradenium	0.4	1.2	0.1	0.4	0.2	0.3	0.4	0	0.1	0.4	0.1	0.3	0.2	0.8	0.7	0.5	0.3	0.6	0.6
Ruschia cymosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3
Ruschia sp.	1.2	0	0.1	0	0.2	0.1	0.2	0.4	0	0	0.2	0.2	0.1	0	0.1	0	0	5.8	0.3
Ruschia spinosa	19.2	21.4	20.8	22.6	27.9	30.4	27.6	24.2	23.6	22.1	21.8	19	20	20.4	20.3	20.4	24.1	24.8	34.7
Salsola nigrescens	0.2	0.1	0.1	0	0.2	0.4	0	0.1	0.1	0.1	0.3	0.2	0.3	0	0.3	0.3	0.1	0	0
Salsola tuberculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3
Sceletium sp.	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0.1	0	0.1	0
Sphalmanthus usitatus	0	0	0	0	0.4	0	0	0	0	0	0	1	3.1	0	0	0	0.1	0	0
Tetragonia fruticosa	1.2	0.3	0.5	1	1	1	0.8	0.9	0.7	0.4	1	1	1.6	1	0.4	0.7	0.4	1	1.2
Tripteris sinuatum	0	0.1	0.1	0.3	0.8	0.7	0.1	0.1	0.2	0	0.2	0.4	0.7	0.5	0.1	0.1	0.4	0.7	1.5
Tylecodon reticulatus	0.1	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0
Zygophyllum microphyllum	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.2	0.3	0.4	0.2	0.4	0.2	0.3	0.2	0.1	0.1	0.2
Total crown cover	**32.7**	**35.6**	**33.6**	**35.7**	**45.5**	**53.8**	**48.2**	**40.9**	**40.8**	**34.8**	**38.3**	**35.2**	**40.6**	**41.1**	**41.8**	**36.1**	**41.1**	**55.3**	**57.8**

Table 11. Final ratings (1-5) given to species based on available information. Le Roux et al (1994) provide a 1-10 palatability rating and a 1-5 star general value rating. Van Breda and Barnard (1991) provide a 1-4 star palatability rating. Roux and Vorster (1983) described species as being characteristic of certain phases of increasing degradation from 1-5. Stokes (1994) showed various species to be associated with varying degrees of veld condition, from which the present author subjectively assigned ratings from 1-5 of increasing desirability.

Species	**le Roux *et al* (1994)**	**van Breda and Barnard (1991)**	**Roux & Vorster (1983)**	**Stokes (1994)**	**Other**	**Final rating**
Antimima hantamensis	0	0	0	5	0	5
Lessertia pauciflora	0	0	1	0	desirable	5
Osteospermum scariosum	0	0	1	0	desirable	5
Tripteris sinuatum	10, *****, Highly palatable, often grazed short	****, vulnerable to grazing	0	5	0	5
Ariderla noctiflora	Palatable. Less palatable on brak soil. Indicates good veld (7, ****)	0	0	0	0	4
Eriocephalus africanus	0	***	0	0	0	4
Heroroa odorata	0	0	0	0	indicator of undisturbed veld	4
Ruschia spinosa	3, **, Indicates veld deterioration, young shoots readily grazed	0	3-4	5	0	4
Salsola tuberculata	8, ****, Palatable, grazing resistant	***, good grazing plant and drought resistant	0	0	0	4
Tetragonia fruticosa	0	***	0		0	4
Zygophyllum microphyllum	0	0	0	4	0	4
Atriplex spp.	Palatable. Less palatable on brak soil. Protects bare soil (7, ****)	0	0	0	0	3
Felicia filifolia	6, ****, Not very palatable, but varies	***, highly vulnerable to winter grazing	0	0	0	3
Psilocaulon utile	unpalat. Grazed under pressure. (2, *)	0	0	3	0	3
Augea capensis	0	0	3-4	1	edible when dry	2
Delosperma sp.	0	0	0	2	0	2
Eriocephalus ericoides	Variable palatability, according to habitat and season (4, **)	0	3	0	0	2
Galenia fruticosa	6, ***, Palatable...but variable	**, Protected from overgrazing because unpalatable in winter	3-4	0	0	2
Lycium arenicolum	0	0	3-4	0	0	2
Pteronia pallens	0	0	0	2	Undesirable stable state	2
Eriocephalus spinescens	Less palatable and spinous. (2, *)	0	3-4	0	0	1
Galenia africana	0	0	3-4	0	0	1
Malephora luteola	0	0	0	1	0	1