Square Kilometre Array (SKA): Vegetation map, classification and description of vegetation units

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EXECUTIVE SUMMARY

Background

The South African Environmental Observation Network (SAEON) requested a classification and description of the vegetation and the compilation of a fine-scale vegetation map of the National Research Foundation (NRF) properties on which the Square Kilometre Array (SKA) is being developed. These properties were declared the Meerkat National Park by proclamation 15 of 2020 (Government Gazette 2020) on 27 March 2020 and the South African National Parks (SANParks) is currently the Land Management Authority.

Methods

According to the terms of reference the vegetation study was to follow the approach of the Zürich-Montpellier (Braun-Blanquet) School of Phytosociology. A stratified-random sampling approach was applied to ensure representativeness of sampling and site selection was based on a physiographic-physiognomically stratified satellite image of the study area. A total of 232 sample plots (approximately 625 m^2 in size) were surveyed in April 2022 and May 2022.

To determine sampling sufficiency a Species Accumulation Curve (SAC) of all data points was generated using Estimates S (version 9) with 100 randomizations (Colwell 2013). Various diversity, such as species richness, evenness, Shannon-Wiener (H'), Simpson, Exponent of Shannon-Wiener and Inverse Simpson index of diversity, were computed.

High quality satellite imagery for the study area was available on Sentinel and Google Earth$_{TM}$ and vegetation units were therefore hand drawn on the satellite images to create a raster vegetation map of the associations. This map was cleaned of line annotations in a raster environment and then converted to a vector map. A series of vector filters was applied to smooth lines and to remove very small polygons and other inconsistencies. The vegetation map, clipped to the study area, is available in GIS format as well as A0 print format.

Study area

The study area lies between the towns of Brandvlei, Williston, Van Wyksvlei and Carnarvon. The NRF properties, representing the core area, cover ca. 135 000 ha. A 5 km buffer zone of adjacent farmland was included in the study area, which enlarged the study area to *ca*. 236 991 ha.

The study area is situated on the interior plateau of South Africa, above the Great Escarpment, in the Upper Karoo and southern Bushmanland regions of the Northern Cape. The landscape in the southern and southeastern sections of the study area is characterised by steeply sloped, flat-topped mesas and buttes, while the central section comprises extensive plains with open low hills or ridges. To the north small bands of low hills or ridges are found. The lowest parts of the study area are the depressions, pans or "vloere", which occur predominantly in the northern and northwestern parts, often in the buffer zone. These vloere consist of flat and very even surfaces of pans and broad bottoms of intermittent rivers.

Geologically, the study area lies close to the northwestern margin of the Main Karoo Basin of South Africa and is underlain by largely undeformed sediments of the Karoo. The Karoo formations represented include the Tierberg and Waterford Formations assigned to the Ecca Group. Preceding the final break-up of Gondwana the thick pile of Karoo Supergroup sediments was intruded and baked by doleritic magmas of the Karoo Dolerite Suite in the Early Jurassic Period.

The Fc, Ah and Ia Land Types cover most of the study area with small areas of the Ib and Ae Land Types. In the Fc Land Type, the soils are shallow Glenrosa and Mispah forms, with lime generally present in the entire landscape. The Ah

Land Type comprises red and yellow apedal, freely drained soils with a high base status and usually with less than 15% clay, whereas the Ae Land Type consists of red high base status soils, >300 mm deep, with no dunes. The Ia Land Type contains 60% pedologically youthful deposits, >1000 m deep to the underlying rock (e.g. alluvium) and in the Ib Land Type exposed rock covers 60 – 80% of the area.

The rainfall data of four stations surrounding the SKA indicate a range in mean annual rainfall from 146 mm at Brandvlei in the west, to 157 mm at Williston in the southwest, 210 mm at Van Wyksvlei in the north to 249 mm at Carnarvon in the southeast. The rainy season is predominantly from January to April when about 60% of the annual rainfall occurs, with March the wettest month. The driest months are from June to September, when less than 10 mm of rain per month is recorded.

Five national vegetation types are represented in the study area. The Bushmanland Basin Shrubland (Nkb 6) dominates the plains in the central and northern parts of the study area and constitutes 63.8% of the core area. The Upper Karoo Hardeveld (Nku 2) is found on skeletal soils in rocky areas developing over sedimentary rocks as well as Jurassic dolerite sills and dykes. In the study area it occurs in a belt across the southern section on steep slopes and makes up 18.6% of the core area. The Western Upper Karoo (Nku 1) and Northern Upper Karoo (Nku 3) cover very small areas. The Bushmanland Vloere (AZi 5) is an azonal vegetation type embedded in the Bushmanland Basin Shrubland. It occurs on flat terrain on endorheic pans (vloere) and wide courses of intermittent rivers and makes up 13.6% of the core area.

Results

The species accumulation curve (SAC) for all 232 sample plots surveyed (considered as the representativeness of species level sampling over the full study area), reached an asymptote and the point where a line representing one new sample adding one new species was tangent to the curve at approximately 90 sample plots. Thus, sampling sufficiency was already reached after 90 plots had been surveyed. The total sampling effort captured 100% of the number of species predicted by the Michaelis-Menten model.

The four species with the highest frequency of occurrence (≥44%) were all grass species (*Enneapogon desvauxii, Aristida adscensionis, Stipagrostis ciliata* and *Stipagrostis obtusa*). These are basically the dominant grasses in the Bushmanland Basin Shrubland. The woody species with the highest frequency of occurrence (≥36%) were shrub or large dwarf shrubs such as *Rhigozum trichotomum, Lycium cinereum, Lycium bosciifolium* and *Phaeoptilum spinosum*. Herbaceous species with a high frequency of occurrence (≥30%) included *Sesamum capense, Galenia* cf. *pubescens* and *Tribulus cristatus.*

The classification of the floristic data revealed 17 associations (A) and 12 sub-associations (SA) (refer to Appendix A). Each of the 17 associations is described in terms of its (a) location and environmental features; (b) floristic composition; (c) vegetation structure; and (d) plant diversity. A list of IUCN red-listed, CITED listed; ToPS-listed species; protected tree species as well as specially protected or protected species in the Northern Cape is provided per association.

The Cluster Analysis and Principal Coordinates Analysis (PCoA) on the full dataset showed the presence of two clusters. Cluster 1 consisted predominantly of the high mountains with a few plots in Association 5, an association considered transitional between the mountains and the rocky plains. Cluster 2 comprised the dunes, plains (rocky as well as sandy) and plateaux (Cluster 2A); and wetlands (Cluster 2B). Further ordinations within the clusters demonstrated the separation of the associations in ordination space.

Mean species richness per plot was high in the mountain associations A2 and A3, A5 – A9 in the plains and plateaux associations as well as in A17 in the wetland associations. The lowest species richness was found in A1 (dune crests); A4 (dolerite zebra stripes); and A16 (*Prosopis glandulosa* invaded drainage lines). The Shannon-Wiener index of diversity incorporates species evenness and consequently diversity of A16, which was strongly dominated by *Prosopis glandulosa*, had a very low value.

The mountain association A2 had the highest percentage (41.2%) of all species being protected/specially protected in the Northern Cape followed by Association A9, the high mountain plateaux, with 29.1% protected/specially protected species. At the other end of the scale were A1, the dune grassland, and A16, the *Prosopis glandulosa* drainage lines, with 11.0% and 11.3% respectively being protected. There were few CITES-listed species in the study area, most of them were *Aloe/Aloidendron* species or succulent *Euphorbia* species. *Boscia albitrunca* was the only nationally protected tree species and occurred predominantly in the mountain or plateaux associations. The only IUCN red-listed (threatened) species were *Aloidendron dichotomum* which has a Vulnerable status and *Roepera divaricata* which is Endangered. The latter species was however not encountered during the current survey. *Hoodia gordonii* was the only NEM:BA ToPS listed species encountered in the study area.

A provisional check list of the plant species (the term species is used here in a general sense to denote species, subspecies and varieties) in the study area was compiled from (a) the list provided by Milton (2021) on the indigenous angiosperm species collected or recorded in the 3021 degree square in which the SKA core area falls; (b) the latest NewPosa list for the 3021 degree square (accessed May 2022); and (c) the species recorded during the current vegetation survey. In total 563 taxa, representing 67 families, are listed for the study area. Of these species 327 were reported by Milton (2021); plus 40 additional species listed for the one degree square on NewPosa; and 416 were encountered during the current vegetation survey.

The five most species-rich families are Asteraceae (19.1% of all species), Poaceae (12.6% of all species), Aizoaceae (9.0% of all species), Fabaceae (6.4% of all species) and Scrophulariaceae (5.1% of all species).

Nine species (1.7% of the total number of species) are listed as declared alien invasive species.

- Category 1b species include: *Atriplex lindleyi* subsp. *inflata; Salsola kali; Xanthium strumarium; Opuntia ficus-indica; Argemone ochroleuca; Cenchrus setaceus*; and *Datura ferox*;
- Category 2: *Atriplex nummularia*; and
- Category 3: *Prosopis glandulosa.*

Conclusions and Recommendations

In the phytosociological table (Appendix A), the plant associations were arranged along a dry to wet gradient. This gradient started with the dune association (A1) on the dry extreme, through the mountain associations (A2 – A4), rocky or gravelly plains and plateaux (A5 – A10), through the sandy plains (A11), the floodplains (A12 – A14), vloere (A15) to the riparian associations (A16 & A17) on the wet extreme. If the dune crest association (A1) is excluded, an environmental gradient (from left to right) from shallow rocky soils of the mountains to the deep alluvial soils of the vloere or pans is also evident.

There was a strong relationship between the various plant associations and the underlying geology. A relationship between the broad land types and the plant associations was also apparent. Elevation was clearly influential as demonstrated when overlaid onto ALOS hill-shading DSM. However, aspect was less important than expected at the scale of the current investigation, although the large *Aloidendron dichotomum* subpopulations appeared to be associated with a northern aspect.

The most important drivers in the study area were judged to be land use change, rainfall cycles, grazing, invasive alien species and climate change. Land use change and grazing in the current context would infer positive changes to the ecosystem since overexploitation or overgrazing by livestock will no longer play a role. Physical modifications of watercourses or vloere will also no longer be created.

It is essential that the veld condition and grazing capacity of the Meerkat National Park is regularly determined if wildlife is reintroduced in the park. The Grazing Index Method of Du Toit (1998, 2000) is considered the most

appropriate method for the arid regions of South Africa and is thus recommended to calculate indices of veld condition and to derive a grazing capacity. The method is based on the size, dry matter production and palatability of the different plant species in an area (Du Toit *et al.* 1995, Du Toit 2003).

The timing of the phytosociological surveys was not ideal for collecting herbarium specimens because many of the dwarf shrubs were not flowering. In total 153 herbarium specimens (no sterile specimens collected) were sent to the Compton Herbarium for identification. These specimens will be housed in the Compton Herbarium and according to the Terms of Reference duplicates will be sent to the SANParks Herbarium in Kimberley. We would however recommend that the duplicates rather be housed in an accredited herbarium and that SANParks builds up a 'virtual' herbarium of images of the plant species that can be easily accessed. We would recommend that a few dedicated plant collecting trips are scheduled for different seasons to capture the full plant diversity of the study area. SAEON Research Associates could assist with this task.

A vegetation monitoring programme covering the Meerkat National Park has been initiated by SAEON. The selection of the current monitoring sites were based on land types and it is recommended that the sites are also related to the plant associations distinguished in this study to ensure that all associations are represented.

Suggestions are made on topics that could be considered for future monitoring. Topics include:

- Monitoring of plant populations of Species of Conservation Concern;
- Land-use mapping;
- Vegetation dynamics;
- Recovery of the vegetation after human-induced disturbance;
- Alien invasive plant species; and
- Fixed-point photography.

1. INTRODUCTION

The South African Environmental Observation Network (SAEON) requested a baseline vegetation assessment of the National Research Foundation (NRF) properties on which the Square Kilometre Array (SKA) is being developed. These properties were declared the Meerkat National Park by proclamation 15 of 2020 (Government Gazette 2020) on 27 March 2020 and the South African National Parks (SANParks) is currently the Land Management Authority. The focus of this study is to classify and describe the vegetation units and compile a fine-scale vegetation map of the SKA site and immediate surrounds. Current knowledge on the vegetation in the study site is scant, apart from the study by Van der Merwe (2020) on the vegetation of the farms Meysdam and Losberg in the centre of the SKA core. A number of botanical assessments were made in the area for the purpose of an Environmental Impact Assessment (EIA) or Strategic Environmental Assessment (SEA). For example, McDonald undertook a botanical assessment for the EIA of the Meerkat and KAT-7 telescopes in 2006 and 2008 (Strategic Environmental Focus 2007, 2009); Milton (2017) provided a Terrestrial Ecology and Biodiversity report for the SEA of SKA Phase 1; Todd & Henschel (2016) produced a fine-scale habitat map for the SEA, but did not provide a description of the units; and Todd (2020) reported on a walkthrough of Phase 1. In 2021 Milton produced a baseline review of the core SKA properties and surrounds, which provides a comprehensive background on available environmental data.

The scope of work called for a vegetation classification and map of the NRF properties and a detailed description of the baseline vegetation and identified plant associations/subassociations. The current study includes diagnostic species, dominant species, threatened, endemic and protected species (grasses, herbs, shrubs and trees) per identified plant association/subassociation.

The identification and description of vegetation units across the landscape forms the basis of scientifically based environmental and veld management plans and are critical first steps in building a framework for planning ecosystem management. A vegetation map is essential to assess (i) the presence of rare and sensitive habitats and flora; (ii) to determine veld condition and the grazing and browsing capacity; (iii) the suitability of habitats for herbivores; (iv) the extent of alien plant invasion; and if applicable, (v) the extent of bush encroachment.

To develop a wildlife management plan for the Meerkat National Park, a sound knowledge of the vegetation condition is essential and it is hoped that the current report will provide the necessary background. The resulting vegetation, description and mapping will not only provide baseline data on the current status of the vegetation, but can also be used to guide site selection for various scientific studies (e.g. monitoring of vegetation change, vegetation dynamics and biodiversity studies) and management purposes (e.g. veld condition, grazing capacity assessments and ecological restoration).

2. METHODS

2.1 Approach

In the Braun-Blanquet approach to vegetation classification, vegetation types are perceived as units, which can be recognised by their total floristic composition. Vegetation units (e.g. plant communities / associations) are delimited and ordered into a hierarchical classification by using so-called diagnostic plant species. Diagnostic species comprise both character[1] and differential[2] species (Bruelheide 2000) and these species are useful for the identification of the vegetation types in the field.

A vegetation classification is, however, not synonymous with a vegetation map. Vegetation classification consists of grouping stands or plots into vegetation types / plant communities / associations[3] (Tart *et al.* 2005) with each type representing a taxonomic concept with defined limits, about which meaningful and reliable statements can be made (Jennings *et al.* 2006). Mapping of vegetation types requires that a classification of the floristic data is completed first, because this classification circumscribes the entities to be mapped and the vegetation map delineates the geographical distribution of the entities.

The current study thus aims to provide an objective classification of the vegetation in the SKA study area which will form the basis of the vegetation map of the study area.

2.2 Field methodology

A stratified-random sampling approach was applied to ensure representativeness of sampling. Site selection was based on a physiographic-physiognomically stratified satellite image of the study area. A total of 232 sample plots were surveyed in April 2022 and May 2022.

Sample plots were approximately 625 m^2 in size. Vegetation surveys were conducted following the approach of the Zürich-Montpellier (Braun-Blanquet) School of Phytosociology (Werger 1974). At each sample plot the following assessments were made:

- *Floristic assessment:* all plant species were recorded (trees, shrubs, grasses, sedges, ferns, forbs, geophytes, succulents and aliens) and a cover-abundance value, according to the following modified Braun-Blanquet scale (Brown *et al*. 2013) was allocated to each species:
    + means a canopy cover-abundance estimate of less than 1%;
    1 means a canopy cover of 1 – 5%;
    2a means a canopy cover value of >5 to 15%;
    2b means a canopy cover value of >15 – 25%;
    3 means a canopy cover value of >25 – 50%;
    4 means a canopy cover value of >50 – 75%; and
    5 means a canopy cover value of >75%.

[1]According to Bruelheide (2000): **Character species** — A plant species that shows a distinct maximum concentration (quantitatively and by presence) in a vegetation type;
[2] According to Bruelheide (2000): **Differential species** — A plant species that shows a distinct accumulation of occurrences in one or more vegetation units and is distinguished from a character species which should show a distinctive accumulation of occurrences in only one type.
[3] In the Zurich–Montpellier school of phytosociology, **an association** is the basic unit of vegetation, an abstract entity that is defined floristically from field data or relevés. Each association generally has a distinctive faithful species and a group of constant (i.e. high-presence) species which give it a coherent structure. The companion species of the association often form the faithful species of the next and succeeding hierarchical levels, alliances, and orders into which similar associations are grouped.

- *Structural assessment:* Estimates were made of the canopy cover of the following layers: >2 m woody layer (trees); >1 m – 2 m woody layer (shrubs); ≤1 m woody layer (dwarf shrubs); grass layer; and forb layer (non-grassy herbaceous plants).
- *Habitat assessment:* habitat features such as topography; geology; aspect; slope; soil texture; soil colour; rock and boulder cover; rock size; gravel cover; and drainage conditions were recorded.

2.3 Vegetation analysis

Classification of the floristic data was done with the TURBOVEG and JUICE computer programs (Hennekens & Schaminee 2001, Tichy 2002). TURBOVEG software was used to capture the data and a TWINSPAN (Hill 1979) was run as a first step in the classification of the data. To improve the separation into groups, Ward's cluster analysis was run in PC-Ord (McCune & Grace 2002, McCune & Mefford 2011). For the cluster analysis, the cover-abundance values were converted to percentages and the percentage values standardised using a natural logarithmic ($\log_e$) standardisation.

The table of sample plots against species was further refined using Braun-Blanquet tabulation procedures (Werger 1974) to produce a hierarchical classification.

To visualise the relationships between the associations, the floristic data were ordinated using Principal Coordinates Analysis (PC0A) in the PC-Ord 6 computer program (McCune & Grace 2002, McCune & Mefford 2011). As for the cluster analysis, cover-abundance values were converted to percentages and the percentage values $\log_e$-standardised. The Bray-Curtis measure was applied for the analysis. Ordinations were run on the total data set as well as on the large clusters. In some instances successive ordinations had to be run to visualise the separation of plot groups to association level.

Species Accumulation Curves (SAC) for all data points were generated using Estimates S (version 9) with 100 randomizations (Colwell 2013). Curves were generated for the full data set as well as for the large clusters that were identified. Sampling sufficiency was determined by establishing whether the point had been reached where a line representing one new sample plot adding one new species was tangent to the curve (Brewer & McCann 1982). Moreno & Halffter (2000) proposed that a satisfactory level of completeness would have been attained if 90% of the total fauna (flora in this study) predicted by their model would have been reached. Their model is based on the Michaelis-Menten equation (Soberôn & Llorente 1993) and therefore Michaelis-Menten curve-fitting (Raaijmakers 1987) in Estimates S (Colwell 2013) was also used to determine a predicted species total. The actual number of species encountered was then expressed as a percentage of the predicted number of species to determine whether a sampling sufficiency of 90% had been reached.

Species richness, evenness, Shannon-Wiener (H') and the Simpson index of diversity were computed per plot in PC-Ord 6 (McCune & Grace 2002, McCune & Mefford 2011) and a mean per association calculated. Additionally, Shannon-Wiener, Exponent of Shannon-Wiener and Inverse Simpson index of diversity were computed in Estimates S for each association as a whole (thus all sample plots combined). The diversity parameters were calculated as follows:

i. Species richness (S), was expressed as number of species per sample plot;
ii. Shannon-Wiener index (H´), H´= $-\sum_i \frac{ni}{n} ln \frac{ni}{n}$ where n is number of individuals;
iii. Exponent H´ was calculated to convert H´ to the effective number of species. This conversion provides a true diversity indicating the number of equally-common species required to give the particular value of H´ (Jost 2006);
iv. Evenness (E), was calculated as the Shannon-Wiener index divided by the logarithm of the number of taxa (S);

v. The complement of Simpson's index of dominance represents the diversity, thus Diversity = 1 - $\sum_i^S p_i^2$ where p_i = proportion of individuals belonging to species *I*; and
vi. Inverse Simpson index of diversity calculated as 1/(1 – D).

2.4 Mapping

High quality satellite imagery for the study area was available on Sentinel and Google Earth$_{TM}$ and vegetation units were therefore hand drawn on the satellite images to create a raster vegetation map of the associations. This map was cleaned of line annotations in a raster environment and then converted to a vector map. A series of vector filters was applied to smooth lines and to remove very small polygons and other inconsistencies. The vegetation map, clipped to the study area, is available in GIS format as well as A0 print format.

All area calculations were done using an UTM zone 34 South, WGS 84 projection.

2.5 Taxonomy

Taxonomy follows NewPosa (NewPosa.sanbi.org).

Few of the plants were in flower when the surveys were undertaken. Herbarium specimens were collected where material was sufficient for a positive identification by a herbarium. At the time of writing the report, none of the specimens had yet been identified, however names will be changed when the verified names become available, if necessary.

Field identification was assisted by taxonomic studies on various groups such as *Eriocephalus* (Müller *et al*. 2001), *Pteronia* (Bello 2018), *Melolobium* (Moteetee & Van Wyk 2006), *Aptosimum* (Kolberg & Van Slageren 2016), *Lycium* (Venter 2006), *Roepera* (Van Zyl 2000), *Tetraena* (Van Zyl 2000), Amaryllidaceae (Duncan *et al*. 2016) and Iridaceae (Goldblatt & Manning 2020). Other sources included: Adams (1976), Bromilow (2010), Bruyns (2005), Coates-Palgrave & Coates-Palgrave (2003), Cole & Cole (2005), Court (2010), Fish *et al*. (2015), Fouche *et al.* (2014), Frandsen 2017, Glen & Van Wyk (2016), Hartman (2002), Henderson (2001), Kirby (2013), Le Roux *et al*. (1994), Manning (2003), Möller & Becker (2019), Roberts & Fourie (1975), Roodt (2015), Shearing & Van Heerden (1994), Smith *et al.* (2017), Van Jaarsveld *et al*. (2000), Van Oudtshoorn (2012), Van Wyk & Van Wyk (2013), Van Wyk & Smith (1996) and Vlok & Schutte-Vlok (2010).

No attempt was made to distinguish between the various *Salsola* spp. with the exception of a so-called *Salsola aphylla/calluna* complex. As mentioned in Mucina & Rutherford (2006) a reliable characterisation of the Bushmanland Vloere is not possible until a taxonomic revision of the South African *Salsola* species has been completed.

3. STUDY AREA

3.1 Location

The study area lies in the Upper Karoo and Bushmanland region of the Northern Cape between the towns of Brandvlei, Williston, Van Wyksvlei and Carnarvon (Figure 1). The NRF properties, representing the core area, cover ca. 135 000 ha. A 5 km buffer zone of adjacent farmland was included in the study area, which enlarged the study area to *ca*. 236 991 ha (Figure 2).

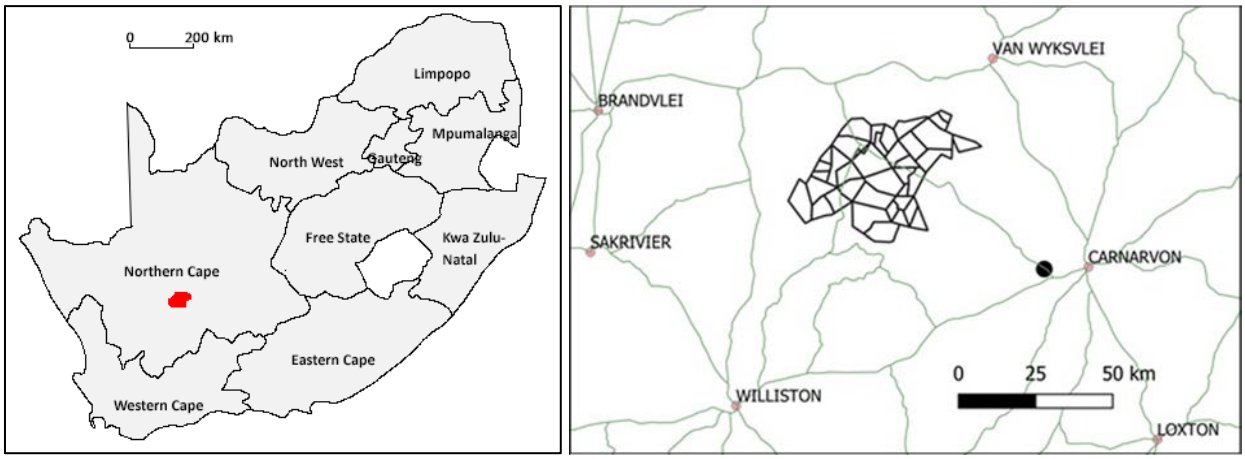


Figure 1: Location of the SKA study area in the Northern Cape province of South Africa (adapted from Van der Merwe *et al.* 2021).

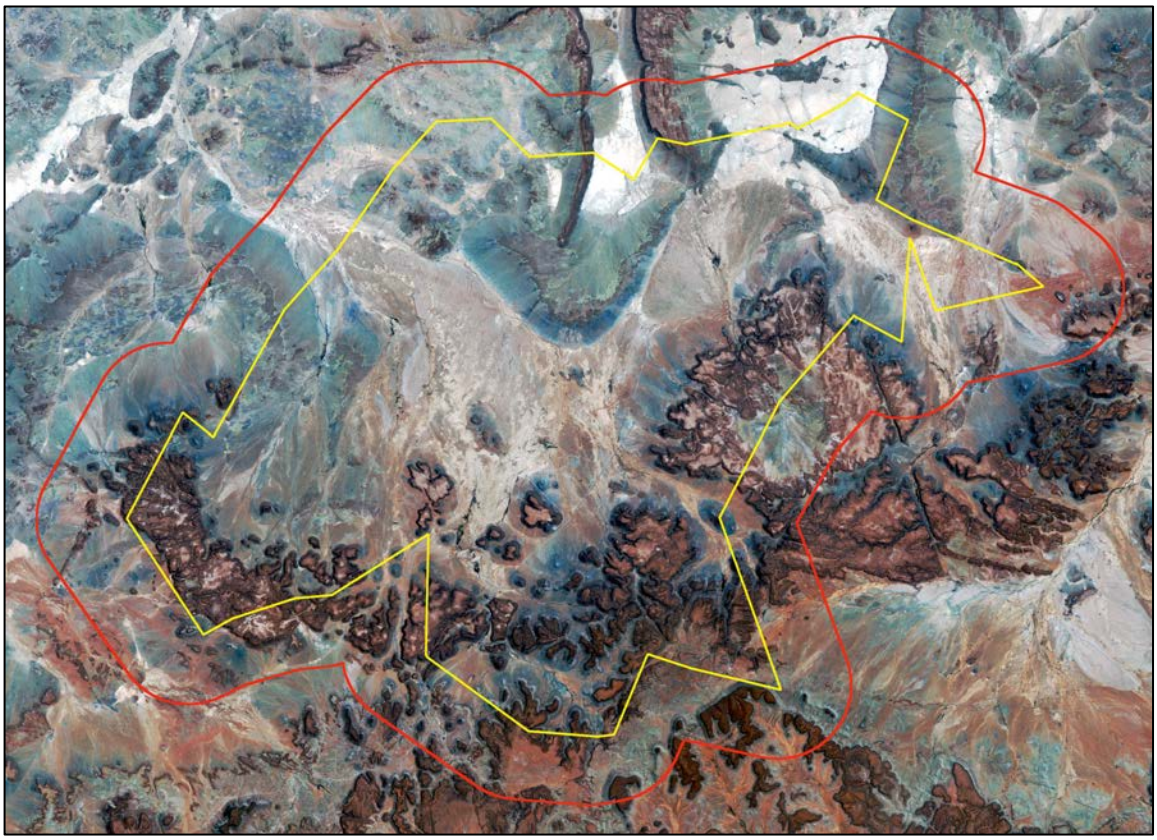


Figure 2: Sentinel satellite image (natural colour) indicating the core properties (yellow line) and a 5 km buffer zone (red line) of the SKA study area.

The 20 parent farms comprising the SKA core area are indicated in Figure 3. Farm names are as used in Government Notice 43145 for the declaration of certain properties as protected area (Government Gazette 2020). However, in the text, spelling of farm names and places follows current usage.

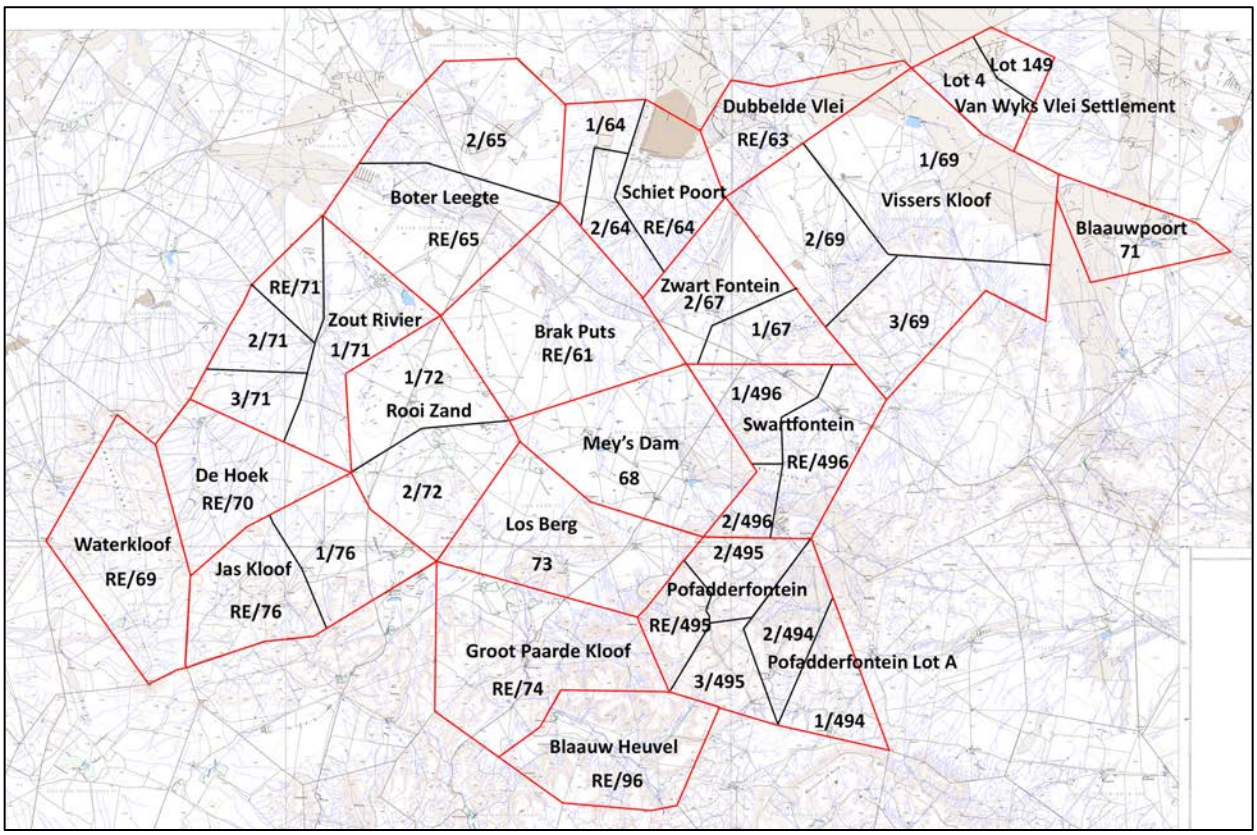


Figure 3: Topocadastral map of the SKA core area and farms. Red lines denote the boundaries of the 20 parent farms and black lines the portions/subdivisions. Farm names are as used in Government Notice 43145 for the declaration of certain properties as protected area (Government Gazette 2020). Local names of the homesteads are not indicated. (Source: Topocadastral maps: 3021AD Rietkop; 3021BC Marcusdam; 3021CA Lynx Kolk; 3021CB Schietpoort; 3021CC Biesies; 3021CD Klein Perdekloof; 3021DA Visserskloof; 3021DB Jagersberg; 3021DC Stuurmansfontein.)

3.2 Topography

The study area is situated on the interior plateau of South Africa, above the Great Escarpment, in the Upper Karoo and southern Bushmanland regions of the Northern Cape. The landscape in the southern and southeastern sections of the study area is characterised by steeply sloped, flat-topped mesas and buttes (Figures 2, 4 & 5) classified as 'rolling or irregular plains with high hills or ridges' and 'open high hills or ridges' terrain types (Kruger 1983, Figure 5). The central section comprises extensive 'plains with open low hills or ridges' as well as 'level plains with some relief' (Figure 5). To the north small bands of 'rolling or irregular plains with low hills or ridges' are found. The lowest parts of the study area are the depressions, pans or "vloere", which occur predominantly in the northern and northwestern parts, often in the buffer zone. These vloere consist of flat and very even surfaces of pans and broad bottoms of intermittent rivers and are classified as 'level plains' in Figure 5.

The region is drained mostly north and westwards by various tributaries of the Orange River and ephemeral watercourses, e.g. Bottersleegte, Soutrivier and Beesdam se leegte and features scattered relicts of a more extensive, drainage network from Late Tertiary (Neogene) times when climates were more tropical and pluvial (Almond 2016).

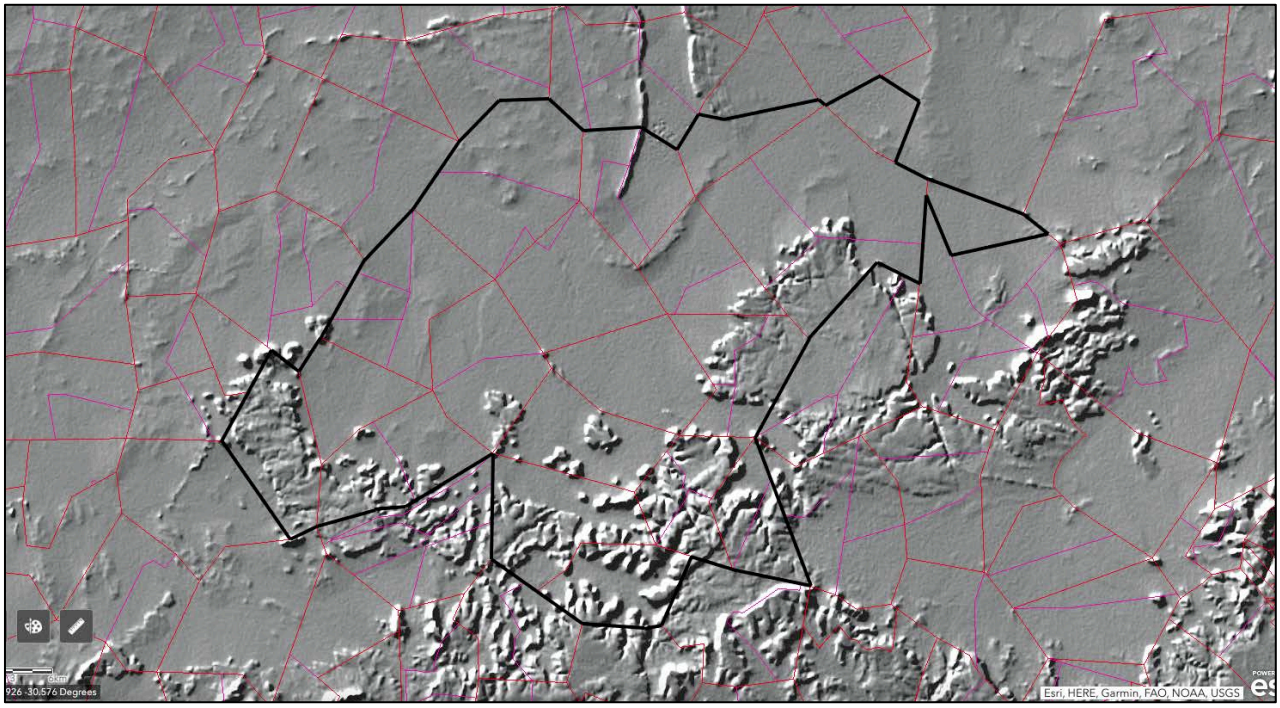


Figure 4: Digital elevation model of the study area (Source: ndagis.nda.agric.za, accessed July 2022).

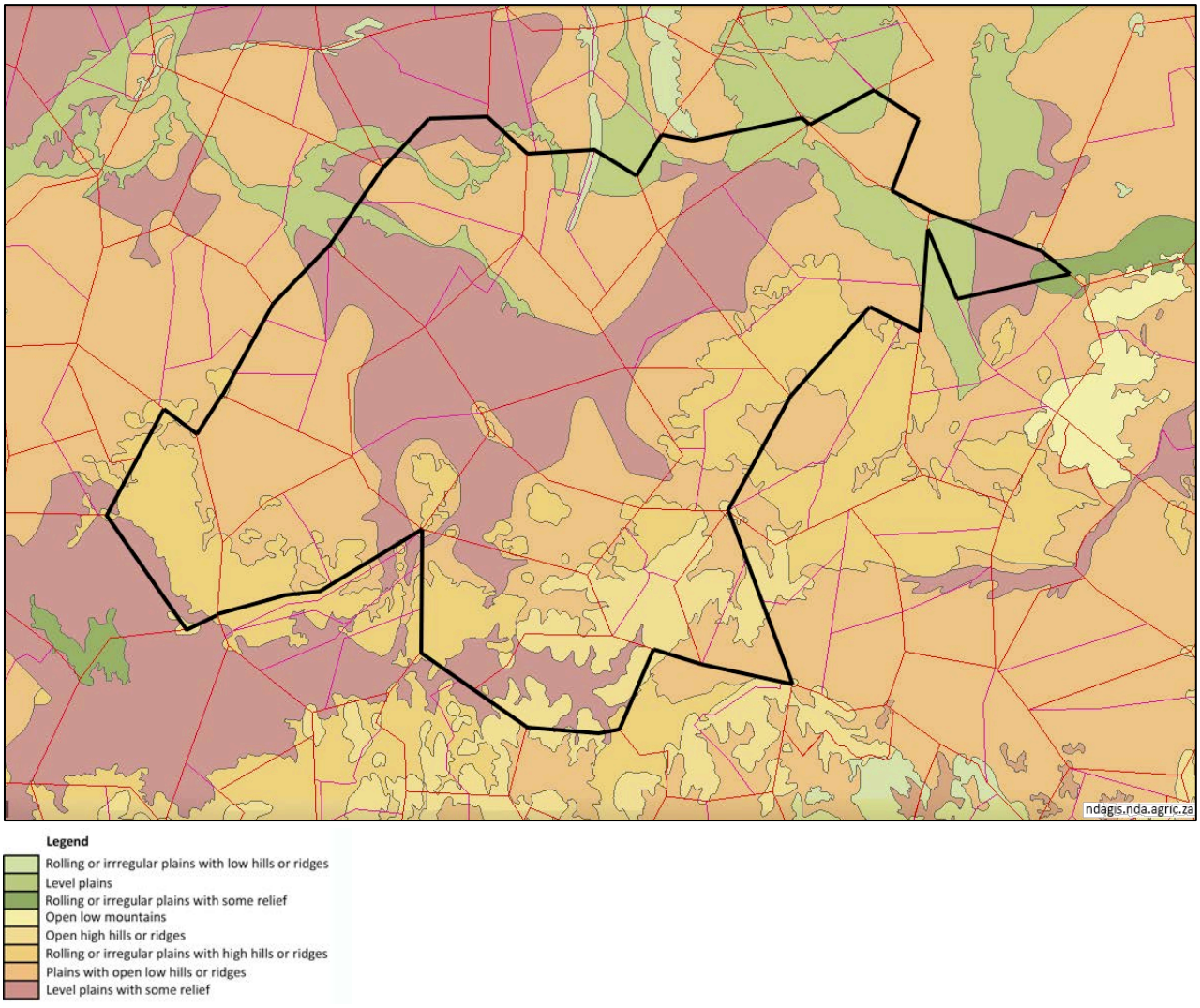


Figure 5: Terrain types in the study area (adapted from ndagis.nda.agric.za, accessed July 2022).

Altitude in the core area ranges from about 970 m at Bottersleegte (Boter Leegte) in the west to 1408 at Vaalberg, southeast of Losberg (Los Berg). The highest point in the buffer zone is 1532 m at Waterval se Berg on the farm Waterval 487 in the southeast of the study area.

3.3 Geology

The following description of the geology of the study area (Figure 6) is based largely on Almond (2016). Geologically, the study area lies close to the northwestern margin of the Main Karoo Basin of South Africa and is underlain by largely undeformed (flat-lying) sediments of the Karoo Supergroup of Early to Middle Permian age (Almond 2016). The Karoo formations represented here include the Tierberg and Waterford Formations assigned to the Ecca Group. Preceding the final break-up of Gondwana the thick pile of Karoo Supergroup sediments was intruded and baked by hot doleritic magmas of the Karoo Dolerite Suite in the Early Jurassic Period. The following types are indicated in Figure 6:

- The plains, gently hilly terrain and lower mountain footslopes of the study area are dominated by dark-grey to olive-green mudrock and fine-grained sandstone of the Tierberg Formation (Pt), Ecca Group. Most of the recessive-weathering Tierberg Formation outcrop area is mantled in superficial deposits such as alluvium and surface gravels.

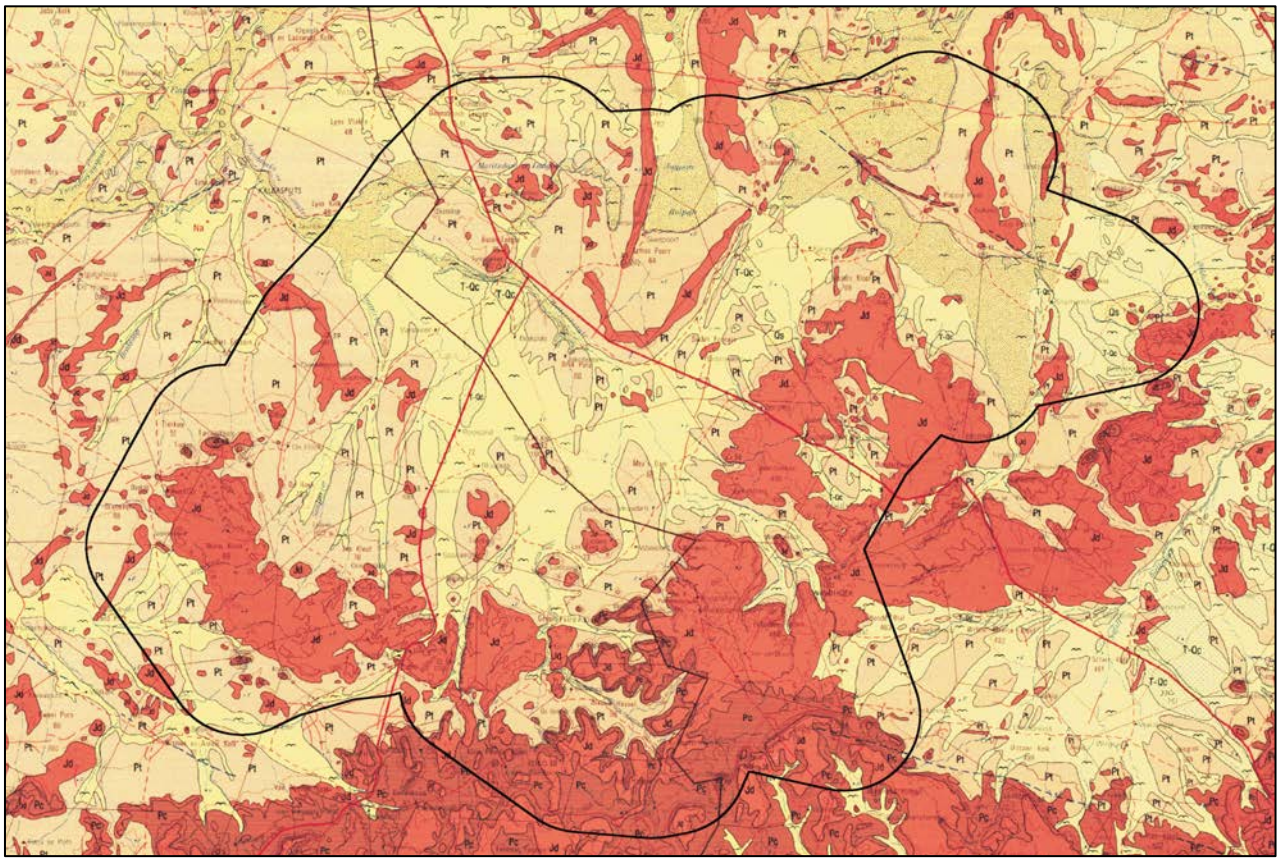


Figure 6: Geological map of the SKA study area. The study area boundary is indicated with a black line (core area plus 5 km buffer zone). (Source: Geology map 1990.)

Legend:
Jd: Karoo Dolerite Suite
Pt: Dark grey to olive-green mudrock and fine-grained sandstone of the Tierberg Formation
Pc: Sandstone-rich, siltstone, grey shale and mudrock of the Waterford Formation
T-Qc: Tertiary/Quaternary calcareous sand and calcrete
Qs: Quaternary sand
Al: Alluvium (two types indicated on Geology map 1990 – darker shade = dry pans or vloere)

- The upper, sandstone-rich, siltstone, grey shale and mudrock portion of the Ecca Group is assigned to the Waterford Formation (Pc) of Middle Permian age. The older 'Carnarvon Formation' name has been discontinued by the South African Committee for Stratigraphy (SACS). The sedimentology of the 'Carnarvon' facies, cropping out in a broad west-east band across the southern portion of the study area, indicates deposition on a shallow, storm-dominated shelf. These resistant-weathering beds build numerous flat-topped mesas in the Kareeberge.
- Numerous Early Jurassic sills and dykes of the Karoo Dolerite Suite (Jd) intrude the Ecca Group rocks in the study area. Subhorizontal dolerite sills cap many of the flat-topped mountains in the region. Dark streams of dolerite blocks patinated with desert varnish or rusty-brown doleritic rock rubble cover many of the hillslopes.
- A wide variety of superficial deposits of Late Caenozoic age cover the Ecca Group bedrocks in the study area. The superficial deposits include a range of alluvial gravels, sands and silts (Al) associated with modern or defunct watercourses such as the Sakrivier, Brakrivier and their tributaries. Low relief plains in the SKA core area to the north of the Kareeberge are underlain by thin to thick alluvial soils and overlie deeply-weathered, often calcrete-veined bedrocks (T-Qc). The soils are generally capped by dense to sparse surface gravels of resistant lithologies such as sandstone or dolerite and have been modified by sheetwash.
- The northern margin of the study area features large and small pans with fine-grained, silty, sedimentary infills and calcrete in the subsurface.
- Colluvial deposits mantling a high proportion of hillslopes include scree fans and streams of rock rubble as well as finer-grained hillwash deposits; these sediments extend onto the gentler footslopes and interdigitate with alluvium in the adjoining plains.
- Some reddish aeolian sand (Qs) is piled into dunes in the eastern parts of the area.

3.4 Land Types

Land types are areas with a uniform climate, terrain form and soil pattern. The SKA study area falls in the Ah, Ae, Fc, Ia and Ib Land Types. The Fc, Ah and Ae Land Types cover most of the plains, the Ia Land Type covers the broad drainage valleys or "vloere" with undifferentiated deep deposits and the Ib Land Type characterises the rocky mountains (Figure 7).

- In the Fc Land Type, the soils are shallow Glenrosa and Mispah forms, with lime generally present in the entire landscape.
- The Ah Land Type comprises red and yellow apedal, freely drained soils with a high base status and usually with less than 15% clay.
- The Ae Land Type consists of red high base status soils, >300 mm deep, with no dunes. It covers a very small area in the southwest of the study area.
- The Ia Land Type contains 60% pedologically youthful deposits, >1000 m deep to the underlying rock (e.g. alluvium).
- In the Ib Land Type exposed rock covers 60 – 80% of the area.

Soils with limited pedological development cover the largest portion of the study area, with strongly saline soils covering a substantial portion of the area (Figure 8). Rocky areas are found in the southeastern mountains and small areas in the east are classified as sandy soils with little or no profile development (ndagis.nda.agric.za, accessed July 2022).

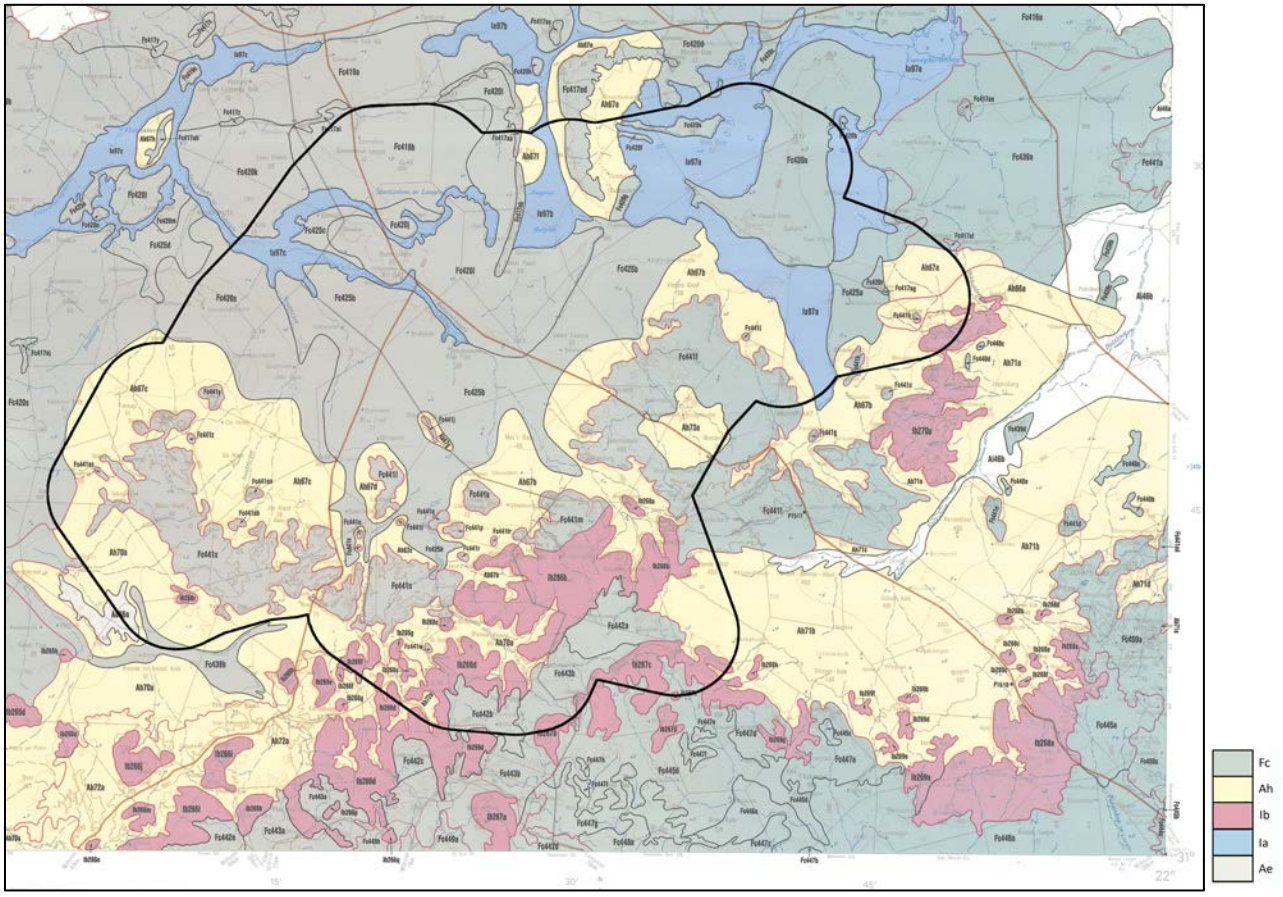


Figure 7: Land types in the SKA study area. The study area boundary is indicated with a black line (core area plus 5 km buffer zone). (Source: Land Type Survey Staff 1990; Map 3020.)

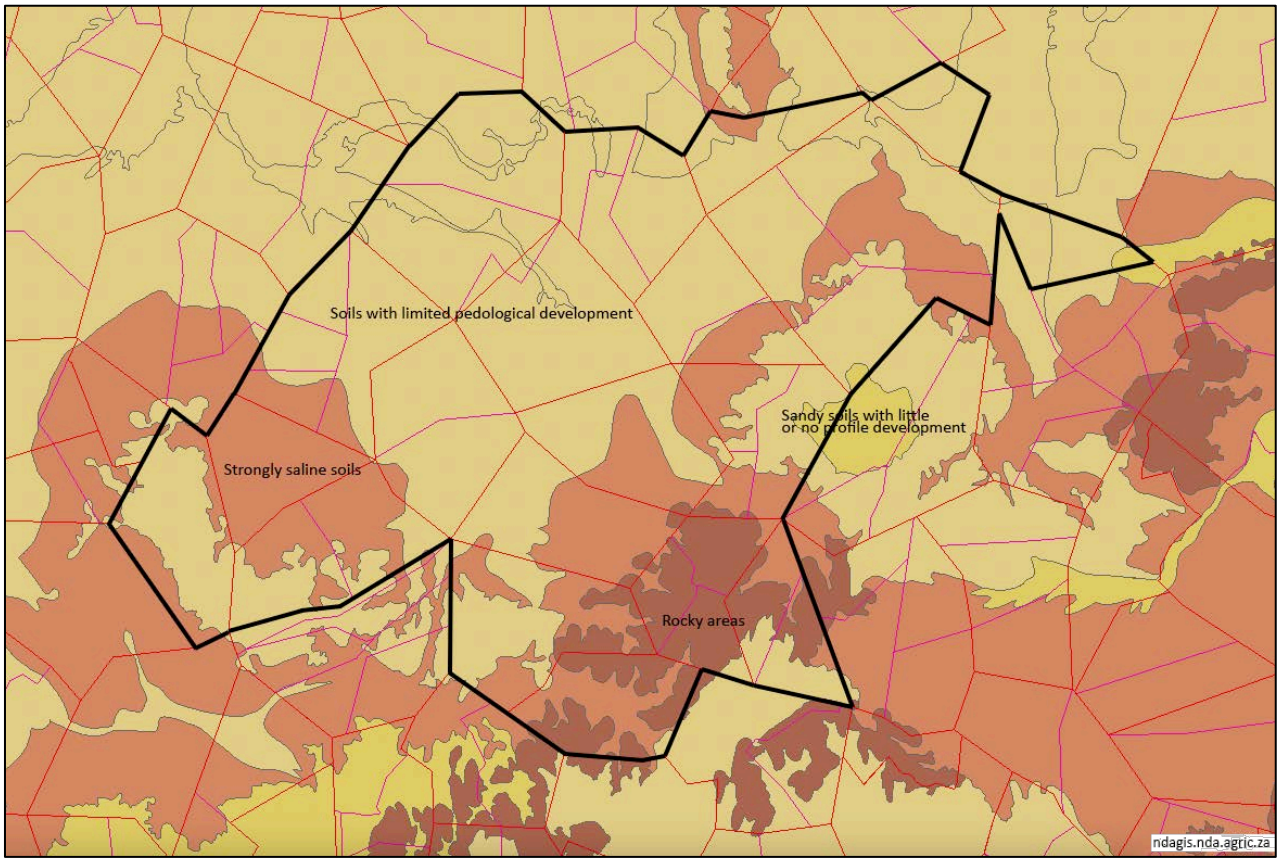


Figure 8: Soil types in the study area (Source: ndagis.nda.agric.za, accessed July 2022).

3.5 Climate

3.5.1 Regional climate

The area is characterised by an arid, seasonal climate with sometimes a weak bimodal precipitation regime where two peaks occur, one in March and another in November. The region is known for thermic extremes with temperatures above 40°C in summer and frequent occurrence of frost in winter. Rainfall occurs mostly in late summer and early autumn (February, March and April).

3.5.2 Rainfall

The rainfall data of four stations surrounding the SKA indicate a range in mean annual rainfall from 146 mm at Brandvlei in the west, to 157 mm at Williston in the southwest, 210 mm at Van Wyksvlei in the north to 249 mm at Carnarvon in the southeast (Table 1). The lowest and highest annual rainfall recorded at Carnarvon were 102 mm and 493 mm respectively, at Brandvlei 37 mm and 377 mm, at Van Wyksvlei 49 mm and 513 mm and at Williston 50 mm and 360 mm (Table 2).

Table 1: Mean monthly and yearly rainfall for some rainfall stations in the region around SKA (Weather Bureau 1998)

Month	Carnarvon	Van Wyksvlei	Brandvlei	Williston
Jan	21	29	16	8
Feb	42	35	20	19
Mar	45	42	29	29
Apr	37	28	21	20
May	12	11	9	13
June	11	8	7	8
July	6	4	6	13
Aug	7	6	4	6
Sept	7	6	4	8
Oct	16	10	12	9
Nov	21	12	12	15
Dec	24	19	6	9
Year	249	210	146	157

Carnarvon Agr station 0165898; 30 58' S, 22 00' E; 1280 m; 20 years
Van Wyksvlei station 0193561 AB; 30 21' S; 21 49' E; 962 m; 30 years
Brandvlei station 0190868 B0; 30 28' S, 20 29' E; 914 m; 25 years
Williston station 0136/740 8; 31 20' S, 20 55' E; 1079 m; 22 years

Based on rainfall data from weather stations in the region, the rainy season at the SKA is predominantly from January to April when about 60% of the annual rainfall occurs, with March the wettest month (Table 1, Figure 9). The driest months are from June to September, when less than 10 mm of rain per month is recorded.

Table 2: Maximum rainfall (mm) in 24 h, highest monthly maximum and lowest monthly minimum rainfall at (a) Carnarvon (Agr weather station 0165898; 30° 58' S, 22 00' E; 1280 m; 20 years); (b) Brandvlei (0190868 B0; 30° 28' S, 20° 29' E; 914 m; 25 years); (c) Van Wyksvlei (0193561AB; 30° 21' S, 21 49' E; 962 m; 30 years); and (d) Williston (0136/740 8; 31 20' S, 20 55' E;1079 m; 22 years) (Weather Bureau 1998)

a.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
*Max	38	68	63	77	23	28	18	15	32	32	58	47	77
*High	104	145	112	115	29	34	29	38	38	65	69	125	493
*Low	0	1	2	1	0	1	0	0	0	0	0	0	102

b.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
*Max	51	78	51	98	25	22	30	14	19	71	42	28	98
*High	77	93	116	137	59	36	30	29	33	85	83	31	377
*Low	0	0	0	0	0	0	0	0	0	0	0	0	37

c.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
*Max	69	73	71	70	37	38	10	20	25	50	38	73	73
*High	214	189	232	105	51	40	16	50	29	65	56	147	513
*Low	0	0	0	0	0	0	0	0	0	0	0	0	49

d.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
*Max	24	36	38	42	29	18	89	35	34	24	44	30	89
*High	47	68	81	68	45	27	97	86	60	38	63	52	360
*Low	0	0	0	0	1	0	1	0	0	0	0	0	50

*Maximum = maximum rainfall recorded over 24 h
*High = highest monthly maximum rainfall (mm) (and highest annual rainfall)
*Low = lowest monthly minimum rainfall (mm) (and lowest annual rainfall)

3.5.3 Temperature

The mean annual temperature for Carnarvon, Brandvlei, Van Wyksvlei and Williston is 16.0°, 17.7°C, 18.2°C and 16.6°C respectively (Table 3). The highest extreme maximum temperature measured was 42.6°C at Van Wyksvlei and the lowest minimum temperature measured was -9.1°C at Carnarvon. Frost may occur from March to November.

Table 3: Temperature data for (a) Carnarvon Agr weather station (0165898; 30° 58' S, 22 00' E; 1280 m; 30 years); (b) Brandvlei (0190868 B0; 30° 28' S, 20 29' E; 914 m; 25 years); (c) Van Wyksvlei (0193561 AB; 30° 21' S, 21 49' E; 962 m; 30 years); and (d) Williston (0136/740 8; 31° 20' S, 20 55' E; 1079 m; 22 years) (Weather Bureau 1998)

a.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Mean	23.1	22.5	20.0	16.0	11.9	8.7	8.5	10.0	13.2	16.4	19.5	21.6	16.0
Max	31.4	30.3	27.4	23.0	18.9	15.7	15.9	17.9	21.6	24.9	28.0	29.9	23.8
Min	14.8	14.8	12.6	9.0	4.8	1.8	1.0	2.1	4.8	8.0	11.0	13.3	8.2
*Max	38.5	38.6	36.6	33.6	28.8	23.0	25.1	27.7	34.0	35.5	36.5	39.0	39.0
*Min	6.5	4.6	-3.7	-1.0	-4.2	-7.5	-7.5	-9.1	-6.5	-2.5	-0.5	1.6	-9.1

b.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Mean	24.7	24.5	22.2	18.0	13.3	10.4	10.2	11.5	15.0	18.1	21.3	23.6	17.7
Max	33.6	33.2	30.5	25.9	21.6	18.4	18.6	20.2	24.0	27.1	30.2	32.6	26.3
Min	15.8	15.9	14.0	10.2	5.1	2.3	1.8	2.7	5.9	9.3	12.4	14.7	9.2
*Max	41.5	40.4	40.2	37.0	31.0	28.0	28.2	31.5	35.5	39.2	39.7	41.5	41.5
*Min	4.1	5.5	4.5	-1.0	-2.4	-5.0	-6.1	-6.1	-4.5	-3.0	0.3	4.0	-6.1

c.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Mean	25.9	25.2	22.6	18.0	13.6	10.1	9.8	11.7	15.6	18.9	22.4	24.6	18.2
Max	34.3	33.3	30.5	25.7	21.7	18.3	18.6	20.7	24.7	27.7	31.1	33.2	26.7
Min	17.4	17.1	14.7	10.2	5.4	1.9	1.0	2.7	6.5	10.0	13.6	16.0	9.7
*Max	42.3	41.6	40.3	36.8	32.5	26.9	27.6	31.1	37.2	38.8	40.5	42.6	42.6
*Min	7.2	7.0	0.5	0.6	-4.2	-7.9	-9.0	-7.6	-5.8	0.2	0.9	4.2	-9.0

d.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Mean	24.4	24.0	21.4	16.4	12.2	9.5	8.6	10.5	13.8	17.1	20.1	22.4	16.6
Max	32.8	31.9	29.0	24.1	20.0	16.9	16.1	18.6	22.3	25.6	28.3	30.8	24.5
Min	16.1	16.0	13.7	8.7	4.6	2.0	1.2	2.5	5.3	8.6	11.9	14.0	8.7
*Max	39.4	40.6	36.7	33.3	31.7	24.4	24.4	30.0	35.0	35.7	38.3	40.0	40.5
*Min	6.1	4.4	4.0	-1.1	-3.3	-6.1	-8.7	-6.1	-3.9	-1.3	2.2	3.3	-8.7

Mean = mean of maximum + minimum temperature/2
Max = mean daily maximum temperature for the month
Min = mean daily minimum temperature for the month
*Max = extreme maximum temperature recorded
*Min = extreme minimum temperature recorded

3.5.4 Climate diagrams

The climate diagrams for the four weather stations around the study area are summarised in Figure 9. Note that the x-axis is from July to June. The rainfall and temperature curves are based on the mean monthly rainfall and mean monthly temperature respectively. When the rainfall curve stays below the temperature curve, it indicates a dry period. No wet period occurs at Brandvlei, Van Wyksvlei or Williston. A weak bimodal precipitation curve occurs at Carnarvon, Brandvlei and Williston.

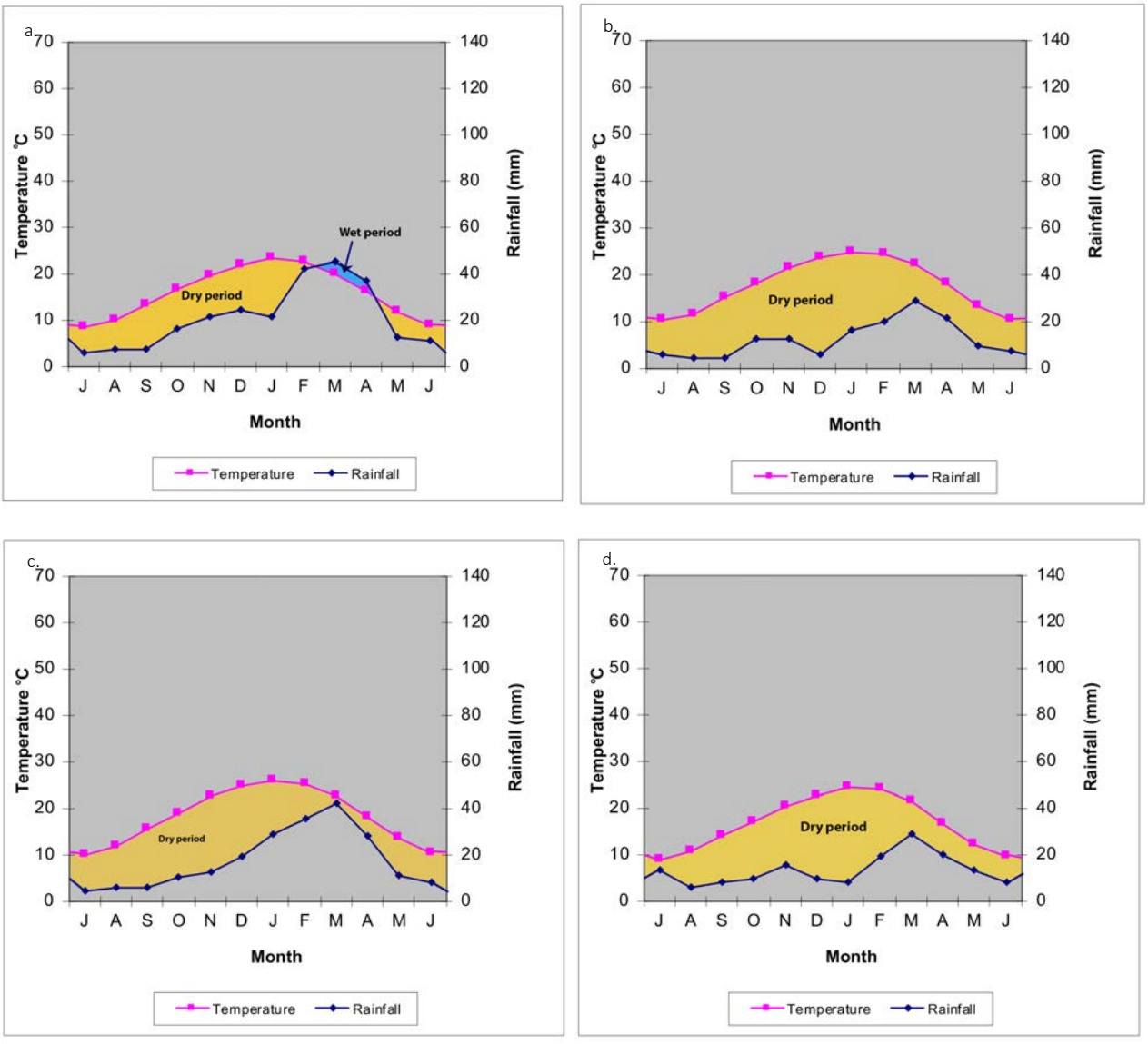


Figure 9: Climate diagrams for (a) Carnarvon; (b) Brandvlei; (c) Van Wyksvlei; and (d) Williston.

3.5.5 Humidity and cloud cover

At Carnarvon the relative air humidity at 14:00 ranges from 38% to 39% in April, May and June to 25% to 26% from November to January (Table 4). Cloud cover at Carnarvon at 14:00 is the highest from February to April and the lowest from June to August. The highest humidity at 14:00 at Van Wyksvlei occurs in June and the lowest in November and December (Table 4). The cloud cover at 14:00 is highest in March and the lowest in July.

Table 4: Relative air humidity (%) and cloud cover (eights) at (a) Carnarvon Agr (0193561AB; 30° 21' S, 21 49' E; 962 m; 30 years) and (b) Van Wyksvlei (0165898; 30° 58' S, 22 00' E; 1280 m; 30 years) (Weather Bureau 1998)

a.

Months	% Relative humidity		Cloud cover	
	08:00	14:00	08:00	14:00
Jan	56	25	1.4	2.4
Feb	64	32	1.9	3.0
Mar	71	36	2.2	2.9
Apr	75	39	2.4	2.8
May	76	38	2.4	2.4
Jun	76	39	2.2	2.1
Jul	74	35	2.0	1.8
Aug	69	32	2.1	2.0
Sept	64	29	2.4	2.5
Oct	56	27	2.2	2.7
Nov	53	25	1.7	2.5
Dec	55	26	1.6	2.4
Year	66	32	2.1	2.5

b.

Months	% Relative humidity		Cloud cover	
	08:00	14:00	08:00	14:00
Jan	53	27	1.3	2.1
Feb	60	31	1.6	2.5
Mar	67	34	1.9	2.7
Apr	74	36	2.0	2.6
May	76	37	1.9	2.1
Jun	78	40	1.8	1.9
Jul	75	37	1.6	1.5
Aug	68	33	1.6	1.6
Sept	62	29	1.9	1.9
Oct	56	27	1.9	2.4
Nov	52	26	1.6	2.2
Dec	51	26	1.3	2.0
Year	65	32	1.7	2.1

4. PREVIOUS DESCRIPTIONS OF THE VEGETATION IN THE REGION

4.1 Introduction

This section provides an overview of how the classification of the vegetation in the study area has evolved over time and how various authors have interpreted the vegetation in the study area.

4.2 Phytogeography

The vegetation maps of South Africa compiled in the nineteenth and early twentieth century were mostly of a phytogeographical nature. During the nineteenth century most geographers relied on descriptions of early explorers to compile their maps. Some of these early maps were quite simple, with only a few different units identified, e.g. Grisebach (1871) (Figure 10a) and Engler (1882) (Figure 10c). Overall, many of these early phytogeographers agreed that the northwestern parts of the country were part of the so-called Kalahari Region. In contrast, the central part of the country, where the current study area is located, was interpreted in different ways and consequently labelled differently. Thus Rehman (1880) called the area 'Roggeveld' (Figure 10b); Engler (1882) considered it as part of his 'Karroo' (Figure 10c); Bolus (1886) called it the 'Compositae Region' (Figure 10d); and Drude (1887) included it in his expanded 'Karroo' (Figure 10e). About ten years later Schimper (1898) descripted the area as 'Grass Steppe' (Figure 10f); and in a revised map Bolus (1905) termed it 'Upper Region' (Figure 10g); whereas Marloth (1908) considered it as 'Karoo Highveld' (Figure 10h).

The phytogeographic map of Lebrun (1947) was compiled for the entire Africa and is at a fairly coarse scale for southern Africa (Figure 11). Nevertheless, it clearly illustrates the viewpoint at that point in time, that apart from the Cape Region (6) the rest of the vegetation in southern Africa was part of the Sudano-Zambezian Region (4). Within South Africa, Lebrun (1947) recognised the Kalahari (4.5), Namaqualand-Karoo (4.6) and South African Savanna and Forest (4.7) as the three domains of the Sudano-Zambezi Region.

Monod (1957) was the first to distinguish three regions in southern Africa: the Cape Region (C); the Sudano-Angolian Region (B.I) and additionally the Karoo-Namib Region consisting of the Namaqualand, Karoo and Namib Domains (B.IV) (Figure 12). The current study area is situated in the Karoo Domain (B.IV.1) of the Karoo-Namib Region.

Later phytogeographical studies by White (1965), Troupin (1966), Volk (1966), White (1971, 1976), Werger (1978) (Figure 13) and White (1983) (Figure 14) all recognised the Karoo-Namib Region, but differed in their delineation of the region.

The Karoo Domain of Werger (1978) (Figure 13) covers the summer rainfall regions of the central South African plateau. Werger described the vegetation as typically a dwarf shrubland on wide, rolling plains and pediments. 'The dwarf shrubs have many xeromorphic features such as narrow, ericoid and pubescent leaves and often resinous glands. Succulents are not very abundant. On hillsides larger shrubs and small trees can be found and along riverbeds a woodland often develops'.

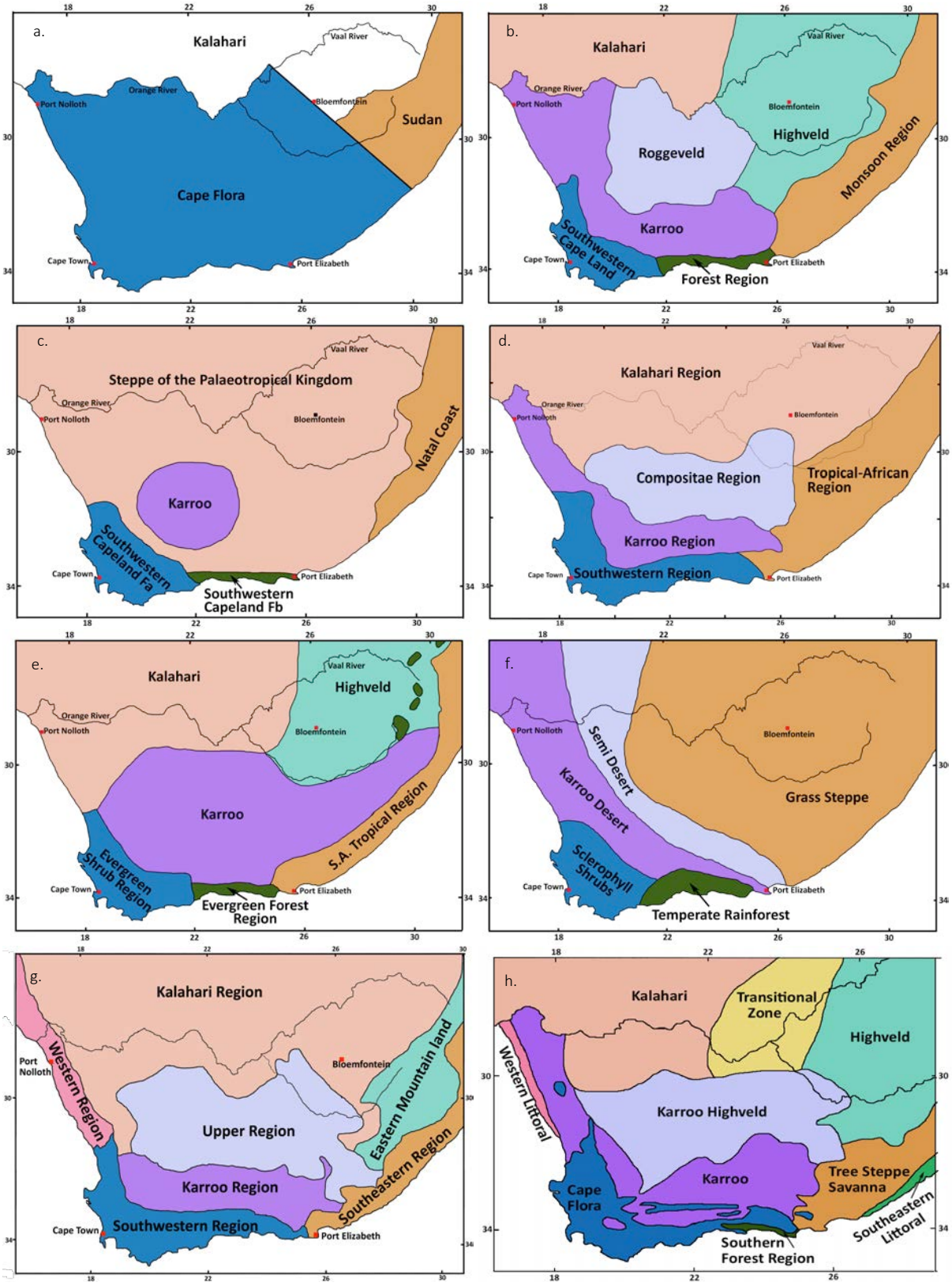


Figure 10: Early phytogeographical maps of South Africa. (a) Grisebach (1871); (b) Rehman (1880); (c) Engler (1882); (d) Bolus (1886); (e) Drude (1887); (f) Schimper (1898); (g) Bolus (1905) and (h) Marloth 1908. Note spelling of 'Karroo' by early phytogeographers.

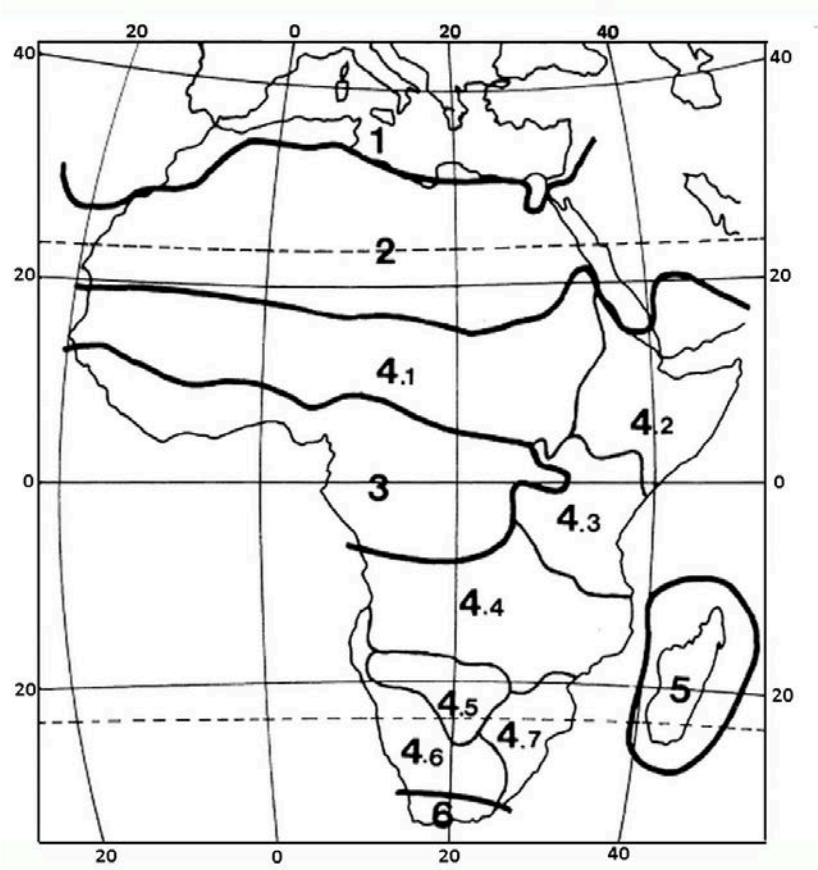


Figure 11: Phytogeographical map of Africa according to Lebrun (1947).

Legend

1. Mediterranean Region
3. Saharo-Sindian Region
3. Guinean Region
4. Sudano-Zambezian Region
    - 4.1 Sahelo-Sudanian Domain
    - 4.2 Somalo-Ethiopian Domain
    - 4.3 Oriental Domain
    - 4.4 Zambezian Domain
    - 4.5 Kalahari Domain
    - 4.6 Namaqualand-Karoo Domain
    - 4.7 South African Savanna & Forest Domain
5. Malagasian Region
6. Cape Region

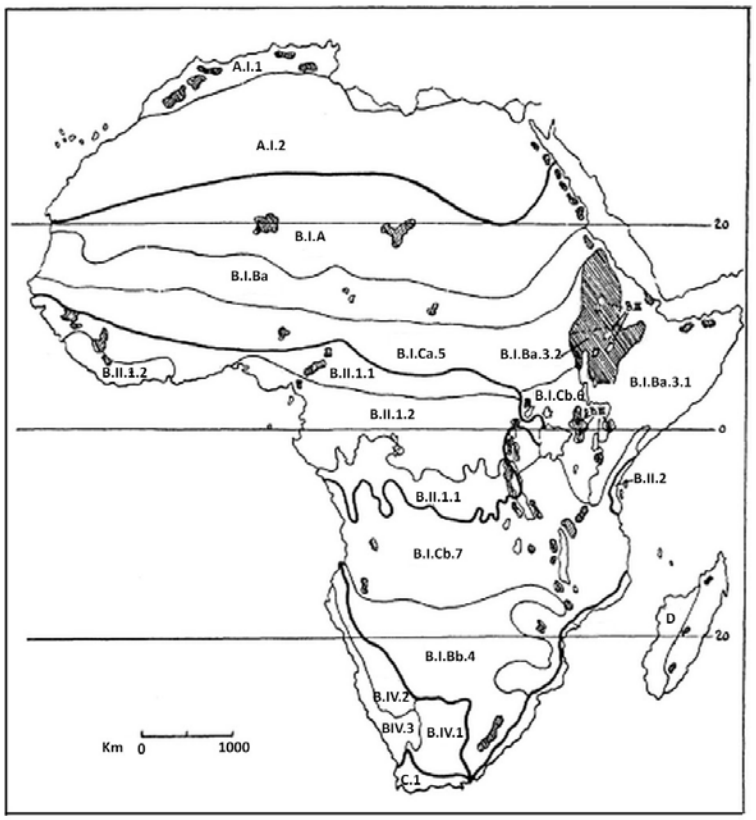


Figure 12: Phytogeographical map of Africa according to Monod (1957).

Legend

A. Mediterranean Region
    - A.1.1. Eumediterranean Subregion
    - A.1.2. Saharo-Sindian Subregion

B.I. Sudano-Angolian Region
    - B.I.A.1. Saharo-African Domain
    - B.I.Ba.2 Atlantico-Nilotic Domain
    - B.I.Ba.3.Somalo-Ethiopian Domain
    - B.I.Bb.4. Southern Domain (e.g. Kalahari)
    - B.I.Ca.5. Senegalo-Nilotic Domain
    - B.I.Cb.6. Oriental Domain
    - B.I.Cb.7. Angolo-Zambezian Domain

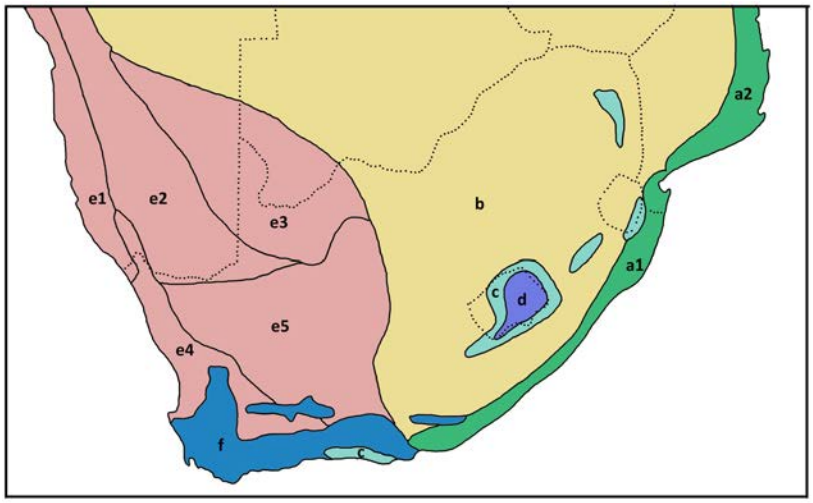
B.II. Guineo-Congolian Region
    - B.II.1.Atlantico-Congolian Domain
    - B.II.1.1. Peripheral Subdomain
    - B.II.1.2. Central Subdomain
    - B.II.2. Eastern Forest Domain

B.III. Afro-Alpine Region

B.IV. Karoo-Namib Region
    - B.IV.1. Karoo Domain
    - B.IV.2. Namaqualand Domain
    - B.IV.3. Namib Domain

C. Cape Region

D. Malagasian Region



Legend

a Indian Ocean Coastal Belt
- a1 Tongaland – Pondoland Regional Mosaic
- a2 Zanzibar – Inhambane Regional Mosaic

b Zambezian Domain, Sudano-Zambezian Region

c Afromontane Region

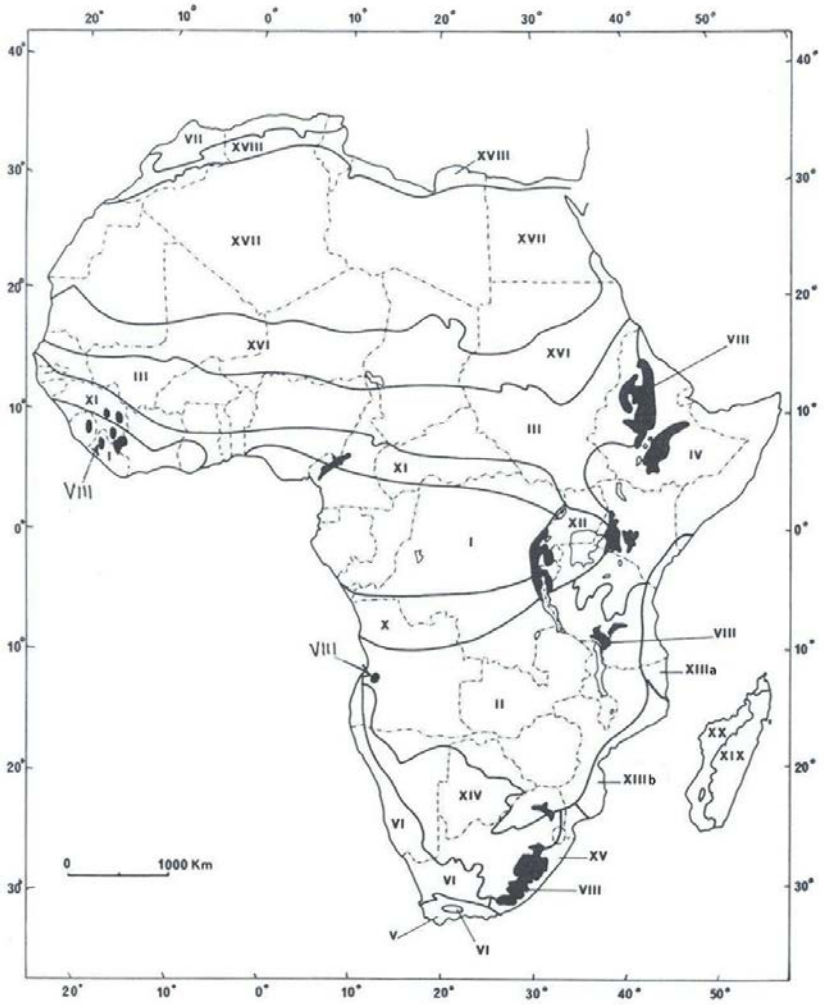
d Austral Domain, Afro-Alpine Region

e Karoo-Namib Region
- e1 Namib Domain
- e2 Namaqualand Domain
- e3 Southern Kalahari Domain
- e4 Western Cape Domain
- e5 Karoo Domain

f Fynbos Region

Figure 13: Phytogeographical map of southern Africa according to Werger (1978).

In 1983 White published his seminal work on the vegetation of Africa, which is currently accepted as the reference work on African phytogeography (Figure 14). According to White (1983) the study area is phytogeographically part of the Karoo-Namib Regional Centre of Endemism (VI). In a further subdivision of this Centre of Endemism it was mapped as Dwarf Karoo Shrubland. He described the vegetation as dominated by dwarf shrubs, most of which belong to the Asteraceae. Bushes and trees were said to be absent. Shrubs were few in species and represented chiefly by *Rhigozum trichotomum*. Succulents were present, but mostly inconspicuous with relatively few species. Grasses were relatively abundant. The soils were often slightly saline, and halophytes, particularly *Salsola tuberculata*, were widespread and locally dominant. The enormous brackish flats or 'vloere', were in some cases covered with *Salsola aphylla* and other halophytes, but elsewhere practically bare.



Legend

I Guineo-Congolian Regional Centre of Endemism
II Zambezian Regional Centre of Endemism
III Sudanian Regional Centre of Endemism
IV Somalia-Masai Regional Centre of Endemism
V Cape Regional Centre of Endemism
VI Karoo-Namib Regional Centre of Endemism
VII Mediterranean Regional Centre of Endemism
VIII Afromontane Archipelago-like Regional Centre of Endemism
IX Afro-alpine Archipelago-like Region of Extreme Floristic Impoverishment (not shown)
XI Guinea-Congolia/Sudania Regional Transition Zone
XII Lake Victoria Regional Mosaic
XIII Zanzibar-Inhambane Regional Mosaic
XIV Kalahari-Highveld Regional Transition Zone
XV Tongaland-Pondoland Regional Mosaic
XVI Sahel Regional Transition Zone
XVII Sahara Regional Transition Zone
XVIII Mediterranean/Sahara Regional Transition Zone
XIX East Malagasy Regional Centre of Endemism
XX West Malagasy Regional Centre of Endemism

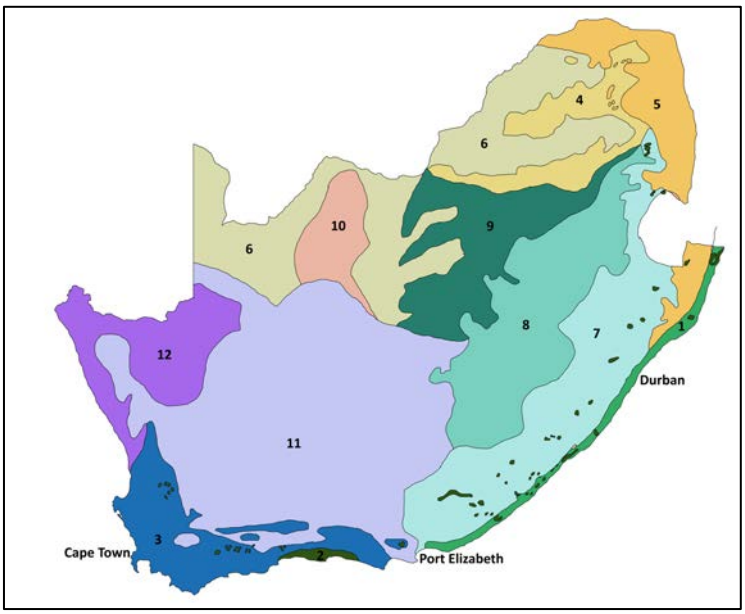
Figure 14: The main phytochoria of Africa and Madagascar according to White (1983).

4.3 Mapping of vegetation types

More detailed mapping of the vegetation types in South Africa started in the 1930s.

4.3.1 Pole Evans (1936)

Pole Evans (1936) produced the first fairly detailed vegetation map of South Africa in which he recognised 12 vegetation types in total (Figure 15). The study area is located in the so-called 'Desert Shrubs' unit (11), a large heterogeneous unit.



Legend

1.	Evergreen & Deciduous Forest & Subtropical Forest	7.	Long Grassland
2.	Temperate Evergreen Forest	8.	Short Grassland
3.	Evergreen Fynbos Savanna	9.	Mixed Grassland Desert shrubs
4.	Evergreen & Deciduous Trees and Shrubs	10.	Thornveld & Desert Shrubs
5.	Subtropical Evergreen & Deciduous Trees and Thornbush	11.	Desert Shrubs
6.	Thornveld Grassland	12.	Succulent Desert Plants & Desert Grass

Figure 15: Vegetation map of South Africa according to Pole Evans (1936).

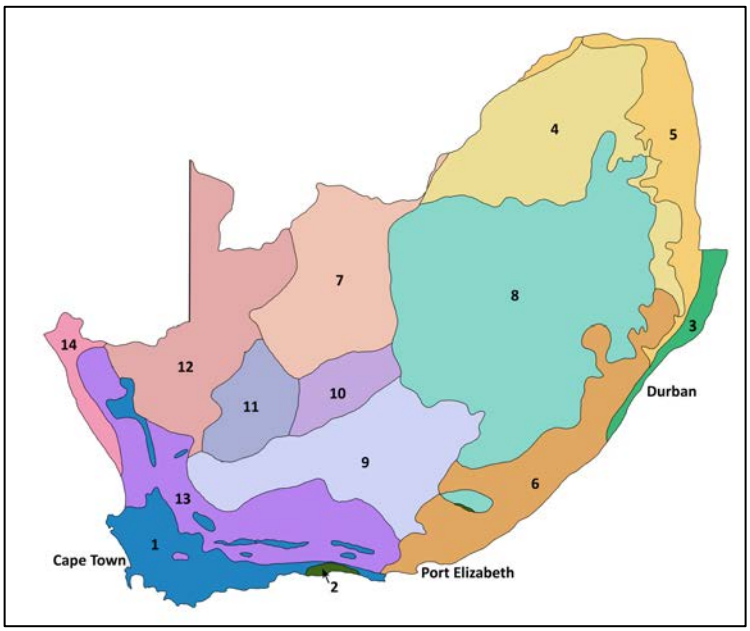
4.3.2 Adamson (1938)

In 1938, Adamson produced a vegetation map in which he recognised 14 vegetation types (Figure 16). The study area falls in the so-called '*Lycium* Community' unit (11).

4.3.3 Acocks (1953)

Acocks's map of the Veld Types of South Africa was published in 1953 (Figure 17). He defined a veld type as a 'unit of vegetation whose range of variation is small enough to permit the whole of it to have the same farming potential'. His map was therefore primarily intended to depict the distribution of the agro-economic divisions of the vegetation in the country. Acocks sampled approximately 3300 sites across South Africa to compile his veld type map.

The study area falls in the Arid Karoo Veld Type and in the Driedoring Veld variation. According to Acocks this veld type was severely degraded due to overgrazing. The dominant dwarf shrubs were *Pentzia spinescens, Eriocephalus spinescens, Galenia sarcophylla, Ruschia intricata, Tetraena microcarpa* and *Pteronia leucoclada. Rhigozum trichotomum* was said to occur in patches and narrow belts, forming a honeycomb pattern. The dominant grasses were *Stipagrostis obtusa, Stipagrostis ciliata, Enneapogon desvauxii* and *Aristida adscensionis.* After good rains annual species, such as *Tribulus* spp. could be abundant.



Legend

	1. Sclerophyll	Semi-desert: Arid Bush	
Forest			9. Karroo Bush
	2. Temperate		10. *Gnidia* Community
	3. Subtropical		11. *Lycium* Community
Savanna			12. *Rhigozum* Community
	4. Bushveld	Semi-desert: Succulent Shrubland	
	5. Lowveld		13. Succulent Shrubland
	6. Temperate Savanna (including warm temperate forest)		14. Coastal Succulent Shrubland
	7. Bush Savanna Grassland		
Grassland			
	8. Grassland		

Figure 16: Vegetation map of South Africa according to Adamson (1938).

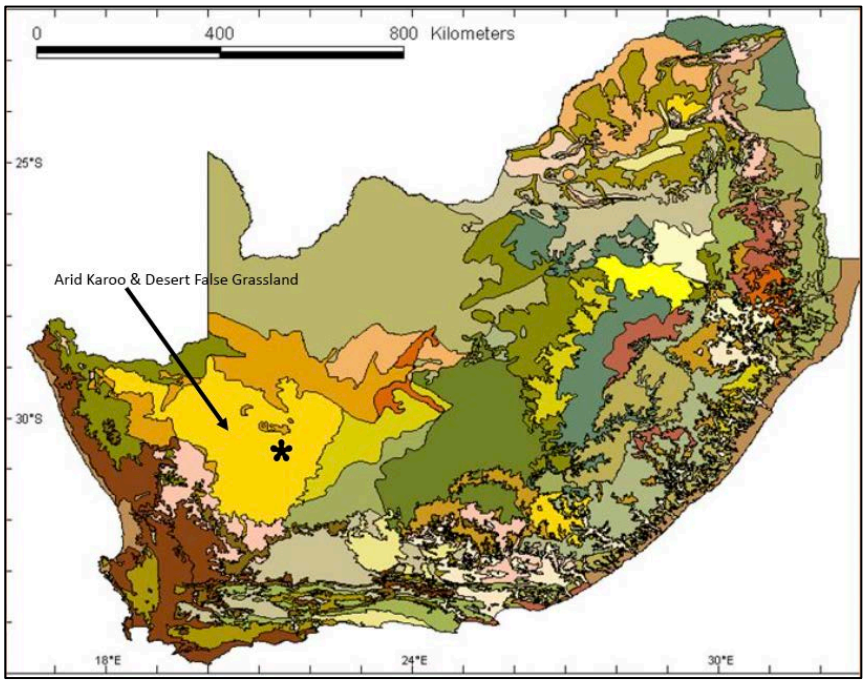


Figure 17: Vegetation map of South Africa according to Acocks (1953). Approximate position of SKA site indicated by star. Full legend not provided.

4.3.4 Low & Rebelo (1998)

According to the map of Low & Rebelo (1998) the study area lies in the Bushmanland Nama Karoo (Figure 18). In the sandy areas the dominant species were indicated as *Stipagrostis obtusa, Stipagrostis ciliata* and *Salsola tuberculata*, whereas the dominant species in the rocky areas were *Rhigozum trichotomum, Eriocephalus spinescens* and *Ruschia intricata*. A small part of the study area in the mountainous terrain around Groot Paarde Kloof was mapped as Orange River Nama Karoo, however this does not seem to be appropriate.

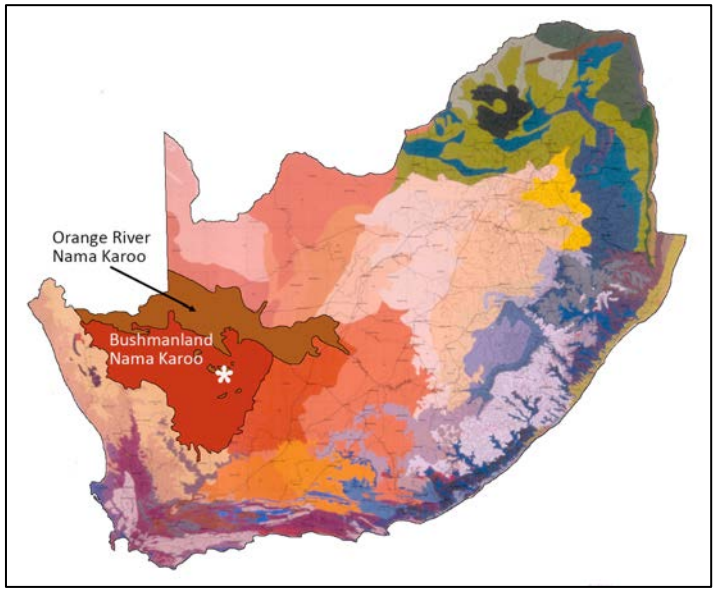


Figure 18: Vegetation map of South Africa according to Low & Rebelo (1998). Approximate location of SKA site indicated by star. Full legend not provided.

4.3.5 Mucina & Rutherford (2006)

Five national vegetation types have been mapped for the study area (Figure 19).

Bushmanland Basin Shrubland (Nkb 6)
This vegetation type dominates the plains in the central and northern parts of the study area and constitutes 63.8% of the core area (Milton 2021). It is underlain primarily by mudstones and shales of the Ecca Group as well as Dwyka tillites and about 20% of the rock outcrop is formed by Jurassic dolerite sills and dykes. Prominent shrubs and dwarf shrubs include *Rhigozum trichotomum, Lycium cinereum, Aptosimum spinescens, Pentzia spinescens, Hermannia spinosa, Phaeoptilum spinosum, Mesembryanthemum noctiflorum* and various species in the genera *Eriocephalus, Osteospermum, Pteronia, Salsola, Tetraena* and *Roepera*. The dominant grasses are *Stipagrostis obtusa, Stipagrostis ciliata, Enneapogon desvauxii* and *Aristida adscensionis*, while prominent herbs include *Tribulus* spp., *Gazania lichtensteinii, Leysera tenella* and *Dicoma capensis*. The endemic taxon is *Tridentea dwequensis*.

Upper Karoo Hardeveld (Nku 2)
This vegetation type is found on skeletal soils in rocky areas developing over sedimentary rocks (mudrock and arenites) as well as Jurassic dolerite sills and dykes. In the study area it occurs in a belt across the southern section on steep slopes and makes up 18.6% of the SKA core area (Milton 2021). Prominent shrubs and dwarf shrubs include *Rhigozum obovatum, Lycium cinereum, Searsia burchellii, Diospyros austro-africana, Chrysocoma ciliata, Eriocephalus ericoides, Euryops lateriflorus, Felicia muricata, Limeum aethiopicum, Nenax microphylla, Justicia incana* and *Pteronia* spp. The dominant grasses are *Aristida diffusa, Cenchrus ciliaris, Sporobolus fimbriatus, Stipagrostis obtusa, Stipagrostis ciliata, Enneapogon desvauxii* and *Aristida adscensionis*, while prominent herbs include *Leysera tenella, Gazania krebsiana,*

Lepidium africanum and *Pelargonium minimum*. A large number of endemic taxa have been listed for the vegetation type, such as: *Aloe chlorantha, Crassula barbata, Delosperma robustum, Sceletium expansum, Stomatium suaveolens, Cineraria polycephala, Euryops petraeus, Lotononis azureoides, Selago magnakarooica, Anisodontea malvastroides, Cineraria arctotidea, Vellereophyton niveum, Adromischus fallax, Adromischus humilis, Gethyllis longistyla, Lachenalia aurioliae* and *Ornithogalum paucifolium*.

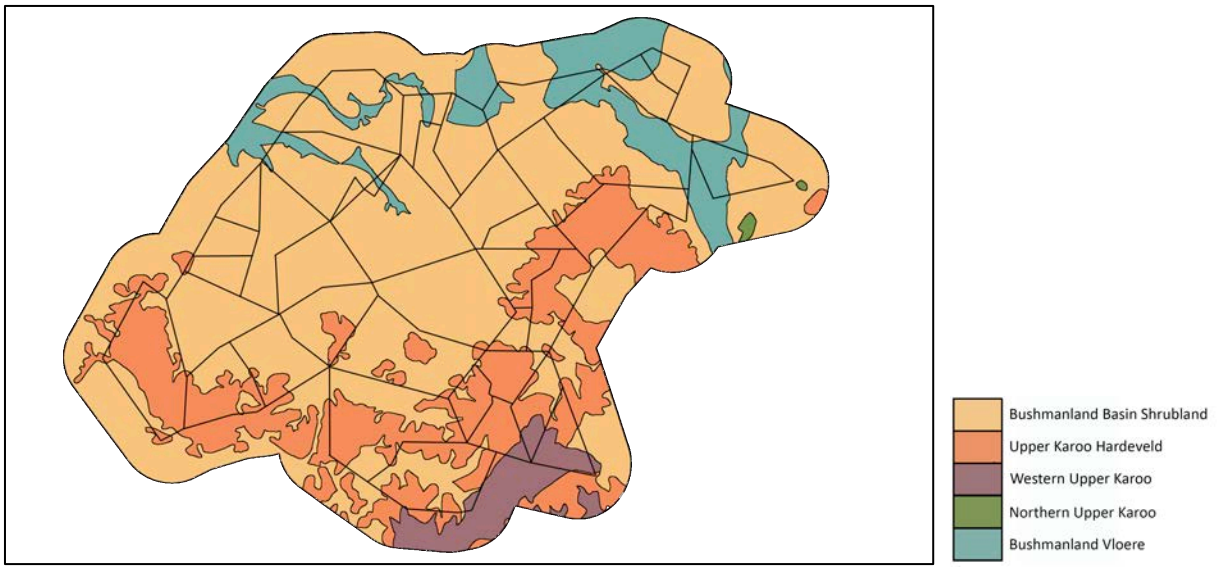


Figure 19: Vegetation types of the SKA study area according to Mucina & Rutherford (2006) and revised by SANBI (2006-2018).

Western Upper Karoo (Nku 1)

This vegetation type occurs in the dissected upper catchment of the Sakrivier on skeletal soils on Karoo sediments (mudrock, shales and arenites) as well as Jurassic dolerite bedrock. It makes up 3.8% of the SKA core area (Milton 2021). Within the study area, this unit is confined to the southeastern section. Prominent shrubs and dwarf shrubs include *Rhigozum trichotomum, Lycium pilifolium, Osteospermum sinuatum, Osteospermum spinescens, Chrysocoma ciliata, Eriocephalus ericoides, Eriocephalus spinescens, Helichrysum lucilioides, Tetragonia arbuscula, Pentzia* spp., *Pteronia* spp*., Ruschia intricata* and *Mesembryanthemum noctiflorum*. The dominant grasses are *Aristida congesta, Stipagrostis obtusa, Stipagrostis ciliata, Enneapogon desvauxii* and *Aristida adscensionis*, while prominent herbs include *Lepidium* spp., *Pelargonium minimum* and *Leysera tenella*. Endemic species are *Stomatium villetii* and *Zaluzianskya bella*.

Northern Upper Karoo (Nku 3)

This vegetation type is found on flat to gently sloping terrain on Ecca shales, Dwyka diamictites and sometimes on Jurassic dolerites. Only a tiny fragment of this unit occurs in the northeastern buffer zone of the study area and constitutes only 0.1% of the core area (Milton 2021). The woody vegetation includes small trees such as *Senegalia mellifera* and *Boscia albitrunca* and shrubs or dwarf shrubs such as *Lycium* spp., *Rhigozum trichotomum, Chrysocoma ciliata, Lasiosiphon polycephala, Pentzia* spp., *Eriocephalus* spp. and *Osteospermum* spp. The dominant grasses are *Aristida congesta, Aristida diffusa, Eragrostis* spp., *Stipagrostis obtusa, Enneapogon desvauxii* and *Aristida adscensionis*, while prominent herbs include *Sesamum capense, Lessertia pauciflora* and *Gazania krebsiana*. The species endemic to this vegetation type include *Lithops hookeri, Manulea deserticola, Atriplex spongiosa, Galenia exigua* and *Stomatium pluridens*.

Bushmanland Vloere (AZi 5)

This azonal vegetation type occurs on flat terrain on endorheic pans (vloere) and wide courses of intermittent rivers. It is embedded in the Bushmanland Basin Shrubland and makes up 13.6% of the SKA core area (Milton 2021). The alluvial soils often have a high salt concentration. Prominent woody species include *Parkinsonia africana, Rhigozum*

trichotomum, Asparagus glaucus, Eriocephalus decussatus, Eriocephalus spinescens, Lycium pumilum, Pegolettia retrofracta and a multitude of *Salsola* spp. Dominant grasses are *Stipagrostis obtusa, Stipagrostis ciliata* and *Stipagrostis namaquensis*. The vegetation type is threatened by the invasion of *Prosopis glandulosa* and its hybrids. The Bushmanland Vloere is said to be the least studied vegetation type in the country.

4.3.6 MacDonald (2008)

MacDonald (2008 in Strategic Environmental Focus 2009) described the habitats of the core area in an unpublished study for the Meerkat EIA, but no vegetation map was included.

4.3.7 Milton (2017)

Milton (2017) presented a breakdown of the habitats on site with reference to some characteristic plant species in each habitat and provided a sensitivity map of the area, but no vegetation map.

4.3.7 Todd (2017, 2020)

Todd (2017) provided a baseline analysis of the species, habitats and ecosystems present in the SKA. A fine-scale habitat map was produced indicating 16 habitat types based on geology and terrain form. The map illustrates the high habitat heterogeneity and diversity of the SKA site. However, the broad-scale descriptions of vegetation types followed Mucina & Rutherford (2006). Todd (2020) also conducted an assessment of the fauna and flora of the SKA site and the three spiral arms. However, this walk-through aimed at locating and identifying protected or threatened species of fauna and flora which may be impacted by the SKA development and to produce a sensitivity map of the area. Once again the descriptions of vegetation types followed Mucina & Rutherford (2006).

4.3.8 Van der Merwe (2020)

The only phytosociological study of the SKA site to date was undertaken by Van der Merwe (2020). The vegetation of the two core properties (farms) of the SKA, i.e. Meysdam and Losberg was classified and described. Ten plant communities and two subcommunities were identified and described following the Braun-Blanquet methodology. However, the field work was conducted during an extended drought which limited the presence of forbs and geophytes and hampered positive identification of some plant species. These communities/subcommunities were used with landform and terrain units to produce five landscape units of the study area. These were ephemeral rivers; inselberg crest; inselberg slopes; slopes and plains; and open flats and drainage areas. Four units were mapped with ephemeral rivers excluded.

5. RESULTS AND DISCUSSION

5.1 Species Accumulation Curves (SAC)

The species accumulation curve (SAC) for all 232 sample plots surveyed (considered as the representativeness of species level sampling over the full study area), reached an asymptote and the point where a line representing one new sample adding one new species was tangent to the curve at approximately 90 sample plots (Figure 20a). Thus, sampling sufficiency was already reached after 90 plots had been surveyed. The total sampling effort captured 100% of the number of species predicted by the Michaelis-Menten model.

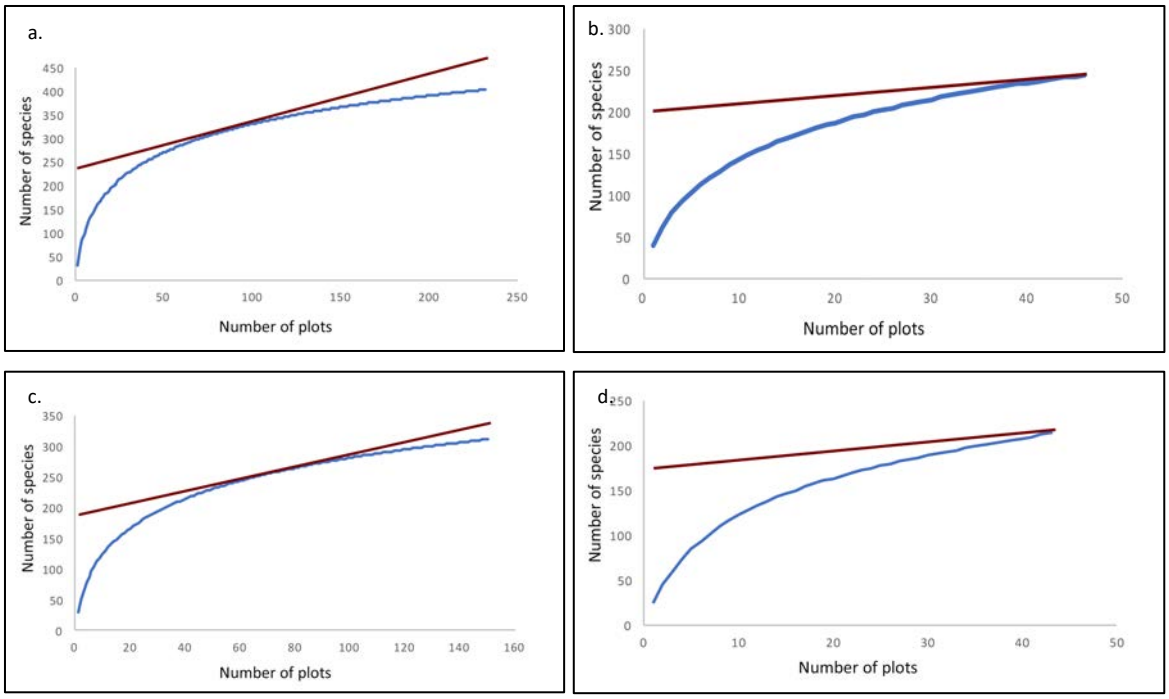


Figure 20: The species accumulation curve (SAC) is represented by the blue line and the maroon line represents an accumulation of one species for every additional sample plot. (a) SAC for 232 sample plots; (b) for the mountain associations (Cluster 1); (c) for the plains and plateaux associations (Cluster 2A); and (d) for the wetland associations (Cluster 2B).

Additionally, SACs were also generated for the broad habitat types distinguished.

- A total of 46 sample plots were surveyed in 2022 in Cluster 1 as defined by the cluster analysis. The SAC for the mountain associations, showed that when all plots had been surveyed, the line representing one new sample, adding one new species, was tangent to the curve (Figure 20b). The total sampling effort in these associations captured 93% of the number of species predicted by the Michaelis-Menten model.
- The SAC generated for the plains and plateaux associations (Cluster 2A; A1, A5 – A13), showed a strong levelling of the curve long before all plots had been sampled (Figure 20c). The point where a line representing one new sample adding one new species, was tangent to the curve when approximately 75 sample plots had been surveyed. A total of 150 sample plots were surveyed in the plains and plateau associations in 2022. The total sampling effort in this habitat captured 100% of the number of species predicted by the Michaelis-Menten model.
- The SAC compiled for the wetland associations (Cluster 2B; A14 – A16), showed that, despite a flattening of the curve, the slope of the curve was still marginally steeper than the line representing one new species for

one new plot (Figure 20d). A total of 43 sample plots were surveyed in the wetland associations. The total sampling effort in this habitat captured 86% of the number of species predicted by the Michaelis-Menten model. Thus, sampling sufficiency in this habitat had not been fully met.

A preliminary total of 403 taxa were recorded in the 232 sample plots. A mean of 33.6 taxa were recorded per sample plot. The mean frequency of occurrence of a plant species was 5.4%, but the most common value (mode) was 0.3%. The latter represents those species that were encountered in only one sample plot. Only 31 species occurred in more than 20% of all sample plots (Table 5).

The four species with the highest frequency of occurrence (≥44%) were all grass species (*Enneapogon desvauxii, Aristida adscensionis, Stipagrostis ciliata* and *Stipagrostis obtusa*). These are basically the dominant grasses in the Bushmanland Basin Shrubland. The woody species with the highest frequency of occurrence (≥36%) were shrub or large dwarf shrubs such as *Rhigozum trichotomum, Lycium cinereum, Lycium bosciifolium* and *Phaeoptilum spinosum*. Herbaceous species with a high frequency of occurrence (≥30%) included *Sesamum capense, Galenia* cf. *pubescens* and *Tribulus cristatus.*

Table 5: The plant species with a frequency of occurrence ≥20%, observed in the SKA study area

Species	Frequency (%)	Species	Frequency (%)
Enneapogon desvauxii	54	*Stipagrostis uniplumis*	26
Aristida adscensionis	49	*Enneapogon scaber*	25
Stipagrostis ciliata	46	*Chenopodium mucronatum*	24
Stipagrostis obtusa	44	*Tragus berteronianus*	24
Rhigozum trichotomum	41	*Aptosimum spinescens*	23
Lycium cinereum	40	*Leobordea platycarpa*	22
Lycium bosciifolium	38	*Limeum argute-carinatum*	21
Sesamum capense	37	*Dicoma capensis*	21
Stipagrostis anomala	37	*Pentzia incana*	20
Phaeoptilum spinosum	36	*Osteospermum sinuatum*	20
Galenia cf. *pubescens*	34	*Tetraena chrysopteros*	20
Tribulus cristatus	30	*Aristida congesta*	20
Salsola spp.	30	*Heliophila* cf. *deserticola*	20
Limeum aethiopicum	28	*Eragrostis lehmanniana*	20
Eriocephalus ambiguus	27	*Fingerhuthia africana*	20
Mesembryanthemum noctiflorum	27		

5.2 Classification and ordination of floristic data

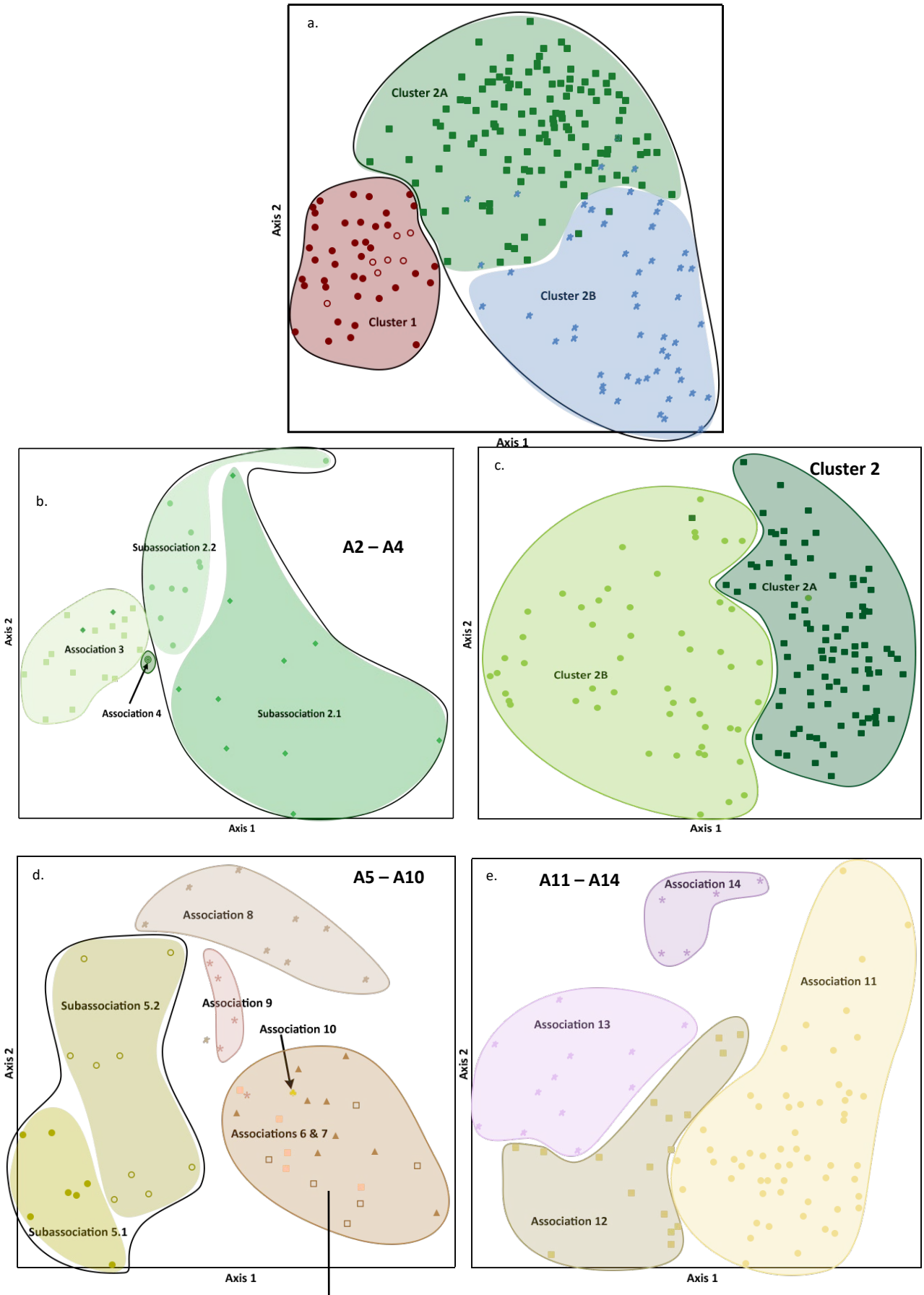
The classification of the floristic data revealed 17 associations (A) and 12 sub-associations (SA) as set out in the list below (refer to phytosociological synoptic table, Appendix A).

A1. *Stipagrostis amabilis – Limeum fenestratum* Dune Grassland
A2. *Rhigozum obovatum – Asparagus striatus – Trichodiadema setuliferum* Mountain Dwarf Shrubland/Grassland
  SA2.1 *Aristida diffusa – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland
  SA2.2 *Drosanthemum floribundum – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland
A3. *Aloidendron dichotomum – Dyerophytum africanum* Mountain Dwarf Shrubland/Grassland
A4. *Berkheya spinosa* Zebra-striped Steep Mountain Dwarf Shrubland
A5. *Ruschia intricata – Crassothonna protecta* Rocky Plains Grassland
  SA5.1 *Ruschia intricata – Crassula deltoidea – Stomatium peersii* Rocky Plains Grassland
  SA5.2 *Ruschia intricata – Euphorbia spartaria* Rocky Plains Grassland
A6. *Rhigozum obovatum – Pegolettia retrofracta – Lotononis rabenaviana* Plateau Grassland
A7. *Lotononis rabenaviana – Lotononis laxa* Low Ridge Grassland
  SA7.1 *Rhigozum trichotomum – Osteospermum sinuatum – Lotononis rabenaviana* Low Ridge Grassland
  SA7.2 *Rhigozum trichotomum – Lyperia tristis – Lotononis rabenaviana* Low Ridge Grassland

A8. *Stipagrostis obtusa – Daubenya marginata – Stipagrostis ciliata* Sandy Plains Grassland
A9. *Enneapogon desvauxii – Ophioglossum polyphyllum – Gazania lichtensteinii* High Mountain Plateau Grassland
A10. *Pentzia calcarea – Salsola* spp. Calcrete Plains Dwarf Shrubland
A11. *Rhigozum trichotomum – Ledebouria ensifolia – Limeum aethiopicum* Plains Dwarf Shrubland/Grassland
A12. *Rhigozum trichotomum – Mesembryanthemum vaginatum – Salsola aphylla/calluna* Plain/Floodplain Dwarf Shrubland
A13. *Salsola* spp. – *Pentzia spinescens – Moraea venenata* Plain/Floodplain Dwarf Shrubland
A14. *Stipagrostis anomala – Stipagrostis obtusa – Tetraena chrysopteros* Calcrete Plains Grassland
A15. *Cuspidea cernua – Panicum coloratum – Drosanthemum hispidum* Vloere Dwarf Shrubland
SA15.1 *Malephora crassa – Lampranthus uniflorus – Salsola aphylla/calluna* Vloere Dwarf Shrubland
SA15.2 *Roepera incrustata – Cuspidea cernua – Chloris virgata* Vloere Dwarf Shrubland
A16. *Stipagrostis namaquensis – Prosopis glandulosa* Riparian Bushveld
SA16.1 *Prosopis glandulosa – Salsola aphylla/calluna* Riparian Bushveld
SA16.2 *Prosopis glandulosa – Setaria verticillata* Riparian Bushveld
A17. *Searsia lancea – Stipagrostis namaquensis – Lycium bosciifolium* Riparian Bushveld/Grassland
SA17.1 *Tamarix usneoides – Searsia lancea – Stipagrostis namaquensis* Riparian Bushveld
SA17.2 *Stipagrostis namaquensis – Phaeoptilum spinosum – Berkheya annectens* Riparian Grassland

The Cluster Analysis and Principal Coordinates Analysis (PCoA) on the full dataset showed the presence of two clusters. Cluster 1 consisted predominantly of the high mountains with a few plots in Association 5 (open circles in Figure 21a), an association that was considered transitional between the mountains and the rocky plains. Cluster 2 comprised the dunes, plains (rocky as well as sandy) and plateaux (Cluster 2A); and wetlands (Cluster 2B). For the ordinations the plots were used as they were allocated to a particular association in the Braun-Blanquet classification. Although the sample plots in A1 (dune association) were part of the ordination of the full dataset, they were not included in the further ordinations of Cluster 2A.

- A subsequent ordination of the mountain associations A2 – A4 (Cluster 1 without the plots in Association 5), separated the three associations within this cluster in ordination space (Figure 21b).
- In the case of Cluster 2, the plains and plateaux associations (A5 – A14) (Cluster 2A) were separated from the wetland associations (A15 – A17) (Cluster 2B) in a subsequent ordination (Figure 21c).
- The PCoA ordination of the plains and plateaux associations (A5 – A14) once again distinguished two groups, which each required successive ordinations for visualization at association level (Figure 21d, e, f).
- Ordination of the wetland associations (A15 – A17) (Cluster 2B) revealed the presence of three associations each with two subassociations (Figure 21g).


a.
Cluster 2A
Cluster 2B
Cluster 1
Axis 2
Axis 1
b.
A2 – A4
Subassociation 2.2
Association 3
Association 4
Subassociation 2.1
Axis 2
Axis 1
c.
Cluster 2
Cluster 2A
Cluster 2B
Axis 2
Axis 1
d.
A5 – A10
Association 8
Subassociation 5.2
Association 9
Association 10
Associations 6 & 7
Subassociation 5.1
Axis 2
Axis 1
e.
A11 – A14
Association 14
Association 11
Association 13
Association 12
Axis 2
Axis 1

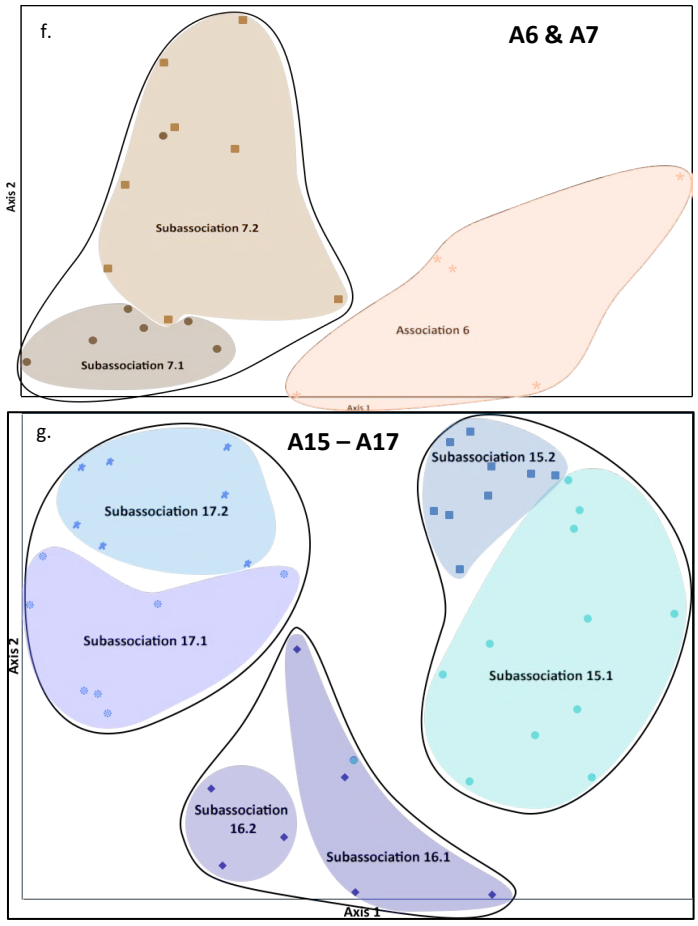


Figure 21: (a) Principal Coordinates Analysis (PCoA) of all 232 plots indicating the two clusters distinguished by the Cluster Analysis (Ward's algorithm); (b) PCoA of the floristic data in the mountain associations (A2 – A4) and (c) PCoA of the floristic data in the plains and plateaux associations (A5 – A14); (d), (e) & (f) further ordinations to separate the associations of the plains and plateaux associations; and (g) PCoA of the floristic data in the wetland associations (A15 – A17). Different colours and symbols denote different associations/subassociations. Colours correspond approximately to those used in the vegetation map.

5.3 Diversity

The diversity data for each association are summarised in tables and figures (Tables 6 & 7, Figures 22 & 23) in this section, but are also referred to in Section 5.5 for each association. Table 6 summarises the diversity parameters as mean per plot values for each association, whereas Table 7 provides the values for Shannon-Wiener (H'), Exponent of Shannon-Wiener (Exp H') and Inverse Simpson (Inv D') diversity parameters considering all samples in the pool. Estimate S computes these indices for each level of sample pooling, from one sample up to the total number in the dataset, adding samples to the pool at random. When considering the sensitivity to rare species, species richness (S) is the most sensitive and Simpson (D') diversity the least, with Shannon-Wiener (H') diversity intermediate.

Table 6: Summary of mean values per plot for species richness (S), evenness (E) and Shannon-Wiener (H' and EXP H') and Simpson (D' and Inv D') indices of diversity for the different plant associations in the SKA study area

	S	E	H'	EXP H'	D'	Inv D'
A1	15.7	0.801	2.207	9.085	0.838	6.155
A2	38.3	0.804	2.919	18.518	0.881	8.394
A3	37.2	0.820	2.961	19.311	0.895	9.500
A4	23.0	0.985	3.087	21.911	0.950	20.161
A5	34.3	0.805	2.837	17.059	0.868	7.604
A6	34.2	0.842	2.970	19.492	0.890	9.094
A7	32.9	0.822	2.866	17.562	0.884	8.617
A8	32.2	0.748	2.598	13.432	0.820	5.564
A9	35.4	0.799	2.845	17.205	0.877	8.125
A10	25.0	0.962	3.097	22.131	0.948	19.120
A11	27.6	0.752	2.481	11.956	0.827	5.796
A12	28.8	0.762	2.554	12.855	0.837	6.151
A13	30.9	0.897	3.063	21.387	0.925	13.252
A14	29.4	0.781	2.632	13.896	0.863	7.316
A15	23.6	0.829	2.580	13.192	0.856	6.932
A16	19.7	0.524	1.548	4.703	0.557	2.257
A17	32.3	0.807	2.800	16.443	0.871	7.782

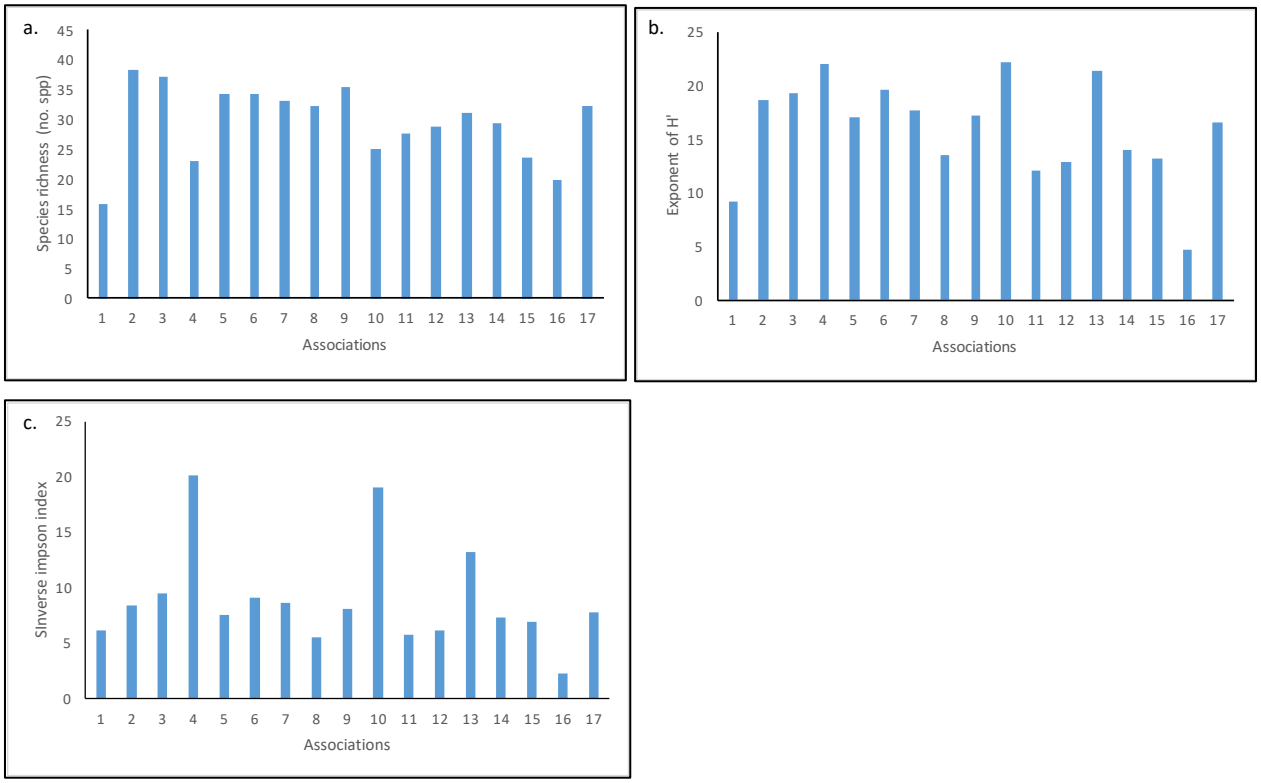


Figure 22: Comparison of various diversity parameters across associations. (a) Mean species richness per plot (S); (b) mean Exponent of Shannon-Wiener index of diversity (Exp H') per plot; and (c) mean Simpson index of diversity (D') per plot.

Mean species richness per plot was high in the mountain associations A2 and A3 (except for A4), A5 – A9 in the plains and plateaux associations (Table 7, Figure 22) as well as in A17 in the wetland associations. The lowest species richness was found in A1 (dune crests); A4 (dolerite zebra stripes); and A16 (*Prosopis glandulosa* invaded drainage lines). The Shannon-Wiener index of diversity incorporates species evenness and consequently diversity of A16, which was strongly dominated by *Prosopis glandulosa*, had a very low value. In contrast A4 and A10 where evenness was high, but species richness low to intermediate, had the highest values. The Inverse Simpson index of diversity shows this effect of evenness even stronger.

Table 7: Summary of number of plots surveyed and total number of species, Shannon-Wiener (H'), Exponent of Shannon-Wiener (Exp H') and Inverse Simpson (Inv D') index of diversity for the different plant associations as a whole

Association	No plots	Tot spp	H'	Exp H'	Inv D'
A1	3	27	2.45	11.55	7.43
A2	23	97	3.85	47.21	14.59
A3	15	125	3.74	41.95	20.12
A4	1	23	3.09	21.91	20.16
A5	15	168	3.81	45.33	14.38
A6	5	86	3.55	35.12	11.46
A7	16	134	3.69	40.39	16.69
A8	9	116	3.50	33.26	12.33
A9	5	79	3.42	30.49	12.96
A10	1	33	3.10	22.13	19.11
A11	60	176	3.33	28.07	10.00
A12	16	132	3.47	32.08	12.64
A13	14	120	3.97	53.10	27.46
A14	5	75	3.13	22.98	10.40
A15	22	134	3.90	49.19	26.22
A16	7	71	1.95	7.01	2.56
A17	14	153	3.95	51.90	21.62

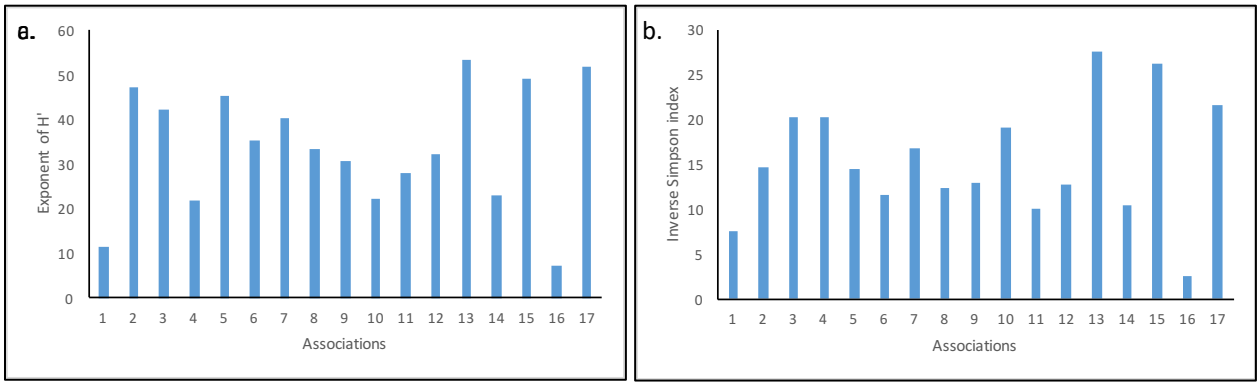


Figure 23: Comparison of various diversity parameters across associations. (a) Exponent of Shannon-Wiener index of diversity (Exp H') for an association as a whole; and (b) Inverse Simpson index of diversity (Inv D') for an association as a whole.

When considering the values in Table 8, A13, A15 and A16 emerged as the associations with the highest Shannon-Wiener and Simpson diversity indices.

5.4 Canopy cover

Mean canopy cover (%) of the various woody and herbaceous strata of the associations are provided in Table 8 and Figure 24.

Table 8: Mean canopy cover (%) of the various woody and herbaceous strata in 17 associations in the SKA study area

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
Forbs	11.7	1.5	4.1	1.0	1.1	1.2	2.1	2.3	5.2	1.0	6.1	6.0	3.1	2.2	2.5	1.0	4.0
Grasses	21.7	30.1	28.7	3.0	29.7	25.0	29.7	44.4	33.0	1.0	22.4	15.6	12.7	43.0	10.9	9.9	22.1
Dwarf shrubs	10.7	15.4	21.8	5.0	11.5	9.6	13.1	10.7	12.0	15.0	24.8	31.2	17.0	9.2	18.8	8.3	9.2
Shrubs	5.0	3.8	3.5	1.0	1.1	1.2	1.4	1.6	1.2	0.0	2.3	2.4	1.8	0.6	1.1	15.7	9.9
Trees	0	0.2	0.7	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.3	0.3	0.0	0.2	36.6	16.1
TOTAL	49.0	51.0	58.8	10.0	43.4	37.0	46.3	59.0	51.6	17.0	55.7	55.5	34.9	55.0	33.4	71.4	61.4

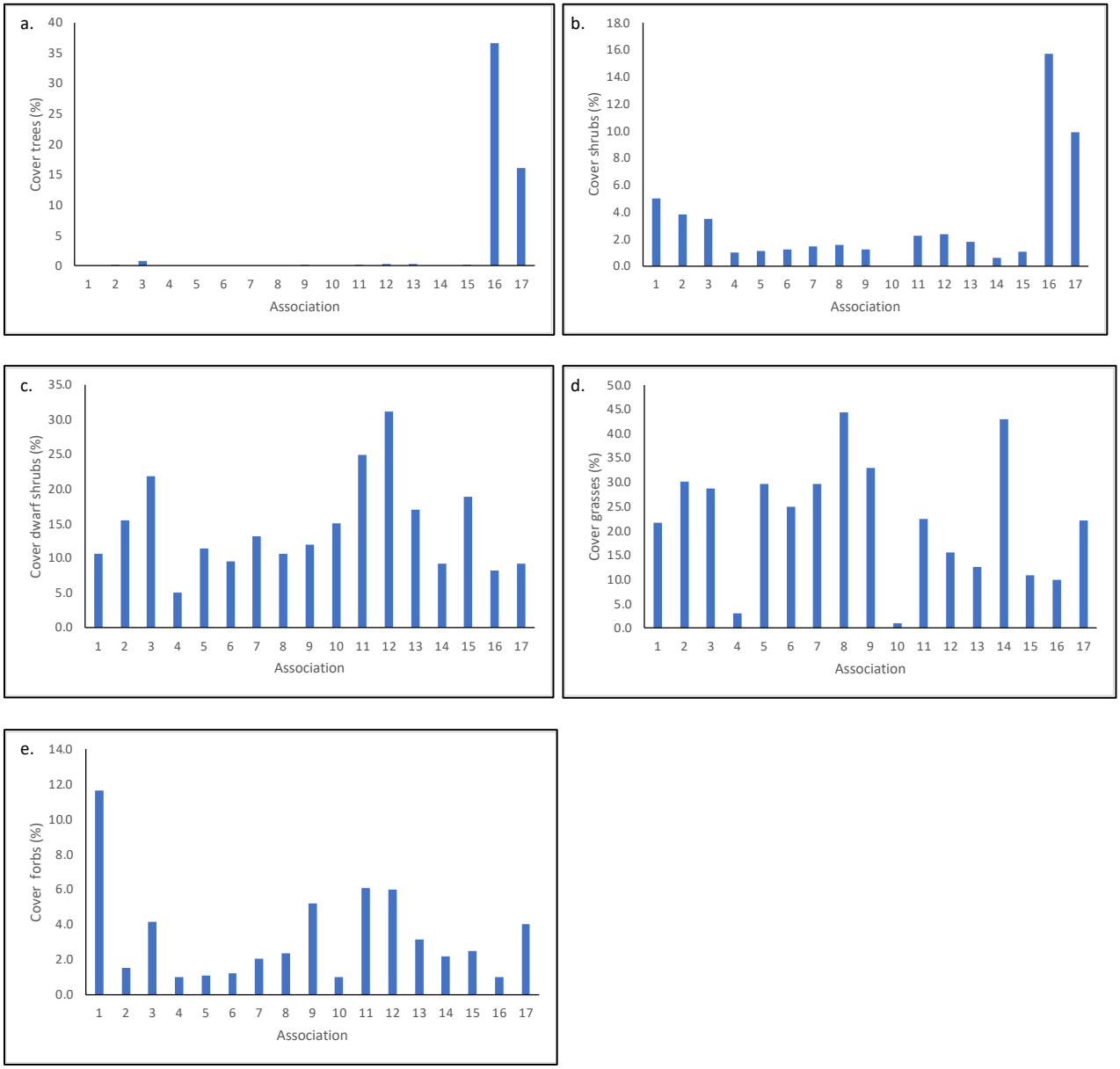


Figure 24: Mean percentage canopy cover for different strata across associations, (a) tree cover; (b) shrub cover; (c) dwarf shrub cover; (d) grass cover; and (e) forb cover.

Canopy cover of the various strata showed large differences across associations. A16 and A17 were the only two associations with a high cover of trees and shrubs. The *Rhigozum trichotomum* associations (A11 & A12) had the highest cover of dwarf shrubs, followed by the mountain association A3 as well as the vloere association (A15). Grass cover was the highest in the plains grassland associations on sand (A8) and in A14, with most of the mountain associations (A2 & A3) and those in plains and plateaux grasslands (A5 – A9) having a relatively high grass cover. Forb cover is expected to be highly variable and will depend on seasonal rainfall. There was a marked decline in forb cover from the first site visit in April to the second in the in May in the current study.

5.5 Description of the associations

The following descriptions are based on the vegetation map (Figure 25), the analysis of the vegetation map to derive surface areas (Table 9) and the synoptic phytosociological table (Appendix A)

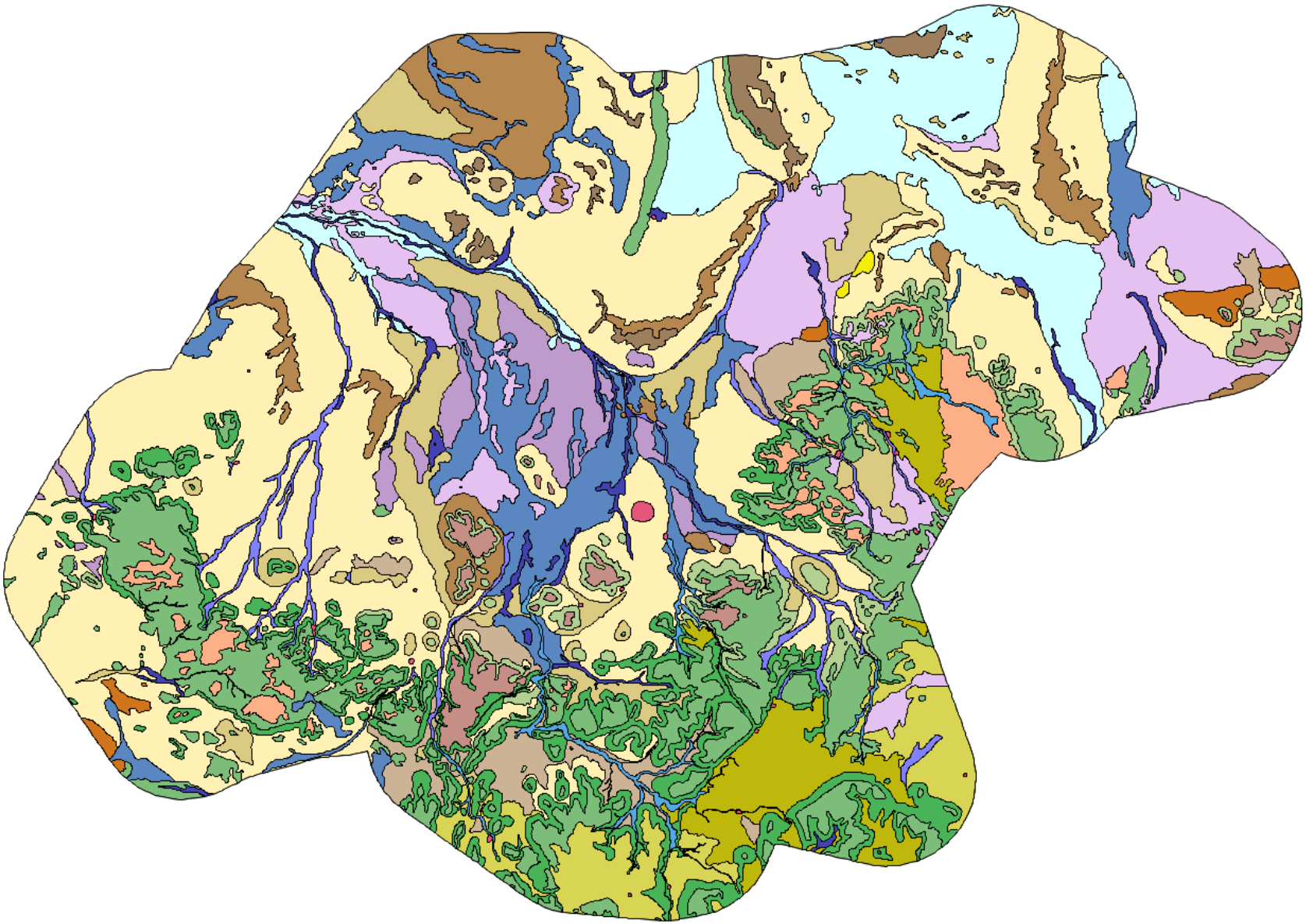


Figure 25: Vegetation map of the SKA study area. Legend follows on next page.

Colour	Key	No	Class
	1	1	*Stipagrostis amabilis – Limeum fenestratum* Dune Grassland
	2	2.1	*Aristida diffusa – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland
	3	2.2	*Drosanthemum floribundum – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland
	4	3	*Aloidendron dichotomum – Dyerophytum africanum* Mountain Dwarf Shrubland/Grassland
	5	4	*Berkheya spinosa* Zebra-Striped Steep Mountain Dwarf Shrubland
	6	5.1	*Ruschia intricata – Crassula deltoidea – Stomatium peersii* Rocky Plains Grassland
	7	5.2	*Ruschia intricata – Euphorbia spartaria* Rocky Plains Grassland
	8	6	*Rhigozum obovatum – Pegolettia retrofracta – Lotononis rabenaviana* Plateau Grassland
	9	7.1	*Rhigozum trichotomum – Osteospermum sinuatum – Lotononis rabenaviana* Low Ridge Grassland
	10	7.2	*Rhigozum trichotomum – Lyperia tristis – Lotononis rabenaviana* Low Ridge Grassland
	11	8	*Stipagrostis obtusa – Daubenya marginata – Stipagrostis ciliata* Sandy Plains Grassland
	12	9	*Enneapogon desvauxii – Ophioglossum polyphyllum – Gazania lichtensteinii* High Mountain Plateau Grassland
	13	10	*Pentzia calcarea – Salsola* spp. Calcrete Plain Dwarf Shrubland
	14	11	*Rhigozum trichotomum – Ledebouria ensifolia – Limeum aethiopicum* Plains Dwarf Shrubland/Grassland
	15	12	*Rhigozum trichotomum – Mesembryanthemum vaginatum – Salsola aphylla/calluna* Plain/Floodplain Dwarf Shrubland
	16	13	*Salsola* spp. *– Pentzia spinescens – Moraea venenata Plain/*Floodplain Dwarf Shrubland
	17	14	*Stipagrostis anomala – Stipagrostis obtusa – Tetraena chrysopteros* Calcrete Plains Grassland
	18	15.1	*Malephora crassa – Lampranthus uniflorus – Salsola aphylla/calluna* Vloere
	19	15.2	*Roepera incrustata – Cuspidea cernua – Chloris virgata* Vloere
	20	16	*Stipagrostis namaquensis – Prosopis glandulosa* Riparian Bushveld
	21	17.1	*Tamarix usneoides – Searsia lancea – Stipagrostis namaquensis* Riparian Bushveld
	22	17.2	*Stipagrostis namaquensis – Phaeoptilum spinosum – Berkheya annectens* Riparian Grassland
	23	18	Infrastructure

Table 9: Surface areas (ha) and percentage of total study area of the plant associations and infrastructure within the study area

Key	No	Class	%	Area (ha)
1	1	*Stipagrostis amabilis – Limeum fenestratum* Dune Grassland	0.60	1 421.1
2	2.1	*Aristida diffusa – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland	6.06	14 372.3
3	2.2	*Drosanthemum floribundum – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland	10.77	25 513.5
4	3	*Aloidendron dichotomum – Dyerophytum africanum* Mountain Dwarf Shrubland/Grassland	2.46	5 834.1
5	4	*Berkheya spinosa* Zebra-Striped Steep Mountain Dwarf Shrubland	0.02	42.5
6	5.1	*Ruschia intricata – Crassula deltoidea – Stomatium peersii* Rocky Plains Grassland	3.25	7 704.0
7	5.2	*Ruschia intricata – Euphorbia spartaria* Rocky Plains Grassland	3.09	7 326.0
8	6	*Rhigozum obovatum – Pegolettia retrofracta – Lotononis rabenaviana* Plateau Grassland	2.11	5 008.9
9	7.1	*Rhigozum trichotomum – Osteospermum sinuatum – Lotononis rabenaviana* Low Ridge Grassland	1.11	2 620.3
10	7.2	*Rhigozum trichotomum – Lyperia tristis – Lotononis rabenaviana* Low Ridge Grassland	4.29	10 160.8
11	8	*Stipagrostis obtusa – Daubenya marginata – Stipagrostis ciliata* Sandy Plains Grassland	2.46	5 822.9
12	9	*Enneapogon desvauxii – Ophioglossum polyphyllum – Gazania lichtensteinii* High Mountain Plateau Grassland	1.06	2 522.2
13	10	*Pentzia calcarea – Salsola* spp. Calcrete Plains Dwarf Shrubland	0.06	149.6
14	11	*Rhigozum trichotomum – Ledebouria ensifolia – Limeum aethiopicum* Plains Dwarf Shrubland/Grassland	30.87	73 155.0
15	12	*Rhigozum trichotomum – Mesembryanthemum vaginatum – Salsola aphylla/calluna* Plain/Floodplain Dwarf Shrubland	5.04	11 949.7
16	13	*Salsola* spp. *– Pentzia spinescens – Moraea venenata Plain/*Floodplain Dwarf Shrubland	7.46	17 668.4
17	14	*Stipagrostis anomala – Stipagrostis obtusa – Tetraena chrysopteros* Calcrete Plains Grassland	2.27	5 374.3
18	15.1	*Malephora crassa – Lampranthus uniflorus – Salsola aphylla/calluna* Vloere	7.33	17 373.3
19	15.2	*Roepera incrustata – Cuspidea cernua – Chloris virgata* Vloere	6.08	14 408.7
20	16*	*Stipagrostis namaquensis – Prosopis glandulosa* Riparian Bushveld	1.18	2 795.9
21	17.1	*Tamarix usneoides – Searsia lancea – Stipagrostis namaquensis* Riparian Bushveld	0.85	2 015.0
22	17.2	*Stipagrostis namaquensis – Phaeoptilum spinosum – Berkheya annectens* Riparian Grassland	1.46	3 467.4
23	18	Infrastructure	0.12	284.8
Total			**100.00**	**236 990.7**

*Note: Subassociations of A16 were not mapped separately.

Association 1 (A1): *Stipagrostis amabilis – Limeum fenestratum* Dune Grassland

Although A1 forms part of the plains and plateaux cluster (Cluster 2A), its position in the Braun-Blanquet table (Appendix A) does not reflect this relationship, due to the absence of so many common species.

Location and environmental features:
This dune association (Figure 26) was found predominantly in the northeast of the study area on the farm Blaaupoort (Snymanshoop) where it occurred in a mosaic with the dune streets/dune valleys of A8. As mapped in Figure 25, it covers 1 421 ha (0.6% of the total area), however the mosaic on Blaaupoort (Snymanshoop) overestimates the size of only the dune component. Geologically, A1 occurred on red to red-brown Quaternary sands (Qs), mostly on the Ah Land Type. No rocks or gravel were recorded. Mean altitude in the association was 1 041 m above sea level (a.s.l.) (Table 10).

Table 10: Summary of the dominant environmental features of Association 1 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	Upper slope
	Plateau	Ridge/hill	Pan				
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1041						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.0	5.0	10.7	21.7	11.7	49.0	

Key to colours:

0-25	>25-50	>50-75	>75

Floristic composition:
A1 was defined by a strong diagnostic species group (species group 1; Appendix A) represented by *Stipagrostis amabilis, Limeum fenestratum, Hermannia gariepina, Citrullus lanatus* and *Crassothonna cylindrica*.

- There were no **trees** in this association.
- The most prominent **shrubs** were *Lycium bosciifolium, Lacominaeae lineata* and *Phaeoptilum spinosum*.
- The **dwarf shrub layer** was dominated by *Rhigozum trichotomum*, with *Plinthus karooicus, Calobota spinescens* and *Eriocephalus ambiguus* noted occasionally.
- The dominant **grass** species was *Stipagrostis amabilis*, with other common species including *Stipagrostis anomala* and *Stipagrostis ciliata*.
- **Forbs** were abundant and represented by *Limeum fenestratum* (d), *Sesamum capense* (d), *Hermannia gariepina, Leobordea platycarpa, Gisekia pharnaceoides, Mesembryanthemum guerichianum* and *Tribulus* spp. Several **creepers**, such as *Citrullus lanatus* and *Cucumis africanus* were encountered.

Figure 26: A1: *Stipagrostis amabilis – Limeum fenestratum* Dune Grassland on the farm Blaaupoort (Snymanshoop).

Vegetation structure:
The grass layer was the dominant layer (mean 21.7% cover) with forbs (mean 11.7%) and dwarf shrubs (mean 10.7%) also contributing substantially to the mean total cover of 49% (Tables 8 & 10).

Plant diversity:
Mean per plot values for species richness, were the lowest of all associations and Shannon-Wiener and Simpson indices of diversity were second lowest of all associations (Tables 6 & 7). The mean number of species per sample plot for the three plots surveyed in A1 was 15.7 with a range from 14 to 17 species. When considering the association as a whole, A1 had the second lowest values for the Exponent of Shannon-Wiener (Exp H') and Inverse Simpson (Inv D') indices.

IUCN red-listed and protected species:
Only 11% of the species recorded in A1 qualified as NCNCA protected species (Table 11) with no CITES, NFA, IUCN or Tops-listed species.

Table 11: Red-listed and/or protected species recorded in Association 1

At a glance statistics on red-listed and/or protected species in A1

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	3	0	0	0	0
% of species	11				
Species/Genus/ Family	Aizoaceae 2 spp. *Euphorbia inaequilatera*				

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 2 (A2): *Rhigozum obovatum – Asparagus striatus – Trichodiadema setuliferum* Mountain Dwarf Shrubland/Grassland

Location and environmental features:
This association covered approximately 39 886 ha (16.8% of the total area) and occupied the mountain slopes and plateaux of the dolerite (Jd) mountains occurring predominantly in the southern part of the study area (Figure 25). Mean altitude was 1 186 m a.s.l. Inclines were generally moderate to steep with no clear preference for a particular aspect (Figure 27). The orange-brown to red-brown soils had a rock cover of >50% and a gravel cover <30%. Almost 90% of all plots were underlain by dolerite and >50 to 74% of all plots in A2 were classified as belonging to the Fc Land Type (Table 12).

Floristic composition:

A2 was defined by a weak diagnostic species group (species group 4; Appendix A) represented by *Trichodiadema setuliferum, Hermannia vestita, Pentzia quinquefida* and *Pelargonium ramosissimum*.

- **Tree** cover was low (0.2%) with scattered individuals of *Boscia albitrunca, Searsia lancea* and *Aloidendron dichotomum* noted.
- The dominant **shrub** species was *Rhigozum obovatum*, with other notable shrub species being *Searsia burchellii, Phaeoptilum spinosum* and *Lycium bosciifolium*.
- The most prominent **dwarf shrubs** were *Justicia spartioides, Microloma incanum, Berkheya spinosa, Hermannia desertorum, Aptosimum spinescens, Pentzia incana, Sericocoma avolans* and *Eriocephalus ericoides*. Other common dwarf shrub species included *Forsskaolea candida, Asparagus striatus, Asparagus capensis, Barleria rigida, Blepharis mitrata, Mesembryanthemum noctiflorum, Trichodiadema setuliferum, Limeum aethiopicum, Tetragonia arbuscula* and on the footslopes often *Rhigozum trichotomum*.
- The dominant **grasses** were represented by *Aristida adscensionis, Enneapogon scaber, Enneapogon desvauxii* and *Fingerhuthia africana*. Other common grass species were *Heteropogon contortus, Eragrostis nindensis, Stipagrostis anomala, Stipagrostis obtusa, Eragrostis lehmanniana, Cenchrus ciliaris* and *Aristida congesta*.
- Prominent species in the **forb** layer were *Galenia sarcophylla, Galenia* cf. *pubescens, Jamesbrittenia tysonii, Leobordea leptoloba, Chenopodium mucronatum, Talinum caffrum, Mesembryanthemum guerichianum, Amaranthus schinzianus* and *Sesamum capense*.

Table 12: Summary of the dominant environmental features of Association 2 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	Upper slope
	Plateau	Ridge/hill	Pan				
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1186						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.2	3.8	15.4	30.1	1.5	51.0	

Key to colours:

0-25	>25-50	>50-75	>75

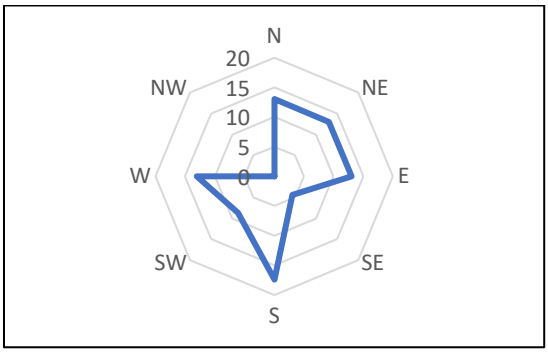


Figure 27: Chart indicating the percentage of plots in Association 2 facing in different directions.

Figure 28: SA2.1 The *Aristida diffusa – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland on slopes of dolerite mountains.

Two subassociations were distinguished:

SA2.1 *Aristida diffusa – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland (Figure 28)

SA2.2 *Drosanthemum floribundum – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland (Figure 29)

Subassociation 2.1 primarily occupied the steep midslopes, whereas SA2.2 was found on moderately steep midslopes and also on plateaux. SA2.1 was defined by a strong diagnostic species group (species group 2; Appendix A) containing species such as *Aristida diffusa, Wahlenbergia nodosa, Solanum tomentosum* and *Felicia filifolia* amongst others. The diagnostic species group for SA2.2 (species group 3; Appendix A) was not as strong, however, SA2.2 also contained some prominent species in species group 51 (Appendix A), such as *Osteospermum sinuatum, Geigeria ornativa* and *Gazania lichtensteinii* that were not present in SA2.1.

Vegetation structure:

At the time of the survey, the grass layer had the highest cover (mean 30.1%), however, many of the grasses were annual and the grass layer might not be as prominent in years with a lower rainfall. The dwarf shrubs had the second highest cover (mean 15.4%) with the trees, shrubs and forbs making small contributions to the mean total cover (Tables 8 & 12).

Figure 29: SA2.2 The *Drosanthemum floribundum – Rhigozum obovatum* Mountain Dwarf Shrubland/Grassland on the rocky plateaux of dolerite mountains.

Plant diversity:

A total of 97 species were recorded in the 23 plots surveyed in A2. Mean species richness per plot in A2 was the highest (38.3) of all associations with a range from 24 to 55 species. Overall, the Shannon-Wiener and Simpson indices in A2 were at the higher end of the scale both for the mean values per plot and when considering the association as a whole (Tables 6 & 7).

IUCN red-listed and protected species:
One protected tree species (*Boscia albitrunca*), one ToPS-listed species and one IUCN red-listed species were recorded in A2. Three species were listed in Appendix II of CITES and 41.2% of all species were protected in the Northern Cape, the highest percentage of protected and CITES-listed species of all associations (Table 13).

Table 13: Red-listed and/or protected species recorded in Association 2

At a glance statistics on red-listed and/or protected species in A2

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	40	3	1	1	1
% of species	41.2	3.1	1.0	1.0	1.0
Species/Genus/ Family	Aizoaceae 11 spp. Amaryllidaceae 3 spp. Apocynaceae 4 spp. Asphodelaceae 3 spp. Crassulaceae 3 spp. Iridaceae 2 spp. *Boscia* 1 spp. *Euphorbia* 2 spp. *Jamesbrittenia* 2 spp. *Lessertia* 2 spp. *Oxalis* 5 spp. *Pelargonium* 2 spp.	*Aloe claviflora* *Aloidendron dichotomum* *Euphorbia spartaria*	*Boscia albitrunca*	*Aloidendron dichotomum*	*Hoodia gordonii*

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 3 (A3): *Aloidendron dichotomum – Dyerophytum africanum* Mountain Dwarf Shrubland/Grassland

Location and environmental features:

This dwarf shrubland/grassland covered 5 834 ha of the study area (2.5% of the entire area) (Figure 25). A3 was found on the moderate to steep north-, east- and west-facing slopes of the central and eastern dolerite mountains (Figure 31) at a mean altitude of 1 125 m a.s.l. In contrast to A2, A3 did not occur on the plateaux. Aspect was predominantly north, followed by east and then west (Figure 30). Most plots had a high rock cover (>50 – 75%), but a relatively low gravel cover. Geologically, more than 50 – 75% of the plots were classified as dolerite (Jd), with the remainder of plots classified as mudrock and siltstone of the Tierberg Formation (Pt). All plots occurred in the Fc Land Type (Table 14).

Table 14: Summary of the dominant environmental features of Association 3 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	Upper slope
	Plateau	Ridge/hill	Pan				
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1125						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.7	3.5	21.8	28.7	4.1	58.8	

Key to colours:

0-25	>25-50	>50-75	>75

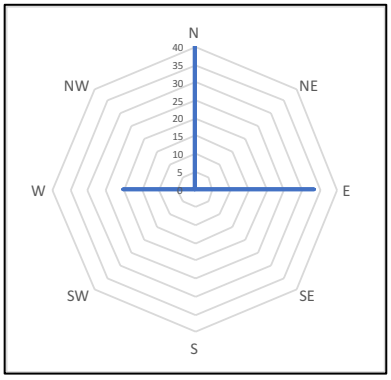


Figure 30: Chart indicating the percentage of plots in Association 3 facing in different directions.

Figure 31: A3: The *Aloidendron dichotomum – Dyerophytum africanum* Mountain Dwarf Shrubland/Grassland on dolerite mountain slopes.

Floristic composition:

A3 was defined by a small diagnostic species group (species group 5; Appendix A) represented by *Aloidendron dichotomum, Tetragonia* sp. and *Galenia namaensis* (Figure 31). Furthermore, the strong affinities between the three mountain associations were highlighted by species groups 6 & 7.

- **Trees** were represented by *Aloidendron dichotomum* and *Boscia albitrunca*, the former species often in dense stands.
- Dominant **shrub** species were *Rhigozum obovatum* and *Phaeoptilum spinosum*, with *Lycium bosciifolium* also commonly noted.
- The **dwarf shrub** layer was dominated by *Justicia spartioides, Microloma incanum* and *Rhigozum trichotomum*. Other prominent dwarf shrubs included *Forsskaolea candida, Barleria rigida, Hermannia desertorum, Sericocoma avolans, Sericocoma pungens, Blepharis mitrata, Eriocephalus ericoides, Limeum aethiopicum, Aptosimum spinescens, Pentzia incana, Osteospermum sinuatum, Mesembryanthemum noctiflorum, Lacomucinaea lineata* and *Berkheya spinosa*, the latter particularly conspicuous on upper slopes.
- **Grasses** were represented by *Aristida adscensionis* (d), *Enneapogon scaber* (d), *Cenchrus ciliaris* (d), *Stipagrostis uniplumis, Stipagrostis obtusa, Stipagrostis ciliata* and *Tragus berteronianus*.
- Prominent **forb** species included *Galenia sarcophylla, Galenia* cf. *pubescens, Jamesbrittenia tysonii, Lotononis laxa, Leobordea leptoloba, Trianthema parvifolia, Gazania lichtensteinii, Chenopodium mucronatum, Amaranthus schinzianus* and *Sesamum capense*.

Vegetation structure:

The grass layer had the highest cover (mean 28.7%) and although dwarf shrub cover was less (mean 21.8%), the dwarf shrub layer visually often appeared dominant. Mean total cover was high at 58.8% (Tables 8 & 14).

Plant diversity:
A total of 125 species were recorded in the 15 plots surveyed in A3. Mean species richness per plot was the second highest of all associations (37.2 species) with a range from 32 to 46. The mean Shannon-Wiener and Simpson indices in A3 were at the higher end of the scale (Tables 6 & 7).

IUCN red-listed and protected species:
One protected tree species (*Boscia albitrunca*) was recorded in A3 and one IUCN Red-listed species (*Aloidendron dichotomum*). Two species were listed in Appendix II of CITES and 17.6% of all species were protected in the Northern Cape (Table 15).

Table 15: Red-listed and/or protected species recorded in Association 3

At a glance statistics on red-listed and/or protected species in A3

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	22	2	1	1	0
% of species	17.6	1.6	0.8	0.8	0
Species/Genus/ Family	Aizoaceae 12 spp. Apocynaceae 1 sp. Asphodelaceae 2 spp. Iridaceae 1 sp. *Boscia* 1 sp. *Jamesbrittenia* 1 sp. *Lessertia* 1 sp. *Oxalis* 2 spp. *Nemesia* 1 sp.	*Aloe claviflora* *Aloidendron dichotomum*	*Boscia albitrunca*	*Aloidendron dichotomum*	

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 4 (A4): *Berkheya spinosa* Zebra-Striped Steep Mountain Dwarf Shrubland

Location and environmental features:
This small association covered only 42.5 ha (0.02% of the total area) (Figure 25). A single plot was surveyed in this association occurring mainly in die buffer zone in the southwest of the study area. These dolerite scree slopes were covered by piles of dolerite rocks with no vegetation, alternating with less-rocky sections with a sparse vegetation cover (Figure 32). The steep slopes had a high rock cover (>75%) and could face in any direction.

Floristic composition:
The association did not have any diagnostic species. It shared species group 7 (Appendix A) common for all the mountain associations, but lacked the species of group 6, which are common to the other mountain associations (A2 & A3).

- Isolated *Boscia albitrunca* individuals were the only **trees** encountered.
- **Shrubs** were represented by *Rhigozum obovatum, Phaeoptilum spinosum, Lycium bosciifolium* and *Bassia salsoloides.*
- The dominant **dwarf shrub** was *Berkheya spinosa*. Other dwarf shrubs included *Microloma incanum, Solanum capense* and *Asparagus glaucus*.
- **Grasses** were sparse and represented by *Enneapogon scaber, Enneapogon cenchroides, Enneapogon desvauxii, Stipagrostis obtusa* and *Cenchrus ciliaris*.
- **Forbs** included *Galenia sarcophylla, Mesembryanthemum guerichianum, Mesembryanthemum articulatum Lepidium africanum, Radyera urens, Cucumis myriocarpus* and *Chenopodium mucronatum*.

Figure 32: The *Berkheya spinosa* Zebra-Striped Steep Mountain Dwarf Shrubland showing piles of bare dolerite rocks.

Vegetation structure:
Plant cover on the rocky piles was generally absent and on the strips in between the rocky piles total plant cover was approximately 10%. The dwarf shrub layer had the highest cover (5%) followed by the grass layer (3%) (Table 8).

Plant diversity:
Twenty three species were recorded in the single plot surveyed. Evenness was the highest of all associations due to the low cover and the lack of dominance. As a result of the high evenness, the Shannon-Wiener and Simpson indices were also among the highest for all associations (Tables 6 & 7).

IUCN red-listed and protected species:
One protected tree species (*Boscia albitrunca*) was encountered, but no CITES listed or IUCN red-listed species were recorded. Six species, representing 26.1% of the total for the association, are classified as protected in the Northern Cape (Table 16).

Table 16: Red-listed and/or protected species recorded in Association 4

At a glance statistics on red-listed and/or protected species in A4

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	6	0	1	0	0
% of species	26.1	0	4.3	0	0
Species/Genus/ Family	Aizoaceae 3 spp. Apocynaceae 1 sp. *Boscia* 1 sp *Oxalis* 1 sp.		*Boscia albitrunca*		

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 5 (A5): *Ruschia intricata – Crassothonna protecta* Rocky Plains Grassland

Location and environmental features:
A5 occurred for the most part in the southeastern buffer zone and was geologically largely associated with the sandstone-rich, siltstone, grey shale and mudrock of the Waterford Formation (Pc). It covered approximately 15 030 ha (6.34% of the entire study area) (Figure 25). The terrain was generally flat, but it could also occur on mountain terraces. Rock cover was usually <30% and gravel cover generally ranged from >10 – 50%. The land type was predominantly Fc and mean altitude was 1 277 m a.s.l. (Table 17).

Table 17: Summary of the dominant environmental features of Association 5 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	Upper slope
	Plateau	Ridge/hill	Pan	Terrace			
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1277						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.0	1.1	11.5	29.7	1.1	43.4	

Key to colours:

0-25	>25-50	>50-75	>75

Floristic composition:

Association 5 occupied a somewhat transitional position between the true mountain associations (A2 – A4) and the plains and high plateaux associations. It was differentiated by a weak diagnostic species group (species group 10, Appendix A) represented by *Syringodea concolor, Diascia engleri, Curio radicans* and *Zaluzianskya peduncularis*. However, the association could easily be identified by the dominance of *Ruschia intricata*.

- **Trees** were sparse and represented by isolated individuals of *Aloidendron dichotomum* and *Boscia albitrunca.*
- The **shrub** layer was dominated by *Rhigozum obovatum, Phaeoptilum spinosum* and *Searsia burchellii*, with *Lycium bosciifolium* and *Osteospermum spinescens* occasionally encountered.
- *Ruschia intricata* was the dominant **dwarf shrub**. Other common dwarf shrubs included *Eriocephalus ericoides, Crassothonna protecta, Asparagus glaucus, Pteronia viscosa, Nenax microphyllus, Asparagus capensis, Limeum aethiopicum, Euphorbia spartaria, Aptosimum spinescens, Monsonia salmoniflora, Mesembryanthemum noctiflorum, Pentzia incana, Osteospermum sinuatum, Hermannia spinosa, Lycium cinereum* and *Thesium hystrix*.
- The dominant **grasses** were *Aristida adscensionis, Enneapogon desvauxii, Aristida congesta* and *Stipagrostis obtusa*. Other abundant grass species were *Eragrostis obtusa, Eragrostis nindensis, Enneapogon scaber* and *Tragus berteronianus*.
- **Forbs** species included *Pelargonium minimum, Manulea fragrans, Chenopodium mucronatum, Crassula deltoidea, Anacampseros albidiflora, Stomatium peersii*, *Ursinia nana* and *Heliophila* cf. *deserticola*.

Figure 33: SA5.1 The *Ruschia intricata – Crassula deltoidea – Stomatium peersii* Rocky Plains Grassland in the southeastern buffer zone.

Two subassociations were distinguished:

SA5.1 *Ruschia intricata – Crassula deltoidea – Stomatium peersii* Rocky Plains Grassland (Figure 33)

SA5.2 *Ruschia intricata – Euphorbia spartaria* Rocky Plains Grassland (Figure 34)

Subassociation 5.1 occurred in the central section of the association, whereas SA5.2 was found more towards the western and eastern sections as well as in more degraded areas. SA5.1 was defined by a strong diagnostic species group (species group 8; Appendix A) containing species such as *Crassula deltoidea, Anacampseros albidiflora, Stomatium peersii* and *Nenax microphylla* amongst others. The diagnostic species for SA5.2 was *Euphorbia spartaria* (species group 9; Appendix A). Apart from the diagnostic species group distinguishing SA5.1, a number of species such as *Rhigozum obovatum, Hermannia desertorum, Eriocephalus ericoides, Pteronia viscosa, Pegolettia retrofracta* and *Searsia burchellii* were more common in SA5.1 than SA5.2. In contrast, *Asparagus glaucus, Eriocephalus ambiguus, Eriocephalus decussatus* and *Lycium bosciifolium* were more common in SA5.2 than SA5.1.

Figure 34: SA5.2 The *Ruschia intricata – Euphorbia spartaria* Rocky Plains Grassland in the southeastern buffer zone.

Vegetation structure:

Grasses had a mean cover of ca. 30%, with dwarf shrubs having a mean cover of 11.5%. Trees, shrubs and forbs contributed little to overall vegetation cover (Tables 8 & 17).

Plant diversity:

A5 was a species-rich association with only 15 plots yielding 168 species. Mean per plot values also indicated a high species richness, as well as high Shannon-Wiener and Simpson indices of diversity. The mean number of species per plot was 34.3 with a range from 25 to 47 species (Tables 6 & 7).

IUCN red-listed and protected species:

Hoodia gordonii was the only NEM:BA ToPS species; *Aloidendron dichotoma* the only IUCN red-listed species; *Boscia albitrunca* the only protected tree species encountered in A5, but three CITES species and 36 NCNCA protected species were recorded (Table 18).

Table 18: Red-listed and/or protected species recorded in Association 5

At a glance statistics on red-listed and/or protected species in A5

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	36	4	1	1	1
% of species	21.4	2.4	0.6	0.6	0.6
Species/Genus/ Family	Aizoaceae 12 spp. Amaryllidaceae 1 sp. Anacampserotaceae 1 sp. Apocynaceae 1 sp. Asphodelaceae 2 spp. Crassulaceae 2 spp. Iridaceae 4 spp. *Boscia* 1 sp. *Dianthus* 1 sp. *Diascia* 1 sp. *Euphorbia* 3 spp. *Jamesbrittenia* 1 sp. *Lessertia* 1 sp. *Manulea* 1 sp. *Nemesia* 1 sp. *Oxalis* 1 sp. *Pelargonium* 2 spp.	*Aloe claviflora* *Aloidendron dichotomum* *Euphorbia spartaria*	*Boscia albitrunca*	*Aloidendron dichotomum*	*Hoodia gordonii*

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Association 6 (A6): *Rhigozum obovatum – Pegolettia retrofracta – Lotononis rabenaviana* Plateau Grassland

Location and environmental features:

Association 6 was found on the plateau of the dolerite mountains (Figure 25), particularly in patches with a high cover of calcrete pebbles (Figure 35) and at a mean altitude of 1 125 m a.s.l. This plateau grassland covered ca. 5 009 ha (2.1% of the study area). Rock cover was <10% and gravel (including calcrete) cover could range from none to >75%. Geologically, the association was mostly underlain by dolerite (Jd). Land type was classified as Fc (Table 19).

Table 19: Summary of the dominant environmental features of Association 6 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	Upper slope
	Plateau	Ridge/hill	Pan				
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1125						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.0	1.2	9.6	25.0	1.2	37.0	

Key to colours:

0-25	>25-50	>50-75	>75

Figure 35: A6: The *Rhigozum obovatum – Pegolettia retrofracta – Lotononis rabenaviana* Plateau Grassland found on patches with a high cover of calcrete on dolerite mountain plateau.

Floristic composition:
This association did not have a diagnostic species group and represented a transition between A5 and A7 with species group 12 indicating affinities with A5 and species group 18 affinities with A7 (Appendix A).

- No **trees** were noted in A6.
- The dominant **shrub** species were *Rhigozum obovatum* and *Lycium bosciifolium* with *Searsia burchellii* and *Phaeoptilum spinosum* often encountered.
- No clear dominance was found among the **dwarf shrub** species. Common species included *Helichrysum lucilioides, Barleria rigida, Drosanthemum lique, Pegolettia retrofracta, Eriocephalus ericoides, Ruschia intricata, Pteronia mucronata, Limeum aethiopicum, Aptosimum spinescens, Pentzia calcarea, Lycium horridum, Osteospermum sinuatum, Tetraena chrysopteros, Roepera lichtensteiniana, Thesium hystrix, Lacomucinaea lineata, Eriocephalus decussatus* and *Salsola* spp.
- The dominant **grass** species were *Enneapogon desvauxii, Stipagrostis obtusa* and *Stipagrostis anomala*, while other common grass species included *Tragus racemosus* and *Stipagrostis ciliata*.
- Prominent **forb** species included *Lotononis rabenaviana, Gazania lichtensteinii* and *Chenopodium mucronatum.*

Vegetation structure:
The grass layer was dominant with a mean cover of 25.0%, followed by the dwarf shrub layer at a mean of 9.6% cover. The forb and shrub layers had low mean cover values (both 1.2%) (Tables 8 & 19).

Plant diversity:
In total 86 species were encountered in the five plots surveyed. Mean number of species per plot was 34.2 with a range from 29 to 40 species. Mean per plot values indicated high species richness, Shannon-Wiener and Simpson indices of diversity (Tables 6 & 7).

IUCN red-listed and protected species:
Eighteen NCNCA protected species were recorded in A6, with one species (*Euphorbia spartaria*) being CITES listed (Table 20).

Table 20: Red-listed and/or protected species recorded in Association 6

At a glance statistics on red-listed and/or protected species in A6

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	18	1	0	0	0
% of species	20.9	1.2	0	0	0
Species/Genus/ Family	Aizoaceae 10 spp. Apocynaceae 1 sp. Iridaceae 2 spp. *Euphorbia* 2 spp. *Lessertia* 1 sp. *Oxalis* 1 sp. *Pelargonium* 1 sp.	*Euphorbia spartaria*			

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Association 7 (A7): *Lotononis rabenaviana – Lotononis laxa* Low Ridge Grassland

Location and environmental features:

A7 occupied footslopes, midslopes and plateaux of low mountains, hill and ridges occurring mostly in the central and northern parts of the study area and covered approximately 12 781 ha (5.4% of the study area) (Figure 25). In most instances the terrain was flat. Rock cover was generally fairly low, but could reach >75%. Gravel was always present and could range from <10% to >75% cover. Geologically, the association was mostly underlain by dolerite (Jd), but >25% of all plots were underlain by mudrock and siltstone of the Tierberg Formation (Pt). Land type was predominantly Fc and mean altitude was 1 038 m a.s.l. (Table 21).

Table 21: Summary of the dominant environmental features of Association 7 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	
	Upper slope	Plateau	Ridge/hill	Pan			
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1038						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.0	1.4	13.1	29.7	2.1	46.3	

Key to colours:

0-25	>25-50	>50-75	>75

Floristic composition:

A7 was differentiated by a weak diagnostic species group (species group 15, Appendix A) represented by *Pteronia glomerata* although *Lotononis laxa* and *Lotononis rabenaviana* are well represented in species groups 16 and 18 respectively.

- The only **tree** species noted was the invasive alien *Prosopis glandulosa*.
- The **shrub** layer was dominated by *Lycium bosciifolium* and *Phaeoptilum spinosum*.
- **Dwarf shrubs** included *Ruschia intricata, Rhigozum trichotomum, Pegolettia retrofracta, Pteronia mucronata, Limeum aethiopicum, Eriocephalus ericoides, Pteronia mucronata, Limeum aethiopicum, Aptosimum*

spinescens, Osteospermum sinuatum, Tetraena chrysopteros, Roepera lichtensteiniana, Thesium hystrix, Lycium cinereum and *Eriocephalus decussatus.*

- The dominant **grass** species were *Enneapogon desvauxii, Enneapogon scaber, Stipagrostis obtusa* and *Stipagrostis anomala*, while other common grass species included *Tragus berteronianus* and *Stipagrostis ciliata*.
- Prominent **forb** species included *Lotononis laxa, Lotononis rabenaviana, Monsonia umbellata, Ursinia nana, Gazania lichtensteinii* and *Chenopodium mucronatum*.

Two subassociations were distinguished:

SA7.1 *Rhigozum trichotomum – Osteospermum sinuatum – Lotononis rabenaviana* Low Ridge Grassland (Figure 36)

SA7.2 *Rhigozum trichotomum – Lyperia tristis – Lotononis rabenaviana* Low Ridge Grassland (Figure 37)

Figure 36: SA7.1 The *Rhigozum trichotomum – Osteospermum sinuatum – Lotononis rabenaviana* Low Ridge Grassland found in the central and northern parts of the study area.

Figure 37: SA7.2 The *Rhigozum trichotomum – Lyperia tristis – Lotononis rabenaviana* Low Ridge Grassland found in the central and northern parts of the study area.

SA7.1 could be distinguished from SA7.2 by the presence of species such as *Hermannia desertorum, Sericocoma avolans, Sericocoma pungens* and *Aloe claviflora*, in species group 13 (Appendix A) as well as the higher abundance of *Osteospermum sinuatum*. On the other hand SA7.2 differed from SA7.1 by the presence of species in species group 14 (*Lyperia tristis* and *Jamesbrittenia atropurpurea,* Appendix A) and the higher abundance of *Asparagus glaucus, Limeum argute-carinatum, Aptosimum procumbens* and *Stipagrostis obtusa*. Thus, SA7.2 occurs on a somewhat sandier substrate.

Vegetation structure:
This grassland had a mean cover of 29.7%. Dwarf shrubs had a mean cover of 13.1%, while the forb and shrub layers had low mean cover values (Tables 8 & 21).

Plant diversity:
The 16 plots surveyed in A7 yielded a total of 134 species. Mean number of species per plot was 32.9 with a range from 26 to 44 species. Mean per plot values indicated a high species richness, Shannon-Wiener and Simpson indices of diversity (Table 6 & 7).

IUCN red-listed and protected species:
Aloe claviflora was the only CITES listed species in A7, with 21.6% of all species being NCNCA protected (Table 22).

Table 22: Red-listed and/or protected species recorded in Association 7

At a glance statistics on red-listed and/or protected species in A7

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	29	1	0	0	0
% of species	21.6	0.7	0	0	0
Species/Genus/ Family	Aizoaceae 11 spp. Apocynaceae 2 spp. Asphodelaceae 1 sp. Iridaceae 4 spp. *Boscia* 1 sp. *Euphorbia* 1 sp. *Jamesbrittenia* 3 spp. *Lessertia* 1 sp. *Manulea* 1 sp. *Oxalis* 3 spp. *Pelargonium* 1 sp.	*Aloe claviflora*			

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Association 8 (A8): *Stipagrostis obtusa – Daubenya marginata – Stipagrostis ciliata* Sandy Plains Grassland

Location and environmental features:
This grassland covered 5 823 ha (2.5% of the study area). A8 was spread out across the study area (Figure 25) and also occurred in a mosaic with A1 (dune association) where it represented the dune streets. It occurred on deep, sandy soils, with no rock cover and mostly no gravel, although calcrete pebbles could be present (Figure 38). The association occurred predominantly on the Ah Land Type, but could be underlain by various geological substrates. Mean altitude was 1 128 m a.s.l. (Table 23).

Floristic composition:
This association was differentiated by a diagnostic species group (species group 17, Appendix A) containing *Daubenya marginata, Gazania jurineifolia, Grielum humifusum, Dimorphotheca pinnata* and *Lycium pilifolium.*

- There were no **trees** in A8.
- The **shrub** layer was represented by *Lycium bosciifolium* (d), *Phaeoptilum spinosum* and occasionally *Bassia salsoloides.*
- The **dwarf shrub** layer included species such as *Rhigozum trichotomum* (d), *Lycium cinereum* (d), *Eriocephalus ambiguus, Ruschia intricata, Aptosimum spinescens, Dicoma capensis, Asparagus glaucus, Pentzia calcarea, Osteospermum sinuatum, Tetraena chrysopteros, Roepera lichtensteiniana, Crassothonna protecta* and *Eriocephalus decussatus*.

Table 23: Summary of the dominant environmental features of Association 8 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	Upper slope
	Plateau	Ridge/hill	Pan				
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1128						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.0	1.6	10.7	44.4	2.3	59.0	

Key to colours:

0-25	>25-50	>50-75	>75

- Dominant **grass** species were *Enneapogon desvauxii, Stipagrostis ciliata* and *Stipagrostis obtusa* with other common species including *Aristida adscensionis, Tragus berteronianus* and *Eragrostis lehmanniana*.
- **Forb** species were represented by *Gazania jurineifolia, Dimorphotheca pinnata, Aptosimum procumbens, Arctotis leiocarpa, Heliophila* cf. *trifurca, Tribulus cristatus, Pelargonium minimum, Manulea fragrans, Chenopodium mucronatum, Ursinia nana* and *Sesamum capense*.

Figure 38: A8: The *Stipagrostis obtusa – Daubenya marginata – Stipagrostis ciliata* Sandy Plains Grassland found on deep, sandy soils.

Vegetation structure:
This grassland had a well-developed grass layer with a mean cover of 44.4%. Dwarf shrubs had a mean cover of 10.7%, while the forb and shrub layers had low mean cover values (Tables 8 & 23).

Plant diversity:
A total of 116 species were enumerated in the nine plots surveyed. Mean number of species per plot was 32.2 with a range from 19 to 40 species. Mean species richness per plot for A8 was considered high, however mean evenness per plot was the second lowest of all associations. As a result of the low evenness, the Shannon-Wiener index of diversity was intermediate, but Simpson index of diversity was high (Table 6 & 7).

IUCN red-listed and protected species:
Euphorbia braunsii was the only CITES listed species in A8, with 19.0% of all species being NCNCA protected (Table 24).

Table 24: Red-listed and/or protected species recorded in Association 8

At a glance statistics on red-listed and/or protected species in A8

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	22	1	0	0	0
% of species	19.0%	0.8	0	0	0
Species/Genus/ Family	Aizoaceae 7 spp. Amaryllidaceae 1 sp. Iridaceae 2 spp. Tecophilaeaceae 1 sp. *Daubenya* 1 sp. *Euphorbia* 2 spp. *Lessertia* 3 spp. *Manulea* 1 sp. *Oxalis* 3 spp. *Pelargonium* 1 sp.	*Euphorbia braunsii*			

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 9 (A9): *Enneapogon desvauxii – Ophioglossum polyphyllum – Gazania lichtensteinii* High Mountain Plateau Grassland

Location and environmental features:

Association 9, covering 2 522 ha (1.1% of the study area), occupied the high, dolerite mountain plateaux (Figure 39), at a mean altitude of 1 204 m a.s.l., in the study area (Figure 25). Rock cover ranged from <10% to mostly >10 – 30% and gravel cover from >10 – 75%. Geologically, all plots were classified as dolerite (Jd) and the land type was Fc in all instances (Table 25).

Figure 39: A9: *Enneapogon desvauxii – Ophioglossum polyphyllum – Gazania lichtensteinii* High Mountain Plateau Grassland found on high dolerite plateaux.

Floristic composition:

The diagnostic species for A9 were *Ophioglossum polyphyllum* and *Melolobium* cf. *canescens* (species group 20, Appendix A).

- **Trees** were represented by scattered individuals of *Aloidendron dichotomum* and *Boscia albitrunca*.
- *Lycium bosciifolium* was the only **shrub** species recorded.
- Common **dwarf shrub** species in A9 included *Galenia sarcophylla, Drosanthemum lique, Melolobium* cf. *canescens, Ruschia intricata, Limeum aethiopicum, Drosanthemum hispidum, Mesembryanthemum junceum,*

Peliostomum leucorrhizum, Tetraena chrysopteros, Salsola spp., *Lycium cinereum, Mesembryanthemum noctiflorum* and *Roepera lichtensteiniana*.

- The dominant **grass** species were *Stipagrostis anomala, Enneapogon desvauxii, Aristida adscensionis, Stipagrostis obtusa* and *Stipagrostis ciliata*. Other common grass species included *Tragus berteronianus, Tragus racemosus, Fingerhuthia africana* and *Eragrostis lehmanniana*.
- Prominent **forb** species included *Ophioglossum polyphyllum, Aptosimum procumbens, Pelargonium minimum, Lasiopogon glomerulatus, Gazania lichtensteinii, Tribulus terrestris, Ursinia nana, Sesamum capense* and *Euphorbia inaequilatera*.

Table 25: Summary of the dominant environmental features of Association 9 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	Upper slope
	Plateau	Ridge/hill	Pan				
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1204						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.2	1.2	12.0	33.0	5.2	51.6	

Key to colours:

0-25	>25-50	>50-75	>75

Vegetation structure:

Structurally, the vegetation was a grassland with a mean grass cover of 33.0% and dwarf shrubs had a mean cover of 12.0%. Due to the large contribution of annual plant species the forb layer had a mean cover of 5.2% (Tables 8 & 25).

Plant diversity:

In total of 79 species were found in the five plots surveyed. Mean number of species per plot was 35.4 with a range from 28 to 43 species. Considering the mean values per plot, the association ranked among the associations with a high diversity (Tables 6 & 7).

IUCN red-listed and protected species:

One protected species (*Boscia albitrunca*), one IUCN red-listed species (*Aloidendron dichotomum*) and one CITES listed species (*Euphorbia braunsii*) were recorded in A9. Almost 30% of all species in the association were NCNCA protected (Table 26).

Table 26: Red-listed and/or protected species recorded in Association 9

At a glance statistics on red-listed and/or protected species in A9

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	23	1	1	1	0
% of species	29.1	1.3	1.3	1.3	0
Species/Genus/ Family	Aizoaceae 11 spp. Amaryllidaceae 1 sp. Asphodelaceae 2 spp. Iridaceae 1 sp. *Boscia* 1 sp. *Euphorbia* 2 spp. *Jamesbrittenia* 1 sp. *Lessertia* 1 sp. *Manulea* 1 sp. *Oxalis* 1 sp. *Pelargonium* 1 sp.	*Euphorbia braunsii*	*Boscia albitrunca*	*Aloidendron dichotomum*	

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 10 (A10): *Pentzia calcarea – Salsola* spp. Calcrete Plains Dwarf Shrubland

Location and environmental features:

This small association, covering 150 ha (0.06% of the study area) was found in the northern part of the study area (Figure 25). These patches were covered by a thick layer of calcrete on Tertiary deposits (T-Qc) (Figure 40). Mean altitude was 1025 m a.s.l.

Figure 40: A10: *Pentzia calcarea – Salsola* spp. Calcrete Plains Dwarf Shrubland found on patches with a thick layer of calcrete.

Floristic composition:

A single plot was surveyed in this association and the only diagnostic species was *Lithops* sp. (species group 22, Appendix A).

- No **trees** were noted in the association and the only **shrub** species was *Lycium bosciifolium*.

- **Dwarf shrubs** were represented by *Eriocephalus ericoides, Crassothonna protecta, Hoodia gordonii, Tetraena microcarpa, Monsonia salmoniflora, Pteronia mucronata, Roepera incrustata, Roepera lichtensteiniana, Limeum argute-carinatum, Pentzia calcarea, Geigeria ornativa* and *Roepera lichtensteiniana*.
- The **grass** layer was poorly developed and included species such as *Stipagrostis anomala, Tragus racemosus, Enneapogon desvauxii, Aristida adscensionis* and *Stipagrostis ciliata*.
- **Forbs** were sparse and represented by *Lotononis rabenaviana, Gazania lichtensteinii* and *Heliophila trifurca*.

Vegetation structure:
Structurally the association was a dwarf shrubland (mean cover of dwarf shrubs 15%) with grasses and forbs each having a mean cover of 1% (Table 8).

Plant diversity:
Twenty-five species were recorded in the single plot surveyed, thus, indicating an intermediate species richness. Evenness, however was the second highest among the associations. Because of the high evenness, the Shannon-Wiener and Simpson indices of diversity were the highest of all associations (Tables 6 & 7).

IUCN red-listed and protected species:
Hoodia gordonii was the only IUCN red-listed species with 12% of all species qualifying as NCNCA protected (Table 27).

Table 27: Red-listed and/or protected species recorded in Association 10

At a glance statistics on red-listed and/or protected species in A10

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	3	0	0	0	1
% of species	12.0	0	0	0	4.0
Species/Genus/ Family	Aizoaceae 1 sp. Apocynaceae 1 sp. *Oxalis* 1 sp.				*Hoodia gordonii*

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Association 11 (A11): *Rhigozum trichotomum – Ledebouria ensifolia – Limeum aethiopicum* Plains Dwarf Shrubland/Grassland

Location and environmental features:
This large association covered most of the plains (73 155 ha, 30.9% of the study area) (Figure 25) in the study area with a small proportion occurring on footslopes or ridges (Figure 41). Rock cover never exceeded 50%, but gravel cover ranged from 0 to >75%. A11 occurred predominantly on mudrock and siltstone of the Tierberg Formation (Pt) in land types Ah or Fc. Mean altitude was 1 048 m a.s.l. (Table 28).

Floristic composition:
A weak diagnostic group, containing *Gisekia pharnaceoides, Hoodia gordonii, Kedrostis capensis* and *Aizoon canariense*, differentiated A11 (species group 23, Appendix A).

- The only **tree** species recorded in A11 was the alien invasive *Prosopis glandulosa*.
- Dominant **shrub** species included *Lycium bosciifolium* and *Phaeoptilum spinosum*, while *Osteospermum spinescens* and *Bassia salsoloides* were also often present.
- The **dwarf shrub** layer was dominated by *Rhigozum trichotomum*. Other prominent dwarf shrub species included *Eriocephalus ambiguus, Limeum aethiopicum, Aptosimum spinescens, Monsonia salmoniflora, Dicoma capensis, Limeum argute-carinatum, Lycium horridum, Lycium cinereum, Tetraena chrysopteros,*

Roepera lichtensteiniana, Osteospermum sinuatum, Pentzia spinescens, Mesembryanthemum noctiflorum, Tetragonia arbuscula and *Salsola* spp.

- The dominant **grass** species were *Stipagrostis anomala, Enneapogon desvauxii, Aristida adscensionis, Stipagrostis obtusa* and *Stipagrostis ciliata*. Other common grass species were *Enneapogon scaber, Aristida congesta, Schmidtia kalahariensis, Stipagrostis uniplumis, Tragus berteronianus* and *Fingerhuthia africana*.
- In the **forb** layer the following species were prominent: *Tribulus cristatus, Galenia* cf. *pubescens* and *Leobordea platycarpa.* Other common forb species included *Gisekia pharnaceoides, Ledebouria ensifolia, Monsonia umbellata, Pelargonium minimum, Trianthema parvifolia, Gazania lichtensteinii, Chenopodium mucronatum, Amaranthus schinzianus* and *Sesamum capense*.

Table 28: Summary of the dominant environmental features of Association 11 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Grassland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	
	Upper slope	Plateau	Ridge/hill	Pan			
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1048						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.1	2.3	24.8	22.4	6.1	55.7	

Key to colours:

0-25	>25-50	>50-75	>75

Figure 41: A11: *Rhigozum trichotomum – Ledebouria ensifolia – Limeum aethiopicum* Plains Dwarf Shrubland/Grassland covering most of the plains in the study area.

Vegetation structure:

Mean cover for the dwarf shrub and grass layers were almost equal at 24.8% and 22.4% respectively. Forbs had a fairly high mean cover at 6.1%, mainly due to the contribution of *Tribulus cristatus* (Tables 8 & 28).

Plant diversity:

The 60 plots surveyed yielded 176 species in total. Mean number of species per plot was 27.6 with a range from 15 to 40 species. All diversity parameters, species richness, Shannon Wiener and Simpson indices, indicated an intermediate diversity for A11 (Tables 6 & 7).

IUCN red-listed and protected species:

Forty NCNCA protected species (22.7% of all species) were encountered in A11, with five CITES listed species, one IUCN red-listed species and one NEM:BA ToPS species (Table 29).

Table 29: Red-listed and/or protected species recorded in Association 11

At a glance statistics on red-listed and/or protected species in A11

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	40	5	0	1	1
% of species	22.7	2.8	0	0.6	0.6
Species/Genus/ Family	Aizoaceae 16 spp. Apocynaceae 5 spp. Asphodelaceae 2 spp. Iridaceae 2 spp. *Colchicum* 2 spp. *Euphorbia* 3 spp. *Jamesbrittenia* 1 sp. *Lessertia* 2 spp. *Manulea* 2 spp. *Oxalis* 4 spp. *Pelargonium* 1 sp.	*Aloe claviflora* *Aloidendron dichotomum* *Euphorbia braunsii* *Euphorbia spartaria* *Hoodia gordonii*		*Aloidendron dichotomum*	*Hoodia gordonii*

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 12 (A12): *Rhigozum trichotomum – Mesembryanthemum vaginatum – Salsola aphylla/calluna* Plain/Floodplain Dwarf Shrubland

Location and environmental features:

A12 occurred predominantly on plains or floodplains (Figure 42) in the central parts of the study area and covered 11 950 ha (5.0% of the study area) (Figure 25). Rock cover never exceeded 50%, but gravel cover ranged from 0 – >75%. Plots were mostly on alluvium or mudrock and siltstone of the Tierberg Formation, with land type predominantly Fc. Mean altitude was 1 023 m a.s.l. (Table 30).

Table 30: Summary of the dominant environmental features of Association 12 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	
	Upper slope	Plateau	Ridge/hill	Pan	Rocky outcrop		
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1023						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.3	2.4	31.2	15.6	6.0	55.5	

Key to colours:

0-25	>25-50	>50-75	>75

Figure 42: A12: *Rhigozum trichotomum – Mesembryanthemum vaginatum – Salsola aphylla/calluna* Plain/Floodplain Dwarf Shrubland found on plains and floodplains in the study area.

Floristic composition:

A12 had a small, weak diagnostic group (species group 24, Appendix A) consisting of *Hessea speciosa* and *Dipcadi crispum*. The association shared the dominance of *Rhigozum trichotomum* with A11, but also showed affinities with A13 by the shared species group 26 containing species associated with floodplains i.e. *Augea capensis, Mesembryanthemum vaginatum* and *Fockea sinuata*. A12 and A13 were thus somewhat transitional between the plains associations and the wetland associations.

- The only **tree** species recorded in A12 was the alien invasive *Prosopis glandulosa*.
- **Shrubs** were represented by *Phaeoptilum spinosum, Osteospermum spinescens, Bassia salsoloides* and *Lycium bosciifolium*.
- The dominant **dwarf shrub** species were *Rhigozum trichotomum* and *Lycium cinereum*. Common shrub species included *Augea capensis, Mesembryanthemum vaginatum, Dicoma capensis, Eriocephalus ambiguus, Salsola aphylla/calluna* complex, *Limeum argute-carinatum, Pentzia calcarea, Osteospermum sinuatum, Tetraena chrysopteros* and *Mesembryanthemum noctiflorum*.
- The **grass** layer was dominated by *Enneapogon desvauxii, Aristida adscensionis, Stipagrostis obtusa* and *Stipagrostis ciliata*. Other common grass species were *Stipagrostis anomala, Schmidtia kalahariensis, Tragus racemosus, Stipagrostis uniplumis* and *Tragus berteronianus*.
- *Tribulus cristatus* and *Galenia* cf. *pubescens* dominated the **forb** layer, with other prominent species being *Leobordea platycarpa, Trianthema parvifolia, Gazania lichtensteinii* and *Sesamum capense*.

Vegetation structure:

Dwarf shrub cover (mean 31.2%) was twice as high as that of the grass layer (mean 15.6%). The forb layer made a substantial contribution (mean 6.0%) to the mean total cover of 55.4%, due mostly to *Tribulus cristatus*. Shrub and tree cover were low (Tables 8 & 30).

Plant diversity:

The 16 plots surveyed yielded 132 species in total. Mean number of species per plot in A12 was 28.8 with a range from 21 to 40 species. All diversity parameters, *viz*. species richness, Shannon Wiener & Simpson indices indicated an intermediate diversity for A12 (Tables 6 & 7).

IUCN red-listed and protected species:

One CITES-listed species (*Euphorbia braunsii*) and 27 NCNCA protected species were recorded in A12 (Table 31).

Table 31: Red-listed and/or protected species recorded in Association 12

At a glance statistics on red-listed and/or protected species in A12

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	27	1	0	0	0
% of species	20.5	0.8	0	0	0
Species/Genus/ Family	Aizoaceae 17 spp. Amaryllidaceae 1 sp. Apocynaceae 1 sp. Iridaceae 2 spp. *Euphorbia* 2 spp. *Lessertia* 1 sp. *Oxalis* 2 spp. *Pelargonium* 1 sp.	*Euphorbia braunsii*			

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 13 (A13): *Salsola* spp. – *Pentzia spinescens* – *Moraea venenata* Plain/Floodplain Dwarf Shrubland

Location and environmental features:

A13 occurred in a band across the central portion of the study area and covered 17 668 ha (7.5% of the study area) (Figure 25). Most sites occurred on plains or floodplains (often relict floodplains) (Figure 43). A large proportion of the sites were found on alluvium or Tertiary deposits, although some were also found on mudrock and siltstone of the Tierberg Formation (Pt). A thick layer of calcrete pebbles was often prominent. Rock cover was always <30%, but gravel cover could range from 0 – >75%. Mean altitude was 1 012 m a.s.l. (Table 32).

Table 32: Summary of the dominant environmental features of Association 13 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	
	Upper slope	Plateau	Ridge/hill	Pan			
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1012						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.3	1.8	17.0	12.7	3.1	34.9	

Key to colours:

0-25	>25-50	>50-75	>75

Floristic composition:

This dwarf shrub association had a weakly defined diagnostic group (species group 25, Appendix A) containing *Septulina glauca, Pteronia sordida* and *Chlorophytum* cf. *undulatum*. Together with A12, A13 was somewhat transitional between the plains associations and the wetland associations.

- The only **tree** species recorded in this association was the alien invasive *Prosopis glandulosa*.
- **Shrubs** were represented by *Bassia salsoloides, Phaeoptilum spinosum, Osteospermum spinescens* and *Lycium bosciifolium.*

- Dominant **dwarf shrubs** were *Eriocephalus ambiguus, Salsola aphylla/calluna* complex and other *Salsola* spp. Other abundant dwarf shrub species included *Augea capensis, Mesembryanthemum vaginatum, Dicoma capensis, Asparagus glaucus, Pteronia adenocarpa, Limeum argute-carinatum, Pentzia calcarea, Osteospermum sinuatum, Tetraena chrysopteros, Lycium cinereum, Mesembryanthemum noctiflorum* and *Pentzia spinescens.*
- The **grass** layer was dominated by *Stipagrostis anomala, Aristida adscensionis, Enneapogon desvauxii, Stipagrostis obtusa, Stipagrostis uniplumis* and *Stipagrostis ciliata*. Other common grass species were *Chloris virgata, Tragus racemosus* and *Tragus berteronianus*.
- Prominent **forb** species included *Tribulus cristatus* (d), *Leobordea platycarpa, Aptosimum procumbens, Tetraena simplex, Lessertia pauciflora, Trianthema parvifolia, Aptosimum indivisum* and *Moraea venenata*.

Vegetation structure:
The dwarf shrub layer was dominant (mean 17.0% cover), while the grass layer was poorly developed (mean of 12.7% cover). Forbs, shrubs and trees made small contributions to total cover (Tables 8 & 32).

Plant diversity:
The 14 plots surveyed in A13 yielded 120 species. Mean number of species per plot was 30.9, ranging from 22 to 46 species. Although the mean species richness per plot was ranked as intermediate, the Shannon-Wiener and Simpson indices of diversity were considered as high among the associations in the study area (Tables 6 & 7).

Figure 43: A13: *Salsola* spp. – *Pentzia spinescens – Moraea venenata* Floodplain Dwarf Shrubland occurring in a band across the central portion of the study area.

IUCN red-listed and protected species:
Twenty percent of all species found in A13 were NCNCA protected and one species was CITES listed (Table 33).

Table 33: Red-listed and/or protected species recorded in Association 13

At a glance statistics on red-listed and/or protected species in A13

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	24	1	0	0	0
% of species	20.0	0.8	0	0	0
Species/Genus/ Family	Aizoaceae 13 spp. Apocynaceae 2 spp. Iridaceae 2 spp. *Colchicum* 1 sp. *Euphorbia* 2 spp. *Lessertia* 2 spp. *Oxalis* 2 spp.	*Euphorbia braunsii*			

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 14 (A14): *Stipagrostis anomala – Stipagrostis obtusa – Tetraena chrysopteros* Calcrete Plains Grassland

Location and environmental features:

A14 covered 5 374 ha (2.3% of the study area) and occurred predominantly in the central portion of the study area (Figure 25) on plains bordering the so-called vloere or dry pans (Figure 44). Rock cover was none or low (<10%), but calcrete was prominent at most sites. Geologically, the sites occurred mostly on mudrock and siltstone of the Tierberg Formation (Pt) and the land type was classified as Fc in most instances. Mean altitude was 1 046 m a.s.l. (Table 34).

Table 34: Summary of the dominant environmental features of Association 14 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	
	Upper slope	Plateau	Ridge/hill	Pan			
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1046						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.0	0.6	9.2	43.0	2.2	55.0	

Key to colours:

0-25	>25-50	>50-75	>75

Floristic composition:

A14 did not have a diagnostic species group and was defined more by the lack of any of the species groups defining A5 – A13 in the plains and plateaux associations (Appendix A). It shared the common species groups (species groups 28 – 30) of the plains and plateaux associations as well as species groups 31 & 32 shared by the plains and plateaux and mountains associations.

- No **tree** species was recorded in this association.
- **Shrubs** were represented by *Osteospermum spinescens* and *Lycium bosciifolium.*
- Dominant **dwarf shrubs** were *Eriocephalus ambiguus, Lycium horridum* and *Salsola* spp. Other abundant dwarf shrub species included *Mesembryanthemum nodiflorum, Tetraena microcarpa, Dicoma capensis,*

Rhigozum trichotomum, Asparagus glaucus, Salsola aphylla/Salsola calluna complex, *Limeum argute-carinatum, Pentzia calcarea, Lycium cinereum* and *Roepera lichtensteiniana*.

- The **grass** layer was well developed and dominated by *Stipagrostis anomala, Enneapogon desvauxii, Stipagrostis obtusa* and *Stipagrostis ciliata.*
- Prominent **forb** species included *Leobordea platycarpa, Aptosimum procumbens, Tetraena simplex, Pelargonium minimum* and *Gazania lichtensteinii.*

Vegetation structure:
A14 had a well-developed grass layer (mean 43% cover), with dwarf shrubs being rather sparse (mean 9.2% cover). Forbs and shrubs made small contributions to total cover (Tables 8 & 34).

Plant diversity:
In total 75 species were enumerated in the five plots surveyed. Mean number of species per plot was 29.4 with a range from 20 to 38 species. The mean species richness per plot as well as mean Shannon-Wiener index of diversity both indicated an intermediate diversity for A14. However, the Simpson index ranked the diversity as high (Tables 6 & 7).

Figure 44: A14: *Stipagrostis anomala – Stipagrostis obtusa – Tetraena chrysopteros* Calcrete Plains Grassland occurring on plains bordering the vloere.

IUCN red-listed and protected species:
Seventeen species are listed as Northern Cape protected species (Table 35).

Table 35: Red-listed and/or protected species recorded in Association 14

At a glance statistics on red-listed and/or protected species in A14

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	17	0	0	0	0
% of species	22.7	0	0	0	0
Species/Genus/ Family	Aizoaceae 11 spp. Apocynaceae 1 sp. Iridaceae 1 sp. *Euphorbia* 1 sp. *Lessertia* 1 sp. *Oxalis* 1 sp. *Pelargonium* 1 sp.				

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 15 (A15): *Cuspidea cernua – Panicum coloratum – Drosanthemum hispidum* Vloere Dwarf Shrubland

Location and environmental features:
This dwarf shrubland covered 31 782 ha (13.4% of the study area). SA15.1 was found predominantly in the northern part of the study area with large sections in the buffer zone (Figure 25). SA15.2 occurred mostly in the central portion of the study area. The association was found primarily on the so-called vloere or dry pans (Figures 45 & 46). Rocks and gravel were generally absent. Geologically, the area occupied by A15 was classified as alluvium and most of the sites were in the Ia Land Type. Mean altitude was 994 m a.s.l. (Table 36).

Figure 45: SA15.1: *Malephora crassa – Lampranthus uniflorus – Salsola aphylla/calluna* Vloere found in the northeastern parts of the study area.

Table 36: Summary of the dominant environmental features of Association 15 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	
	Upper slope	Plateau	Ridge/hill	Pan			
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	994						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarf shrubs**	**Grasses**	**Forbs**	**Total**	
	0.2	1.1	18.8	10.9	2.5	33.4	

Key to colours:

0-25	>25-50	>50-75	>75

Floristic composition:
Association A15 was differentiated by a large species group (species group 35, Appendix A) comprising species such as *Cuspidea cernua, Panicum coloratum, Cromidon minutum, Cullen tomentosum, Lepidium desertorum* and *Ammocharis coranica* amongst others.

- The only **tree** species encountered was the alien invasive *Prosopis glandulosa*.
- Prominent **shrub** species included *Bassia salsoloides, Lycium bosciifolium, Osteospermum spinescens, Phaeoptilum spinosum* and *Salsola aphylla/calluna* complex.
- The dominant **dwarf shrub** species were *Lycium cinereum, Salsola* spp. and *Mesembryanthemum noctiflorum*. Other common dwarf shrub species included *Malephora crassa, Lampranthus uniflorus, Hermannia coccocarpa, Roepera incrustata, Drosanthemum hispidum, Asparagus glauca, Hertia cluytiifolia, Atriplex vestita, Mesembryanthemum* cf. *longistylum* and *Mesembryanthemum junceum*.
- *Chloris virgata* and *Enneapogon desvauxii* were the dominant **grass** species, with other prominent grass species being *Panicum coloratum, Aristida adscensionis, Tragus racemosus* and *Tragus berteronianus*.
- **Forbs** were represented by *Cromidon minutum, Cuspidea cernua, Lepidium desertorum, Atriplex lindleyi, Lessertia pauciflora, Berkheya annectens, Galenia* cf. *pubescens* and *Gazania krebsiana*.

Two subassociations were identified:

SA15.1 *Malephora crassa – Lampranthus uniflorus – Salsola aphylla/calluna* Vloere (Figure 45)
SA15.2 *Roepera incrustata – Cuspidea cernua – Chloris virgata* Vloere (Figure 46)

SA15.1 was differentiated by the strong species group 33 (Appendix A), containing *Malephora crassa, Lampranthus uniflorus* and *Lepidium africanum*, with *Hertia cluytiifolia, Atriplex vestita* and *Salsola aphylla/calluna* complex being more conspicuous in SA15.1 than in SA15.2. SA15.2 was differentiated by the strong species group 34 with species such as *Hermannia coccocarpa, Roepera incrustata* and *Osteospermum calendulaceum* amongst others.

Vegetation structure:
The vegetation could be described as a dwarf shrubland with the mean cover of dwarf shrubs being 18.8%. Grasses covered 10.9% of the area, forbs 2.5% and shrubs 1.1%. Trees made a negligible contribution to total vegetation cover Tables 8 & 36).

Plant diversity:
In total 134 species were recorded in the 22 plots surveyed. Mean number of species per plot was 23.6 with a range from 9 to 37 species. The mean number of species per plot, indicated a low species richness, but the Shannon-Wiener index of diversity indicated an intermediate diversity and the Simpson index of diversity a high diversity for the association (Tables 6 & 7).

Figure 46: SA15.2: *Roepera incrustata – Cuspidea cernua – Chloris virgata* Vloere found mostly in a west-central band across the study area.

IUCN red-listed and protected species:
Thirty-one provincially protected species and one CITES species were recorded (Table 37).

Table 37: Red-listed and/or protected species recorded in Association 15

At a glance statistics on red-listed and/or protected species in A15

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	31	1	0	0	0
% of species	23.1	0.7	0	0	0
Species/Genus/ Family	Aizoaceae 22 spp. Amaryllidaceae 2 spp. Iridaceae 1 sp. *Colchicum* 1 sp. *Euphorbia* 2 spp. *Lessertia* 1 sp. *Oxalis* 1 sp. *Pelargonium* 1 sp.	*Euphorbia braunsii*			

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 16 (A16): *Stipagrostis namaquensis – Prosopis glandulosa* Riparian Bushveld

Location and environmental features:
This *Prosopis glandulosa* invaded association (Figures 47 & 48) was associated with the alluvium along the drainage lines and was spread out across most of the study area covering an area of 2 796 ha (1.2% of the study area) (Figure 25). No rocks or gravel was encountered. Land type was either Fc or Ia. Mean altitude was 1 009 m a.s.l. (Table 38).

Table 38: Summary of the dominant environmental features of Association 16 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	
	Upper slope	Plateau	Ridge/hill	Pan			
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1009						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarfshrubs**	**Grasses**	**Forbs**	**Total**	
	36.6	15.7	8.3	9.9	1.0	71.5	

Key to colours:

0-25	>25-50	>50-75	>75

Floristic composition:
A16 did not have a diagnostic species group, but it could be distinguished by the high cover values of *Prosopis glandulosa.*

- The **tree** layer was represented by *Prosopis glandulosa* (d) and a few scattered *Searsia lancea* individuals.
- Prominent **shrub** species included *Lycium bosciifolium* (d), *Bassia salsoloides* and *Osteospermum spinescens.*

- Conspicuous **dwarf shrub** species were *Lycium cinereum* (d), *Mesembryanthemum noctiflorum* (d), *Salsola aphylla/calluna* complex (d), *Atriplex vestita, Pentzia pinnatisecta, Tetraena chrysopteros* and *Mesembryanthemum guerichianum.*
- The **grass** layer was dominated by *Stipagrostis namaquensis,* with other prominent grass species including *Chloris virgata, Eragrostis lehmanniana, Tragus racemosus, Enneapogon desvauxii* and *Aristida adscensionis*.
- **Forbs** were represented by *Galenia* cf. *pubescens* (d) and *Atriplex lindleyi.*

Figure 47: SA16.1: *Prosopis glandulosa – Salsola aphylla/calluna* Riparian Bushveld.

Two subassociations were identified, but have not been mapped separately:

SA16.1 *Prosopis glandulosa – Salsola aphylla/calluna* Riparian Bushveld (Figure 47)
SA16.2 *Prosopis glandulosa – Setaria verticillata* Riparian Bushveld (Figure 48)

Floristically there was only a subtle difference between the two subassociations. SA16.1 showed a higher abundance of *Salsola aphylla/Salsola calluna* complex, *Hertia cluytiifolia* and *Medicago laciniata* than SA16.2, whereas SA16.2 had higher frequencies of occurrence of *Cenchrus ciliaris, Pentzia pinnatisecta, Datura ferox* and *Melianthus comosus* than in SA16.1.

Figure 48: SA16.2: *Prosopis glandulosa – Setaria verticillata* Riparian Bushveld.

Vegetation structure:
The tree layer was dominant with a mean canopy cover of 36.6%, followed by the shrub layer (mean 15.7% cover). Grasses and dwarf shrubs made almost equal contribution to total vegetation cover (mean 9.9% cover and 8.3% cover respectively) (Tables 8 & 38).

Plant diversity:
The seven plots surveyed in A16 yielded 71 species. Mean number of species per plot was 19.7 with a range from 13 to 32 species. A16 was the most species-poor association of all associations and this was demonstrated by a low mean species richness per plot, low Shannon-Wiener and Simpson indices of diversity (Table 6 & 7).

IUCN red-listed and protected species:
Only eight species qualified as NCNCA protected species (Table 39) with no CITES, NFA, IUCN or Tops-listed species.

Table 39: Red-listed and/or protected species recorded in Association 16

At a glance statistics on red-listed and/or protected species in A16

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	8	0	0	0	0
% of species	11.3	0	0	0	0
Species/Genus/ Family	Aizoaceae 7 spp. *Lessertia* 1 sp.				

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association 17 (A17): *Searsia lancea – Stipagrostis namaquensis – Lycium bosciifolium* Riparian Bushveld/Grassland

Location and environmental features:
This riparian association (Figures 49 & 50) occurred along the drainage lines criss-crossing the study area (Figure 25) and covered an area of 5 482 ha (2.3% of the study area). The association was linked to alluvium and the Ah and Fc Land Types. Subassociation 17.1 generally had a higher rock and gravel cover than SA17.2. Mean altitude was 1 090 m a.s.l. (Table 40).

Table 40: Summary of the dominant environmental features of Association 17 at the SKA study site. The colours indicate the percentage of plots falling in a particular category (see key below the table)

Physiognomy	Bushveld	Shrubland	Shrubland & Dwarf Shrubland	Dwarf Shrubland	Dwarf Shrubland & Grassland	Grassland	
Topography	Dune	Drainage line	Floodplain	Plain	Footslope	Midslope	
	Upper slope	Plateau	Ridge/hill	Pan			
Slope	None	Gentle	Moderate	Steep			
Rock cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Gravel cover (%)	None	<10%	>10-30%	>30-50%	>50-75%	>75%	
Geology	Jd	Pt	Pc	T-Qc	Qs	Al	Al (dry pans)
Land Type	Fc	Ah	Ae	Ia	Ib		
Mean altitude (m)	1090						
Mean cover (%)	**Trees**	**Shrubs**	**Dwarfshrubs**	**Grasses**	**Forbs**	**Total**	
	16.1	9.9	9.2	22.1	4.0	61.3	

Key to colours:

0-25	>25-50	>50-75	>75

Floristic composition:
A17 was differentiated from the other associations by diagnostic species group 44 (Appendix A) containing *Setaria verticillata, Eragrostis procumbens, Salvia disermas, Portulaca oleracea, Mesembryanthemum coriarium, Kohautia cynanchica* and *Asparagus retrofractus*.

- The **tree** layer contained species such as *Tamarix usneoides, Searsia lancea* and *Prosopis glandulosa*.

- **Shrubs** were represented by *Lycium bosciifolium, Phaeoptilum spinosum, Osteospermum spinescens, Bassia salsoloides* and *Searsia burchellii.*
- Prominent **dwarf shrub** species included *Melianthus comosus, Atriplex vestita, Salsola aphylla/calluna* complex, *Melolobium candicans, Lycium horridum, Lycium cinereum, Peliostomum leucorrhizum, Tetraena chrysopteros Roepera lichtensteiniana*, *Lacomucina lineata* and *Thesium hystrix*.
- The **grass** layer was dominated by *Stipagrostis namaquensis, Cenchrus ciliaris* and *Stipagrostis ciliata*. Other common grass and sedge species included *Afroscirpoides dioeca, Phragmites australis, Eragrostis porosa, Eragrostis lehmanniana, Eragrostis procumbens, Sporobolus ioclados, Setaria verticillata, Eragrostis echinochloidea, Enneapogon desvauxii, Aristida adscensionis, Tragus racemosus* and *Fingerhuthia africana*.
- A multitude of **forb** species were common e.g. *Salvia disermas, Portulaca oleracea, Convolvulus sagittatus, Salsola kali, Argemone ochroleuca, Dimorphotheca polyptera, Arctotis leiocarpa, Berkheya annectens, Pelargonium minimum, Manulea fragrans, Ursinia nana, Sesamum capense* and *Mesembryanthemum guerichianum.*

Two subassociations were identified:

SA17.1 *Tamarix usneoides – Searsia lancea – Stipagrostis namaquensis* Riparian Bushveld (Figure 49)

SA17.2 *Stipagrostis namaquensis – Phaeoptilum spinosum – Berkheya annectens* Riparian Grassland (Figure 50)

SA17.1 was differentiated by a strong diagnostic species group (species group 40, Appendix A) containing conspicuous species such as *Tamarix usneoides, Searsia lancea, Phragmites australis* and *Afroscirpoides dioeca*. Furthermore, it contained species groups 41 and 42 that were not present in SA17.2. Subassociation 17.2 was differentiated by species group 43 containing *Convolvulus sagittatus* and *Eragrostis echinochloidea*. A higher abundance of species such as *Searsia burchellii, Phaeoptilum spinosum, Mesembryanthemum noctiflorum, Enneapogon desvauxii, Stipagrostis obtusa* as well as a host of annual species further distinguish SA17.2.

Vegetation structure:
The two subassociations differed in structure with SA17.1 being a bushveld and SA17.2 a grassland (Tables 8 & 40).

Plant diversity:
The 14 plots surveyed in A17 yielded a total of 153 species. Mean species richness per plot was 32.3 with a range from 20 to 45 species. Mean values per plot for all the diversity parameters indicated a high diversity for A17 (Tables 6 & 7).

IUCN red-listed and protected species:
13.1% of all species encountered in A17 were NCNCA protected (Table 41) with no CITES, NFA, IUCN or Tops-listed species.

Figure 49: SA17.1: *Tamarix usneoides – Searsia lancea – Stipagrostis namaquensis* Riparian Bushveld often found in more rocky drainage lines associated with mountains.

Figure 50: SA17.2: *Stipagrostis namaquensis – Phaeoptilum spinosum – Berkheya annectens* Riparian Grassland often found in drainage lines on sandy plains.

Table 41: Red-listed and/or protected species recorded in Association 17

At a glance statistics on red-listed and/or protected species in A17

	NCNCA	CITES	NFA	IUCN	NEM:BA: ToPS
No of species	20	0	0	0	0
% of species	13.1	0	0	0	0
Species/Genus/ Family	Aizoaceae 12 spp. *Euphorbia* 1 sp. *Jamesbrittenia* 2 spp. *Lessertia* 2 spp. *Oxalis* 1 sp. *Manulea* 1 sp. *Pelargonium* 1 sp.				

NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

5.6 Flora of the SKA study area

A provisional check list of the plant species (the term species is used here in a general sense to denote species, subspecies and varieties) in the study area was compiled from (a) the list provided by Milton (2021) on the indigenous angiosperm species collected or recorded in the 3021 degree square in which the SKA core area falls; (b) the latest NewPosa list for the 3021 degree square (accessed May 2022); and (c) the species recorded during the current vegetation survey (Appendix B).

The International Union for the Conservation of Nature (IUCN) status, conservation and protected status of all plant species provided in Appendix B were determined from available literature and Acts, e.g. NewPosa database (newposa.sanbi.org) and Red list database of SANBI (redlist.sanbi.org). Furthermore, species that are protected or specially protected according to the NCNCA (2009) are listed in Appendix B; as are species listed in Appendix II of CITES (2021); as well as the category of declared alien invasive species (NEM:BA 2020a). The only ToPS listed species was *Hoodia gordonii.*

5.6.1 Family contributions

In total 563 taxa, representing 67 families, are listed for the study area in Appendix B. Of these species 327 were reported by Milton (2021); plus 40 additional species listed for the one degree square on NewPosa; and 416 were encountered during the current vegetation survey.

The five most species-rich families are Asteraceae (19.1% of all species), Poaceae (12.6% of all species), Aizoaceae (9.0% of all species), Fabaceae (6.4% of all species) and Scrophulariaceae (5.1% of all species).

5.6.2 Protected and threatened species

The mountain association A2 had the highest percentage (41.2%) of all species being protected/specially protected in the Northern Cape followed by Association A9, the high mountain plateaux, with 29.1% protected/specially protected species (Table 42). At the other end of the scale were A1, the dune grassland, and A16, the *Prosopis glandulosa* drainage lines, with 11.0% and 11.3% respectively being protected. There were few CITES-listed species in the study area, most of them were *Aloe/Aloidendron* species or succulent *Euphorbia* species. *Boscia albitrunca* was the only nationally protected tree species and occurred predominantly in the mountain or plateaux associations. The only IUCN red-listed (threatened) species were *Aloidendron dichotomum* which has a Vulnerable status and *Roepera divaricata* which is Endangered. The latter species was however not encountered during the current survey. *Hoodia gordonii* was the only NEM:BA ToPS listed species encountered in the study area.

Table 42: Comparison across associations of the number of threatened and protected species. Percentages refer to the number of species expressed as a percentage of the total number of species recorded in the association. NCNCA = Northern Cape Nature Conservation Act (Act No. 59 of 2009); CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora; NFA = National Forest Act (Act No. 84 of 1998); IUCN = International Union for the Conservation of Nature; NEMBA: ToPS = National Environmental Management: Biodiversity Act (Act No. 10 of 2004): Lists of Threatened and Protected Species

Association	NCNCA		CITES		NFA		IUCN		ToPS	
	Number	%	Number	%	Number	%	Number	%	Number	%
1	3	11.0	0	0.0	0	0.0	0	0.0	0	0.0
2	40	**41.2**	3	**3.1**	1	1.0	1	1.0	1	1.0
3	22	17.6	2	1.6	1	0.8	1	0.8	0	0.0
4	6	26.1	0	0.0	1	**4.3**	0	0.0	0	0.0
5	36	21.4	4	2.4	1	0.6	1	0.6	1	0.6
6	18	20.9	1	1.2	0	0.0	0	0.0	0	0.0
7	29	21.6	1	0.7	0	0.0	0	0.0	0	0.0
8	22	19.0	1	0.8	0	0.0	0	0.0	0	0.0
9	23	29.1	1	1.3	1	1.3	1	**1.3**	0	0.0
10	3	12.0	0	0.0	0	0.0	0	0.0	1	**4.0**
11	40	22.7	4	2.3	0	0.0	1	0.6	1	0.6
12	27	20.5	1	0.8	0	0.0	0	0.0	0	0.0
13	24	20.0	1	0.8	0	0.0	0	0.0	0	0.0
14	17	22.7	0	0.0	0	0.0	0	0.0	0	0.0
15	31	23.1	1	0.7	0	0.0	0	0.0	0	0.0
16	8	11.3	0	0.0	0	0.0	0	0.0	0	0.0
17	20	13.1	0	0.0	0	0.0	0	0.0	0	0.0

5.6.3 Alien invasive species

Nine species (1.7% of the total number of species) are listed as declared alien invasive species.

- Category 1b species include: *Atriplex lindleyi* subsp. *inflata; Salsola kali; Xanthium strumarium; Opuntia ficus-indica; Argemone ochroleuca; Cenchrus setaceus*; and *Datura ferox*;
- Category 2: *Atriplex nummularia*; and
- Category 3: *Prosopis glandulosa*.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Environmental gradient

In the phytosociological table (Appendix A), the plant associations were arranged along a dry to wet gradient. This gradient started with the dune association (A1) on the dry extreme, through the mountain associations (A2 – A4), rocky or gravelly plains and plateaux (A5 – A10), through the sandy plains (A11), the floodplains (A12 – A14), vloere (A15) to the riparian associations (A16 & A17) on the wet extreme. If the dune crest association (A1) is excluded, an environmental gradient (from left to right in the table) from shallow rocky soils of the mountains to the deep alluvial soils of the vloere or pans is also evident.

6.2 Environmental determinants of vegetation associations

There was a strong relationship between the various plant associations and the underlying geology. A relationship between the broad land types and the plant associations was also apparent. Elevation was clearly influential as demonstrated when overlaid onto ALOS hill-shading DSM (Figure 51). However, aspect was less important than expected at the scale of the current investigation, although the large *Aloidendron dichotomum* subpopulations appeared to be associated with a northern aspect.

6.3 Environmental drivers of vegetation change

A driver is any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. These environmental drivers are not to be confused with the environmental determinants (e.g. geology, rockiness, soil depth) that are associated with the vegetation units. The most important drivers in the study area were judged to be land use change, rainfall cycles, grazing, invasive alien species and climate change. Land use change and grazing in the current context would infer positive changes to the ecosystem since overexploitation or overgrazing by livestock will no longer play a role. Overgrazing by livestock is generally first noticed by a decrease in plant cover and thereafter a change in species composition leading to a higher proportion of non-palatable plant species. Upon withdrawal of livestock it is unlikely that the recovery trajectory will be a simple reversal of the degradation process. Physical modifications of watercourses or vloere will also no longer be created.

6.4 Plant collections

The timing of the phytosociological surveys was not ideal for collecting herbarium specimens because many of the dwarf shrubs were not flowering. In total 153 herbarium specimens (no sterile specimens collected) were sent to the Compton Herbarium for identification. These specimens will be housed in the Compton Herbarium and according to the Terms of Reference duplicates will be sent to the SANParks Herbarium in Kimberley. We would however recommend that the duplicates rather be housed in an accredited herbarium and that SANParks builds up a ‘virtual’ herbarium of images of the plant species that can be easily accessed by all researchers on the SKA properties as well as Meerkat National Park staff.

We would recommend that a few dedicated plant collecting trips are scheduled for different seasons to capture the full plant diversity of the study area. SAEON Research Associates could assist with this task.

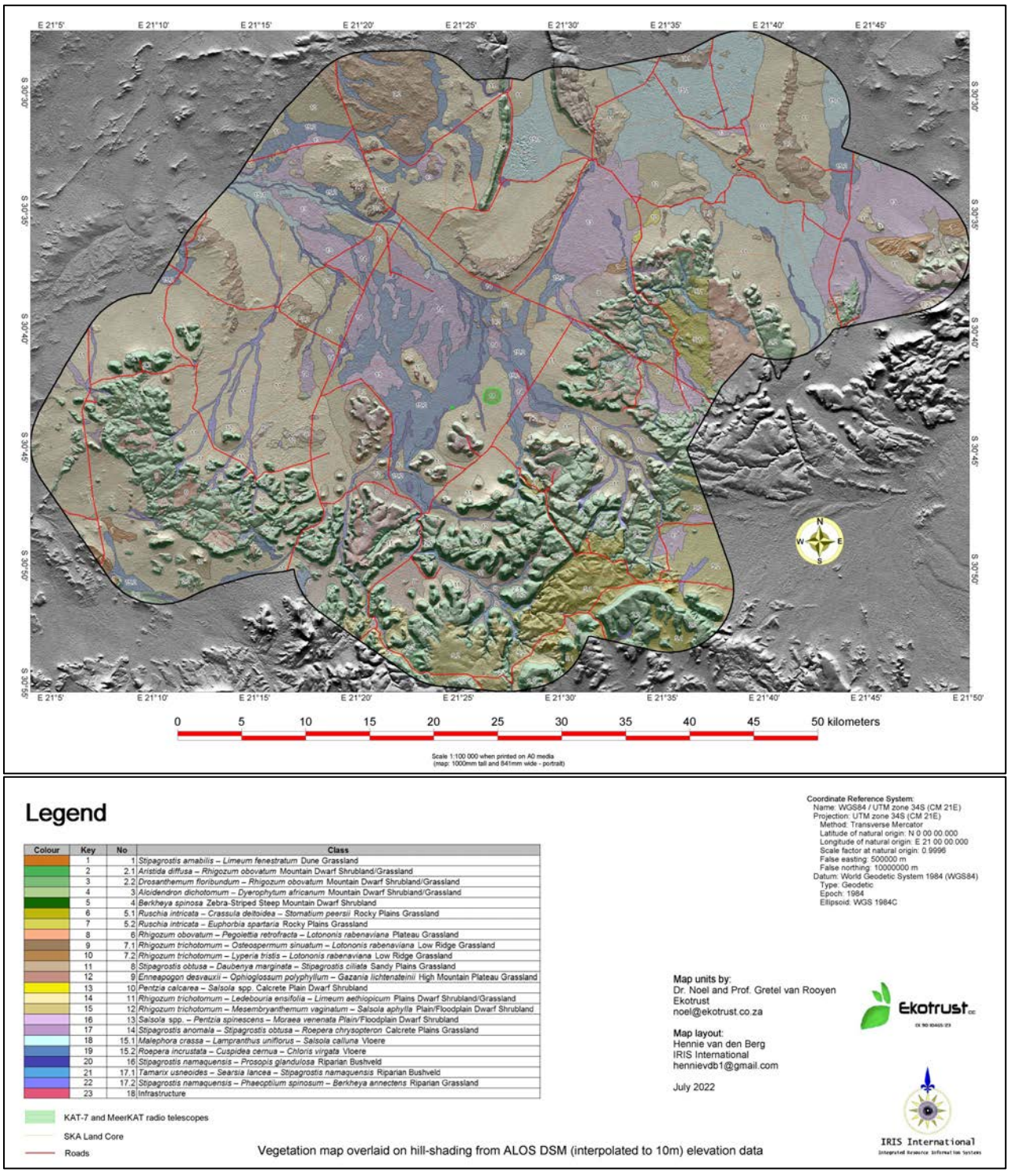

Figure 51: Vegetation map overlaid on hill-shading from ALOS DSM elevation data (interpolated to 10 m).

6.5 Grazing capacity of the Meerkat National Park

It is essential that the veld condition and grazing capacity of the Meerkat National Park is regularly determined if wildlife is reintroduced in the park. The Grazing Index Method of Du Toit (1998, 2000) is considered the most appropriate method for the arid regions of South Africa and is thus recommended to calculate indices of veld condition and to derive a grazing capacity. The method is based on the size, dry matter production and palatability of the different plant species in an area (Du Toit *et al.* 1995, Du Toit 2003). Data gathered for the monitoring programme initiated by SAEON are suitable for analysis by the method of Du Toit (2003).

6.6 Future monitoring of vegetation change

A vegetation monitoring programme covering the Meerkat National Park has been initiated by SAEON. The selection of the current monitoring sites were based on land types and it is recommended that the sites are also related to the plant associations distinguished in this study to ensure that all associations are represented.

Milton (2021) provides some valuable suggestions on topics that could be considered for monitoring projects. The next section expands on the vegetation-related topics provided by Milton (2021) while adding some additional themes. Prioritisation of the topics should be done by staff of the Arid Lands Node in order to ensure that the projects conform to the research and long-term monitoring objectives of the SAEON Arid Lands Node. Where necessary input from an aquatic specialist and/or soil scientist must be requested.

- **Monitoring of plant populations of Species of Conservation Concern (SCC):** The only threatened species are *Aloidendron dichotomum* and *Roepera divaricata*, the latter possibly not correctly identified. SAEON have already initiated the monitoring of selected populations of *Aloidendron dichotomum* within the Meerkat National Park.
- **Land-use change mapping:** It is suggested that satellite-based land-use change mapping is done. Satellite images at intervals of 10 years could be analysed to detect changes in land-use and degradation. After the initial analysis, land-use change mapping should be repeated at 10-year intervals.
- **Vegetation dynamics:** A vegetation monitoring programme was initiated by SAEON in 2022. Unfortunately, the surveys were not done before livestock were withdrawn and therefore a true baseline for vegetation change is not available. The surveys in 2022 were done three years after livestock were withdrawn. Assuming that the monitoring plots cover all the associations identified in this report, the following questions could be investigated:
    - What parameters of the plant associations (e.g. plant cover, species frequency, diversity, species composition, functional types) are changing and if they are changing, what is the direction, extent and rate of that change?
    - If changes are occurring, are they occurring across the landscape or in particular associations/habitats?
    - Can differences in the direction, extent and rate of the change in parameters be linked to the wet-dry gradient along which the associations are arranged?
    - Can differences in the direction, extent and rate of the change in parameters be linked to an altitudinal gradient?
    - What are the causes of the changes in the biological parameters? Can the change be ascribed to inter-annual rainfall cycles, grazing effects or climate change?
    - Wherever associations occur within the core SKA area as well as within the buffer zone a comparison should be made per association of e.g. plant cover, species frequency, diversity, species composition and functional diversity between the core and buffer vegetation. These differences in the vegetation could most probably be ascribed to differences in grazing regime.
    - Vegetation monitoring should be repeated every three years. SAEON have selected close to 100 monitoring sites. All sites could be monitored in a single year or alternatively the monitoring effort could be spread out across three years. If the latter option is chosen, it is essential that all sites within a particular association are monitored in the same year to avoid seasonal rainfall effects on a subset of sites in an association. Monitoring all sites in the same year does have advantages and should be given due consideration – over a 3-year cycle there would be no difference in workload.
    - Data gathered for the monitoring programme initiated by SAEON are suitable for determining grazing capacity by the method of Du Toit (2003). Thus, even although wildlife introductions are not currently planned for the Meerkat National Park, a database on the effect of seasonal rainfall on grazing capacity will be built up by the monitoring programme.
- **Vegetation dynamics (recovery) after human-induced disturbances:** It should be noted that the current project to classify the vegetation and compile a vegetation map focused on the natural vegetation and

severely disturbed sites such as around homestead, watering points and abandoned croplands were avoided. Nevertheless, these severely human-impacted habitats offer valuable monitoring opportunities.

- We are unsure whether the monitoring programme initiated by SAEON included abandoned croplands or not. If not, monitoring of the vegetation recovery on abandoned croplands should be undertaken.
- The importance, extent and recovery of the vegetation in piospheres could be investigated and compared between the core SKA area and the buffer zone.
- A study could be initiated (provided the necessary detailed background information can be found) to compare several parameter of the vegetation (e.g. plant cover, species frequency, diversity, species composition, functional type composition, grazing value) on farms with different grazing histories (stocking densities, type of livestock, or wildlife) within the core SKA area.

- **Alien Invasive species (AIS):** *Prosopis glandulosa* and its hybrids have invaded large tracks of land in the study area and the control of the *Prosopis* invasion should be a priority for the management of the Meerkat National Park.
  - The first step would be to map the *Prosopis* spp. invasion and to allocate a severity of the invasion to each of the mapped patches.
  - Once AIS control has started, records must be kept of the areas treated (mapped), volumes of herbicide applied, and man-hours used. Monitoring should be initiated before the clearing operations commence to act as a benchmark for comparison.
  - Monitoring should be of sufficient detail to track changes in e.g. the density of the infestation, stem diameter, tree height, tree diameter and if needed tree volume/biomass. BECVOL transects could be used for this purpose, or simple transects in which all woody individuals are counted and stem diameter, canopy diameter and tree height are measured. Data should be such that a relative density, relative frequency and relative dominance can be calculated to determine the importance values.
  - Besides the *Prosopis* spp., eight other declared alien invasive species were found in the study area *viz. Argemone ochroleuca, Atriplex lindleyi, Atriplex nummularia, Cenchrus setaceus, Datura ferox, Opuntia ficus-indica, Salsola kali* and *Xanthium strumarium.* At the time of the study these invasions were light, nevertheless, these species should be mapped and monitored.
  - The list of alien invasive species provided in Appendix B is by no means exhaustive. AIS are often concentrated around homesteads and species not yet listed for the region could be present there. The eradication of these species around the homesteads should be a priority of the Meerkat National Park. The success of the control operation should be monitored and follow-up treatment might be necessary.
- **Bush encroachment:** Almost pure stands of *Rhigozum trichotomum* (Association 11) cover large areas of the study area. Although Burchell already commented on the abundance of this species in 1811 (Milton 2021), overgrazing could have led to a further increase in its abundance. While doing the field surveys for the current study it was clear that the severe drought of the preceding years had caused large scale mortality of *Rhigozum trichotomum* in some areas. Monitoring in these stands with a high level of mortality presents an opportunity to determine which species will colonise these stands.
- **Fixed point photographs:** This is an essential component of monitoring. By taking photographs of the vegetation or landscape from the same point at regular intervals and at the same time of year, a visual record can be obtained that could at a later stage be subjected to objective analysis (Masubelele *et al.* 2013). In the current study photographs were taken of 226 of the 232 sample plots. These photographs could be made available to SAEON.

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APPENDIX A: SYNOPTIC TABLE OF THE ASSOCIATIONS AND SUBASSOCIATIONS OF THE SKA STUDY AREA

Note: The full differential table is available as Excel file on request.

	A1	A2.1	A2.2	A3	A4	A5.1	A5.2	A6	A7.1	A7.2	A8	A9	A10	A11	A12	A13	A14	A15.1	A15.2	A16.1	A16.2	A17.1	A17.2
Species group 1																							
Stipagrostis amabilis	5																						
Limeum fenestratum	5										1												
Hermannia gariepina	5																						
Citrullus lanatus	4																		1				
Crassothonna cylindrica	4																						
Species group 2																							
Aristida diffusa		5				1																	
Wahlenbergia nodosa		3																					
Solanum tomentosum		3		1	5			1														1	
Felicia filifolia		2				1																	
Sporobolus fimbriatus		2				1																2	
Stachys cuneata		2						1														1	
Selago albida		2				1					1												
Helichrysum zeyheri		1																					1
Asparagus sp.		1											5										
Species group 3																							
Drosanthemum floribundum			2									1											
Helichrysum pumilio			2				1	1															
Cyperus rubicundus			1																				
Babiana sp.			1																				
Species group 4																							
Trichodiadema cf. *setuliferum*		2	1			2		1															
Hermannia vestita		1	2	1																			
Pentzia quinquefida		1	1			1																	
Pelargonium ramosissimum		1	1																				
Species group 5																							
Aloidendron dichotomum		1		3		1						3		1									
Tetragonia sp.				2						1				1	1								
Galenia namaensis				1																			
Species group 6																							
Justicia spartioides		4	4	4		1								1								1	
Heteropogon contortus		3	2	1																			
Forsskaolea candida		2	2	3																		1	
Dyerophytum africanum		1	1	3																			
Asparagus striatus		4	1	1		2																	1
Talinum arnotii		1	1	2																			
Panicum lanipes		1	1	1																			
Justicia incana		2		1		1								1									
Cleome angustifolia			1	1																			
Amphiglossa sp.		1	1	1																			
Chascanum pinnatifidum		1	1	1						1						1							
Heliophila cf. *carnosa*			1	1																			
Phyllanthus maderaspatensis		1	1	1																			
Species group 7																							
Microloma incanum		3	4	5	5			1	1					1			1						
Galenia sarcophylla		4	3	4	5							3		1	1	1	1		1			3	1
Berkheya spinosa		4	3	3	5																	3	1
Oxalis haedulipes		3	1	3	5									1								1	
Boscia albitrunca		2	1	2	5	1						1											
Solanum capense		2		1	5	1						1		1									1
Species group 8																							
Oedera glandulosa				1		4			1	1						1							
Crassula deltoidea						4																	
Stomatium cf. *peersii*						3																	
Anacampseros albidiflora						3																	
Nenax microphylla						3										1							
Gazania heterochaeta						3																	
Euryops lateriflorus						2																	
Dianthus micropetalus						2																	
Species group 9																							
Euphorbia spartaria			1				3	1						1									

	A1	A2.1	A2.2	A3	A4	A5.1	A5.2	A6	A7.1	A7.2	A8	A9	A10	A11	A12	A13	A14	A15.1	A15.2	A16.1	A16.2	A17.1	A17.2
Species group 10																							
Syringodea concolor						1	2																
Diascia engleri						1	2																
Curio radicans						1	2																
Zaluzianskya peduncularis						1	1																
Species group 11																							
Asparagus capensis		2	3	1		3	2					2			1	1			1				
Hermannia cernua		1	2	1		1	2							1									
Eragrostis obtusa		2	2	1		3	1							1	1								1
Eragrostis nindensis		2	2			2																	
Oedera oppositifolia	2	1	1			1	2	1															
Species group 12																							
Rhigozum obovatum		5	5	4	5	4	1	5														1	
Barleria rigida		3	2	3		3		2	1														
Helichrysum lucilioides		2	1			3	1	3			1			1									
Species group 13																							
Hermannia desertorum		5	4	4		5	2	2	4	1													
Sericocoma avolans		3	4	4		1			3														
Jamesbrittenia tysonii		4	3	1		1			1													1	
Blepharis mitrata		2	2	3		2		2	2					1									
Drosanthemum lique		1	3	1		1	2	3	1			3		1			1		1				
Sericocoma pungens		1	1	2			1	1	3														
Aloe claviflora		1	2	2		1	1	1	2	1		1		1									
Species group 14																							
Lyperia tristis										2				1									
Jamesbrittenia atropurpurea										2				1									
Species group 15																							
Pteronia glomerata									2	2							2						
Species group 16																							
Lotononis laxa		1	2	2					3	3				1									
Pteronia viscosa		2		1		4	2		1	2	1												
Pegolettia retrofracta		1	1	1		3		4	1	2		1		1									
Species group 17																							
Daubenya marginata											3								1				
Dimorphotheca pinnata										1	3			1									1
Gazania jurineifolia							1				2					1			1				
Grielum humifusum											2												1
Lycium pilifolium											2			1					1				
Species group 18																							
Lotononis rabenaviana			1	1				4	3	3	2		5	1									
Species group 19																							
Eriocephalus ericoides		5	3	3		5	3	2	3	3	1		5	1			1			2			
Oxalis primuloides			2					2	3	2	2	1		1		1							
Pteronia glauca		1	1			1	1			1	2			1									
Species group 20																							
Ophioglossum polyphyllum		1	1			1						3			1								
Melolobium cf. *canescens*		1				1						3											
Species group 21																							
Ruschia intricata			2	1		5	4	3	3	3	2	3		1		1	1						
Crassothonna protecta			1	1		4	4		1		2	1	5	1									
Plinthus karooicus	2					1	2	1	1		2					1	1						
Zaluzianskya pilosissima							1			2	1												
Tritonia karooica		1				1	1	2		1													
Species group 22																							
Lithops sp.													5										
Species group 23																							
Gisekia pharnaceoides	2													1									2
Hoodia gordonii		1	1			1							5	1									
Kedrostis capensis														1									
Aizoon canariense														1									
Species group 24																							
Hessea speciosa															1								
Dipcadi crispum														1	1			1					
Species group 25																							
Septulina glauca														1		1							
Pteronia sordida																1							
Chlorophytum cf. *undulatum*															1	1							
Species group 26																							
Augea capensis														1	1	2		1					
Mesembryanthemum vaginatum															2	2							
Ledebouria sp.		1	1												1	1							
Fockea sinuata														1	1	1							
Species group 27																							
Enneapogon scaber		5	5	5	5	3	2	1	5	4		1		2	1	1							
Oxalis sp.		1	2	2		1			1	1	1		5	2	2	1							
Lotononis leptoloba		2	2	4		5	3		2	1	2			1									
Ornithoglossum undulatum		1	2	1						1	1	1		1	1	1							
Species group 28																							

	A1	A2.1	A2.2	A3	A4	A5.1	A5.2	A6	A7.1	A7.2	A8	A9	A10	A11	A12	A13	A14	A15.1	A15.2	A16.1	A16.2	A17.1	A17.2
Mesembryanthemum nodiflorum			1	1			1							1	1		2		2				
Oxalis hirsuta										1	1			1	1	1	2		1				
Pteronia adenocarpa														1	2	2	2		2				
Pteronia leucoclada									1		1			1	1								
Species group 29																							
Ledebouria ensifolia				1					1			1	5	2	1	1	1		2				
Monsonia umbellata							1	1	3	3	1			2	2	1	1						
Tetraena microcarpa			1	1				1	2	1	1		5	1	1	1	3	1					
Moraea venenata				1				1	1	1				1	2	3	2		2				
Species group 30																							
Monsonia salmoniflora						3	2	1	1	2		1	5	2		1	1						
Mesembryanthemum cf. *geniculiflorum*						1	2		1	1				1	1	1							
Euphorbia braunsii						1					1	2		1	1	1			1				
Pteronia mucronata		1	1				2	4	3	1	2	1	5	1	1	1							
Species group 31																							
Limeum aethiopicum		4	4	4		4	3	3	5	5	2	2		3	1	1	1						2
Aptosimum spinescens		3	5	5		3	2	3	5	4	3			1	1	1	2					1	1
Pentzia incana		5	5	4		4	4	2	4	2	2	1		1	1	1	1		1				
Aristida congesta		2	3	1		5	5	2	3	2	2	2		2	1	2		1					
Kewa salsoloides		1	2	1								1		1	1	1		1				1	
Dicoma capensis				1			1	1	3	2	4	2		3	2	2	3	1					
Species group 32																							
Rhigozum trichotomum	5	3	3	5			1	1	5	4	3	1		5	5	1	2		2	2			
Stipagrostis anomala	2	3	2	1		1	3	4	5	5	2	4	5	4	3	4	4	1	2				
Eriocephalus ambiguus	2	1	1	1		1	2	2	2	2	4			4	4	4	3	1					2
Leobordea platycarpa	4		1	1						2	2	1		4	3	4	3		1				
Calobota spinescens	4									1	2			1									
Species group 33																							
Malephora crassa															1			4				1	1
Lampranthus uniflorus														1	2	1		5					
Lepidium africanum		1			5	1			1									2	1		2		
Species group 34																							
Colchicum sp.							1									1			2				
Hermannia coccocarpa			1											1	1	1			4				
Roepera incrustata													5			1			2				
Galenia cf. *secunda*																			2				
Osteospermum calendulaceum		1																	2			1	1
Species group 35																							
Cuspidea cernua														1				2	3				
Ammocharis coranica																		1	2				
Tetragonia echinata																1		1	2	2			1
Panicum coloratum																		2	2		2		
Lepidium desertorum							1				1				1	1		1	2				1
Cromidon minutum																1		2	2				
Cullen tomentosum																		1	2				
Foveolina dichotoma														1				1	1		2		1
Species group 36																							
Drosanthemum hispidum												2			1	1		3	2				
Oedera humilis															1	1	2		1	2		1	
Massonia depressa		1												1	1	1	1	1	1				
Eriocephalus spinescens							1			1					1	1		1					1
Species group 37																							
Asparagus glaucus		1		2	5	2	5			2	3			1	2	3	4	2	3				
Polygala leptophylla			1	1		1			2	1	2	1		1	1		2		2				
Talinum caffrum		2	3	1			1		1	2	1	1		1				1	1				
Species group 38																							
Medicago laciniata							1							1	1			1	2	2			
Hertia cluytifolia			1											1		1		2	2	2		1	
Species group 39																							
Pentzia pinnatisecta																					4		
Species group 40																							
Tamarix usneoides																						3	
Searsia lancea		1																			2	4	1
Afroscirpoides dioeca																						3	
Cyperus sp.																						3	
Phragmites australis																						2	
Species group 41																							
Melianthus comosus																					2	2	1
Datura ferox																					4	2	
Species group 42																							
Atriplex vestita															1	1		3	1	2	4	2	
Atriplex lindleyi																		2	2	2	4	1	
Argemone ochroleuca																1		1	2		2	2	2
Eragrostis bicolor																		1	1	2		2	
Senecio niveus																1		1	1			3	
Sporobolus ioclados		1																2		2		3	
Species group 43																							
Convolvulus sagittatus		1																			2		3

	A1	A2.1	A2.2	A3	A4	A5.1	A5.2	A6	A7.1	A7.2	A8	A9	A10	A11	A12	A13	A14	A15.1	A15.2	A16.1	A16.2	A17.1	A17.2
Eragrostis echinochloidea																							2
Species group 44																							
Setaria verticillata		1	2											1	1			1			2	3	3
Eragrostis procumbens																		1			2	3	3
Salvia disermas							1			1	1				1							1	2
Portulaca oleracea			1											1								1	2
Mesembryanthemum coriarium														1			2					2	1
Kohautia cynanchica				1																		1	1
Asparagus retrofractus			1																			1	1
Species group 45																							
Stipagrostis namaquensis																		1		3	4	5	4
Species group 46																							
Salsola aphylla/calluna complex														1	3	3	2	5	3	5	2	2	3
Salsola kali			1											1	1	1		1	2		2	1	2
Species group 47																							
Prosopis glandulosa									1					1	2	2		3	3	5	5	3	2
Osteospermum spinescens		1					2							1	1	1	1	2	4	3	2	5	2
Chloris virgata		1		1			1							1	2	1		4	5	5	5	3	1
Galenia africana														1	1			1				2	1
Bassia salsoloides				1	5						1			1	2	2		3	3	3	4	4	2
Dimorphotheca polyptera											1			1			1		1				3
Species group 48																							
Limeum argute-carinatum			1				2		1	3	2	2	5	3	2	2	4		2	2			3
Pentzia calcarea						1		3		2	3	2	5	2	2	4	3	1	4	2	4	3	3
Mesembryanthemum cf. *longistylum*								1	2		1			1	2	2	1	4	4	2			1
Aptosimum procumbens		1					2	2	1	2	3	5		1	1	2	4	1	1	2		1	3
Schmidtia kalahariensis				1				1	3	2	1			2	2	1	1	1		2			2
Tetraena simplex			1						1	1				1	1	2	4	2	1	3		1	
Arctotis leiocarpa						1				2	3			1	1		1						3
Lessertia pauciflora											2	2		1	1	2	2	1	5	2			1
Melolobium candicans							1				2	1		1	1	1	1		1			2	3
Mesembryanthemum junceum									1			3		1	1	1		2	2	3		1	1
Berkheya annectens										1	2			1	1	1	2	1	3			1	3
Radyera urens					5		1			1	1			1	1	2	1	1	2			1	1
Species group 49																							
Heliophila deserticola				1		2	3	1	2	3	3			3	2	1		1	2	2			3
Tragus racemosus		1	1			1	2	3	2	2	2	4	5	1	3	2	1	2	3	3	2	2	3
Pelargonium minimum		1	1			3	4	1	2	1	4	2		2	1	2	3	1				2	2
Lycium horridum						2	1	3	3	2				2	2	2	3	1	2	2			3
Manulea fragrans						1	2			1	3	1		1		1							2
Lasiopogon glomerulatus			1			1	2			2	1	5		1	1			2	1		2		3
Species group 50																							
Peliostomum leucorrhizum			1	4			1	2	1	2	2	3		1	2	1		1			2		3
Trianthema parvifolium				2					2		2			2	3	3		1				1	1
Cucumis myriocarpus		1	1	1	5			2			1			1	1	1		2	1	2	2	2	1
Species group 51																							
Osteospermum sinuatum			3	3		3	3	2	4		3	1		2	2	2		1	2	2			1
Tetraena chrysopteros			1	1		1		4	3	4	3	3		2	2	3	5			3			3
Gazania lichtensteinii			3	2			1	5	3	2	2	5	5	1	2	1	1	2	2				2
Geigeria ornativa			3	1		1	2	1	3	2	2	1		1	1	1		1	2			1	2
Eragrostis porosa		1	2	1			1				1			1	1	1		1	1		2	3	3
Hermannia spinosa		1	2	2		2	4	3	3	1	2	2		1		1			1			1	1
Enneapogon cenchroides		1	1	2	5	1			2	1		1		1	1	1					2	3	
Species group 52																							
Enneapogon desvauxii		5	4	2	5	5	5	5	5	5	4	5	5	5	5	5	4	3	3	3	2	1	3
Aristida adscensionis		5	5	5		5	5	2	5	4	3	4	5	4	5	4	1	2	4	2	4	1	3
Stipagrostis obtusa		3	2	3	5	5	4	4	3	4	5	4		5	3	3	5	1				1	4
Lycium cinereum		2	1	1		2	4	1	2	3	5	3		3	5	5	4	4	5	5	4	4	3
Galenia cf. *pubescens*		2	2	3				1	1	1	2	2		4	5	4	2	4	4	5	4	2	4
Mesembryanthemum noctiflorum		1	3	3		2	2	1	1	1		3		2	4	4	1	4	5	5	2		3
Stipagrostis uniplumis		2	2	5			2		3	2	2	1		3	3	2	1	1	2			2	1
Chenopodium mucronatum		4	2	3	5	2	3	3	3	3	4	1		2	1	1			2			1	3
Tragus berteronianus		2	4	3		3	4		1		3	3		2	2	3	2	3	2	2		1	
Fingerhuthia africana		5	4	2		4	1	1		1	2	3		1	2	1	2	1				3	2
Roepera lichtensteiniana		2		1		2	2	5	2	3	2	3	5	2	1	2	3			2		1	3
Amaranthus schinzianus		2	3	3			1		2	1			5	2	1	1		1	1		4	3	2
Tetragonia arbuscula		3	3	2			2	1	2	1	1			2	1	2	2		1			2	2
Cenchrus ciliaris		3	3	4	5			1	1	1				1		1	1				4	5	3
Pentzia spinescens		1	1				2	1	2		2			2	1	3	1	1	2		2	1	2
Aptosimum indivisum		1	1			1		1	1	2		2		1	2	2		1	2				1
Tribulus terrestris		1	1			1		1			1	3		2	2	1	1	1	2	2		2	2
Ursinia nana		1	2			3	2		3	2	3	3		1	1		1	1	1				4
Thesium hystrix		2	1			3	3	4	2	4	1	2		1	1	1		1				1	3
Lacomucinaea lineata	2	3	1	3		3	1	4	1			2			1							2	3
Eriocephalus decussatus		3	1	1			3	3	5	2	2			1		1							1
Searsia burchellii		5	2	1		3	1	1														1	3
Melolobium microphyllum		1	1					1		2	2			2	1							1	1
Lessertia frutescens		1	2	1		1		1		1	1			1		1						2	2

	A1	A2.1	A2.2	A3	A4	A5.1	A5.2	A6	A7.1	A7.2	A8	A9	A10	A11	A12	A13	A14	A15.1	A15.2	A16.1	A16.2	A17.1	A17.2
Gazania krebsiana		1	1	1		3	2				2				1	1		1	3			2	1
Species group 53																							
Stipagrostis ciliata	4	2	2	3		2	2	3	3	4	5	5	5	5	5	5	5	1	1	2		3	4
Lycium bosciifolium	5	2	2	5	5		2	4	5	4	3	2	5	4	1	1	1	1		4	5	5	5
Sesamum capense	5	3	2	5		1	2		5	3	4	3		4	4	2	2		1			2	4
Phaeoptilum spinosum	5	2	3	5	5	2	2	1	5	4	2			4	2	1		1	2			2	5
Tribulus cristatus	2		1	1					5	4	3			4	4	4	3	1	2	2			3
Salsola spp.	2			1		1	1	4	1	2	2	5	5	2	5	5	4	4	5	2			2
Eragrostis lehmanniana	4	2	3	1		2		2		1	5	3		2		1		1	2	2	5	3	4
Mesembryanthemum guerichianum	2	1	2	1	5		2	2		1	1	2		2	2	1	1	1	1	5	4	3	3
Euphorbia inaequilatera	2	1	2			3	1	1	1	2	2	3		1	1	2	2	1					1
Felicia clavipilosa	2	1	1	1		2		1	1	2	2			2		1			1		2	3	1
Infrequent species																							
Heliophila cf. *trifurca*		2	1								1	4	5	1									
Leysera tenella		1		1		1	1					3		1									
Tetraena cf. *tenuis*									1	2				1	1	1	1						1
Kleinia longiflora						1				2		1		1	1								
Cucumis africanus	2		1								1			1									1
Indigofera sp.									1		1			1	1								
Pentzia sphaerocephala		1				2						2										1	1
Tricholaena capensis		1		1							1				1								2
Felicia namaquana										1	1			1	1	1							1
Lasiosiphon polycephala						1		1								1							
Tribulus zeyheri	2		1												1								
Asparagus cf. *bechuanicus*							1			1					1								
Helichrysum sp.														1		1							
Cynanchum orangeanum										1				1									
Mesembryanthemum tetragonum	x															1			1				x
Albuca cf. *spiralis*									2	1	1												
Albuca sp.									1							1	1	1					
Cleretum sp.															1			1		2			
Asparagus suaveolens		1		1							1				1								
Ifloga molluginoides			1	1			1				1												1
Hypertelis cerviana				1					1			1		1									
Boophone disticha		1	1				1					2											
Mesembryanthemum articulatum				1	5														1				
Monsonia glauca			1			1		1	1														
Roepera maculata		1												1		1							
Eragrostis brizantha		1				1								1									2
Eriospermum porphyrium				1					1	1				1									
Mesembryanthemum nitidum						1									1			1					
Senecio sp.	2																					1	
Colchicum albomarginatum										1				1		1			1				
Massonia echinata		1																					
Haemanthus humilis		1																					
Pentameris sp.		1																					
Crassula muscosa		1																					
Lessertia cf. *annularis*		1									1												
Antizoma miersiana		1				1																	
Sceletium emarcidum		1		1																			
Euryops cf. *nodosus*		1																					
Crassula hemisphaerica		1																					
Oxalis pocockiae		1																					
Hermanna pulchella		1		1																			
Cotyledon orbiculata		1																					
Osteospermum armatum		1															1						
Hermannia grandiflora		1				1																	
Sporobolus nervosus		1																					
Oxalis cf. grammopetala			1																				
Jamesbrittenia fruticosa			1																				1
Larryleachia marlothii			1											1									
Cucumis sp.			1																				
Chaenostoma halimifolia			1																				
Bulbine abyssinica			1																				
Cyperus involucratus			1																				
Cynanchum viminale			1																				
Monsonia crassicaulis			1																				
Gethyllis villosa			1																				
Cucumis zeyheri			1																				
Selago divaricata			1											1									
Pteronia tricephala			1							1													
Melinis repens			1				1																
Oropetium capense			1			1																	
Eleusine coracana				1																			
Nemesia karroensis				1			1																
Felicia muricata				1																2			
Dipcadi bakerianum				1																			
Ehretia rigida				1																			
Helichrysum cf. *obtusum*										1	1			1									

	A1	A2.1	A2.2	A3	A4	A5.1	A5.2	A6	A7.1	A7.2	A8	A9	A10	A11	A12	A13	A14	A15.1	A15.2	A16.1	A16.2	A17.1	A17.2
Chrysocoma ciliata																						1	
Chrysocoma sp.						1																	
Pellaea calomelanos						1																	
Crassula corallina						1																	
Felicia cf. *hirsuta*						1								1									
Diospyros austro-africanus						1																	1
Babiana hypogaea										1	1			1	1	1							
Asteraceae sp.						1																	
Hereroa cf. *pallens*						1																	
Microloma armatum						1			1														
Isolepis sp.						1																	
Lapeirousia plicata						1						1											
Stipagrostis hirtigluma							1																
cf. *Corrigiola capensis*							1																
Colchicum volutare							1							1									
Pelargonium sp.							1																
Hibiscus trionum							1												1				
Chascanum pumilum							1																
Chasmatophyllum musculinum								1															
Melolobium calycinum								1									1						
Hermannia filifolia								1															
Hermannia sp.								1															
Jamesbrittenia sp.									1														
Dipcadi sp.									1														
Drimia intricata									1														
Moraea falcifolia										1	1												
Tetraena retrofracta											1											1	
Cyanella cf. *hyacinthoides*											1												
Gethyllis sp.											1												
Galenia crystallina											1												
Oncosiphon sp.											1												
Hermannia modesta											1												
Ruschia abbreviata												1											
Amellus tridactylus												1											
Indigastrum argyraeum														1									
Manulea cheiranthus														1									
Heliophila seselifolia														1									
Schismus inermis														1									
Opuntia ficus-indica														1									
Pteronia sp.														1									
Indigofera cf. *charleriana*														1									
Limeum viscosum														1									
Pseudognaphalium sp.															1								
Pteronia scariosa															1								
Euryops multifidus															1								
Malva aegyptia															1	1							
Eragrostis rotifer															1							1	
Duvalia sp.																1							
Pteronia membranacea																1							
Roepera flexuosa																1							
Hermannia jacobeifolia																	1						
Stomatium sp.																		1					
Pteronia acuminata																		1					
Leptochloa fusca																		1					
Eragrostis rigidior																		1			2		
Mestoklema sp. *(Delosperma?)*																		1					
Ruschia uncinata																			1				
Nerine sp.																			1				
Schoenoplectus sp.																				2			
Bromus sp.																					2		
Conyza scabrida																					2		
Trichodesma africanum																						1	
Cenchrus setaceus																						1	
Cleome gynandra																						1	
Xanthium strumarium																						1	
Deverra denudata																						1	
Cynodon incompletus																						1	
Atriplex nummularia																						1	
Tagetes minuta																						1	
Trifolium sp.																						1	
Juncus sp.																						1	
Boerhavia repens																							1
Eragrostis trichophora																							1
Cotula anthemoides																							1
Tetragonia calycina																							1
Justicia distichotricha																							1
Chenopodium carinatum																							1
Chenopodium album																							1

APPENDIX B: PLANT SPECIES LIST OF THE SKA STUDY AREA

CORE: List sourced from Milton (2021) for the degree 3021 marked as x; B refers to species added for degree square on NewPosa
CURRENT: Refers to species recorded during the current vegetation study (note names have not yet been verified by a herbarium)
Protected Northern Cape: Species listed in the Northern Cape Nature Conservation Act (NCNCA)
CITES (2021): Appendix II listed species
Declared Invasive Species: NEM:BA (2020a)
IUCN: Status of a species according to IUCN categories

Family	Species	CORE	CURRENT	PROTECTED NORTHERN CAPE	CITES	DECLARED INVASIVE SPECIES	IUCN
ACANTHACEAE	*Barleria pungens*	x	x				LC
ACANTHACEAE	*Barleria rigida*	x	x				LC
ACANTHACEAE	*Blepharis mitrata*		x				LC
ACANTHACEAE	*Justicia cuneata*	x	x				LC
ACANTHACEAE	*Justicia distichotricha*		x				LC
ACANTHACEAE	*Justicia incana*	x	x				LC
ACANTHACEAE	*Justicia spartioides*	x	x				LC
AGAVACEAE	*Chlorophytum* cf. *undulatum*		x				-
AGAVACEAE	*Agave americana*		X				NE
AIZOACEAE	*Aizoon canariense*		x	**x**			LC
AIZOACEAE	*Aizoon schellenbergii*	x		**x**			LC
AIZOACEAE	*Cephalophyllum* sp.	x		**x**			LC
AIZOACEAE	*Chasmatophyllum musculinum*		x	**x**			LC
AIZOACEAE	*Cleretum* sp.		x	**x**			-
AIZOACEAE	*Delosperma* sp.	x		**x**			LC
AIZOACEAE	*Drosanthemum floribundum*		x	**x**			LC
AIZOACEAE	*Drosanthemum hispidum*	x	x	**x**			LC
AIZOACEAE	*Drosanthemum lique*	x	x	**x**			LC
AIZOACEAE	*Galenia africana*	x	x	**x**			LC
AIZOACEAE	*Galenia collina*	x		**x**			LC
AIZOACEAE	*Galenia crystallina*		?	**x**			LC
AIZOACEAE	*Galenia fruticosa*		x	**x**			LC
AIZOACEAE	*Galenia namaensis*		x	**x**			LC
AIZOACEAE	*Galenia* cf. *pubescens*	x	cf.	**x**			LC
AIZOACEAE	*Galenia sarcophylla*	x	x	**x**			LC
AIZOACEAE	*Hereroa pallens*		x	**x**			LC
AIZOACEAE	*Lampranthus otzenianus*	x		**x**			LC
AIZOACEAE	*Lampranthus uniflorus*	x	x	**x**			LC
AIZOACEAE	*Lithops* sp.		x	**x**			-
AIZOACEAE	*Malephora crassa*	x	x	**x**			LC
AIZOACEAE	*Mesembryanthemum articulatum*		x	**x**			LC
AIZOACEAE	*Mesembryanthemum coriarium*	x	x	**x**			LC
AIZOACEAE	*Mesembryanthemum geniculiflorum*		cf.	**x**			LC
AIZOACEAE	*Mesembryanthemum guerichianum*	x	x	**x**			LC
AIZOACEAE	*Mesembryanthemum junceum*	x	x	**x**			LC
AIZOACEAE	*Mesembryanthemum longistylum*	x	cf.	**x**			LC
AIZOACEAE	*Mesembryanthemum nitidum*		x	**x**			LC
AIZOACEAE	*Mesembryanthemum noctiflorum* subsp. *noctiflorum*	x	x	**x**			LC
AIZOACEAE	*Mesembryanthemum nodiflorum*		x	**x**			LC
AIZOACEAE	*Mesembryanthemum splendens* subsp. *pentagonum*	x	x	**x**			LC
AIZOACEAE	*Mesembryanthemum tetragonum*	x	x	**x**			LC
AIZOACEAE	*Mesembryanthemum vaginatum*	x	x	**x**			LC
AIZOACEAE	*Mestoklema* sp.		x	**x**			-
AIZOACEAE	*Plinthus karooicus*	x	x	**x**			LC
AIZOACEAE	*Ruschia abbreviata*	x	x	**x**			LC
AIZOACEAE	*Ruschia cradockensis*		x	**x**			LC
AIZOACEAE	*Ruschia intricata*	x	x	**x**			LC
AIZOACEAE	*Ruschia spinosa*	x		**x**			LC

AIZOACEAE	*Ruschia uncinata*		x	**x**			LC
AIZOACEAE	*Sceletium emarcidum*		x	**x**			LC
AIZOACEAE	*Stomatium* cf. *peersii*		x	**x**			-
AIZOACEAE	*Stomatium* sp.		x	**x**			-
AIZOACEAE	*Stomatium suaveolens*		?	**x**			LC
AIZOACEAE	*Tetragonia arbuscula*	B	x	**x**			LC
AIZOACEAE	*Tetragonia calycina*		x	**x**			LC
AIZOACEAE	*Tetragonia echinata*		x	**x**			LC
AIZOACEAE	*Tetragonia fruticosa*	x		**x**			LC
AIZOACEAE	*Tetragonia spicata*	x		**x**			LC
AIZOACEAE	*Trianthema parvifolia* var. *parvifolia*	x	x	**x**			LC
AIZOACEAE	*Trichodiadema setuliferum*		x	**x**			LC
AMARANTHACEAE	*Amaranthus schinzianus*	x	x				LC
AMARANTHACEAE	*Atriplex cinerea* subsp. *bolusii* var. *adamsonii*	x					LC
AMARANTHACEAE	*Atriplex lindleyi*	B	x			**1b**	NE
AMARANTHACEAE	*Atriplex nummularia*		x			**2**	NE
AMARANTHACEAE	*Atriplex semibaccata*	B					NE
AMARANTHACEAE	*Atriplex vestita*		x				LC
AMARANTHACEAE	*Bassia salsoloides*	x	x				LC
AMARANTHACEAE	*Chenopodium album*		x				NE
AMARANTHACEAE	*Chenopodium glaucum*	x					LC
AMARANTHACEAE	*Chenopodium mucronatum*	B	x				LC
AMARANTHACEAE	*Dysphania carinata*		x				NE
AMARANTHACEAE	*Salsola aphylla*	x	x				LC
AMARANTHACEAE	*Salsola apterygea*	x					LC
AMARANTHACEAE	*Salsola calluna*	x	x				LC
AMARANTHACEAE	*Salsola dealata*	x					LC
AMARANTHACEAE	*Salsola geminiflora*	B					NE
AMARANTHACEAE	*Salsola glabrescens*	x					LC
AMARANTHACEAE	*Salsola kalaharica*	x					LC
AMARANTHACEAE	*Salsola kali*		x			**1b**	NE
AMARANTHACEAE	*Salsola smithii*	x					LC
AMARANTHACEAE	*Salsola tuberculata*	x	x				LC
AMARANTHACEAE	*Salsola zeyheri*		x				LC
AMARANTHACEAE	*Sericocoma avolans*	x	x				LC
AMARANTHACEAE	*Sericocoma pungens*	x	x				LC
AMARANTHACEAE	*Sericorema remotiflora*	x					LC
AMARYLLIDACEAE	*Ammocharis coranica*		x	**x**			LC
AMARYLLIDACEAE	*Boophone disticha*	x	x	**x**			LC
AMARYLLIDACEAE	*Gethyllis villosa*		x	**x**			LC
AMARYLLIDACEAE	*Haemanthus humilis* subsp. *hirsutus*	x	x	**x**			LC
AMARYLLIDACEAE	*Hessea speciosa*		x	**x**			LC
AMARYLLIDACEAE	*Nerine laticoma*	x	x	**x**			LC
AMARYLLIDACEAE	*Nerine* sp.			**x**			-
ANACARDIACEAE	*Schinus molle*		x				NE
ANACARDIACEAE	*Searsia burchellii*	x	x				LC
ANACARDIACEAE	*Searsia lancea*	x	x				LC
ANACARDIACEAE	*Searsia viminale*		x				LC
APIACEAE	*Deverra denudata*	x	x	**x**			LC
APOCYNACEAE	*Cynanchum orangeanum*		x	**x**			LC
APOCYNACEAE	*Duvalia* sp.		x	**x**			-
APOCYNACEAE	*Fockea sinuata*		x	**x**			LC
APOCYNACEAE	*Gomphocarpus fruticosus*	x	x	**x**			LC
APOCYNACEAE	*Hoodia gordonii*	x	x	**x**	**x**		DDD
APOCYNACEAE	*Larryleachia marlothii*		?	**x**			LC
APOCYNACEAE	*Microloma armatum*	x	x	**x**			LC
APOCYNACEAE	*Microloma incanum*	x	x	**x**			LC
APOCYNACEAE	*Microloma longitubum*	x		**x**			LC
APOCYNACEAE	*Cynanchum viminale*		x	**x**			LC
APOCYNACEAE	*Xysmalobium gomphocarpoides*	x		**x**			LC
ASPARAGACEAE	*Asparagus bechuanicus*	x	x				LC
ASPARAGACEAE	*Asparagus burchellii*	x					LC
ASPARAGACEAE	*Asparagus capensis*	x	x				LC
ASPARAGACEAE	*Asparagus glaucus*		x				LC
ASPARAGACEAE	*Asparagus mucronatus*		x				LC
ASPARAGACEAE	*Asparagus retrofractus*	x	x				LC
ASPARAGACEAE	*Asparagus* sp.	x					LC
ASPARAGACEAE	*Asparagus striatus*	x	x				LC
ASPARAGACEAE	*Asparagus suaveolens*	x	x				LC
ASPHODELACEAE	*Aloe claviflora*	x	x	**x**	**x**		LC
ASPHODELACEAE	*Aloe karasbergensis*	B					LC

ASPHODELACEAE	*Aloidendron dichotomum*	x	x	**x**	**x**	VU
ASPHODELACEAE	*Bulbine abyssinica*		x	**x**		LC
ASPHODELACEAE	*Gonialoe variegata*	x		**x**	**x**	LC
ASPLENIACEAE	*Asplenium cordatum*	B				LC
ASTERACEAE	*Amellus tridactylus*		x			LC
ASTERACEAE	*Amphiglossa triflora*		x			LC
ASTERACEAE	*Amphiglossa* sp.		x			-
ASTERACEAE	*Arctotheca calendula*	x				LC
ASTERACEAE	*Arctotis adpressa*	x				LC
ASTERACEAE	*Arctotis dimorphocarpa*	B				LC
ASTERACEAE	*Arctotis erosa*	x				LC
ASTERACEAE	*Arctotis leiocarpa*		x			LC
ASTERACEAE	*Arctotis venusta*	x				LC
ASTERACEAE	*Athanasia minuta* subsp. *minuta*	x				LC
ASTERACEAE	*Berkheya annectens*	x	x			LC
ASTERACEAE	*Berkheya heterophylla*	x				LC
ASTERACEAE	*Berkheya pinnatifida*	x				LC
ASTERACEAE	*Berkheya spinosa*	x	x			LC
ASTERACEAE	*Chrysocoma ciliata*	x	x			LC
ASTERACEAE	*Chrysocoma obtusata*	x				LC
ASTERACEAE	*Chrysocoma* sp.		x			-
ASTERACEAE	*Conyza scabrida*		x			NE
ASTERACEAE	*Cotula anthemoides*		x			LC
ASTERACEAE	*Crassothonna cylindrica*		x			LC
ASTERACEAE	*Curio radicans*		x			LC
ASTERACEAE	*Cuspidia cernua* subsp. *annua*	x	x			LC
ASTERACEAE	*Dicoma capensis*	x	x			LC
ASTERACEAE	*Dimorphotheca polyptera*		x			LC
ASTERACEAE	*Eriocephalus ambiguus*	x	x			LC
ASTERACEAE	*Eriocephalus decussatus*	x	x			LC
ASTERACEAE	*Eriocephalus ericoides*	x	x			LC
ASTERACEAE	*Eriocephalus glandulosus*		x			LC
ASTERACEAE	*Eriocephalus pauperrimus*	x				LC
ASTERACEAE	*Eriocephalus spinescens*	x	x			LC
ASTERACEAE	*Euryops lateriflorus*	x	x			LC
ASTERACEAE	*Euryops multifidus*		x			LC
ASTERACEAE	*Euryops* cf. *nodosus*		x			LC
ASTERACEAE	*Felicia clavipilosa*	x	x			LC
ASTERACEAE	*Felicia fascicularis*	x				LC
ASTERACEAE	*Felicia* cf. *filifolia*		x			-
ASTERACEAE	*Felicia hirsuta*	x	cf.			LC
ASTERACEAE	*Felicia macrorrhiza*	x				LC
ASTERACEAE	*Felicia muricata*	x	x			LC
ASTERACEAE	*Felicia namaquana*		x			LC
ASTERACEAE	*Felicia* sp.	x				-
ASTERACEAE	*Felicia* sp. (perennial)	x				-
ASTERACEAE	*Foveolina dichotoma*		x			LC
ASTERACEAE	*Gazania heterochaeta*		X			LC
ASTERACEAE	*Gazania jurineifolia*		x			LC
ASTERACEAE	*Gazania krebsiana*	x	x			LC
ASTERACEAE	*Gazania lichtensteinii*	x	x			LC
ASTERACEAE	*Geigeria filifolia*	x				LC
ASTERACEAE	*Geigeria ornativa*	x	x			LC
ASTERACEAE	*Helichrysum asperum* var. *albidulum*	x				LC
ASTERACEAE	*Helichrysum gariepinum*		x			LC
ASTERACEAE	*Helichrysum lucilioides*	x	x			LC
ASTERACEAE	*Helichrysum micropoides*	x				LC
ASTERACEAE	*cf. Helichrysum obtusum*		x			LC
ASTERACEAE	*Helichrysum pumilio*		x			LC
ASTERACEAE	*Helichrysum zeyheri*	x	x			LC
ASTERACEAE	*Helichrysum* sp.		x			-
ASTERACEAE	*Hertia cluytiifolia*		x			LC
ASTERACEAE	*Ifloga molluginoides*	x	x			LC
ASTERACEAE	*Kleinia longiflora*	x	x			LC
ASTERACEAE	*Lasiopogon glomerulatus*		X			LC
ASTERACEAE	*Leysera tenella*	x	X			LC
ASTERACEAE	*Nidorella resedifolia.* subsp. *resedifolia*	x				LC
ASTERACEAE	*Oncosiphon* sp.		x			-
ASTERACEAE	*Osteospermum calendulaceum*	x	x			LC
ASTERACEAE	*Osteospermum acanthospermum*		x			LC
ASTERACEAE	*Osteospermum armatum*		x			LC

ASTERACEAE	*Osteospermum incanum*	x				LC
ASTERACEAE	*Osteospermum leptolobum*	x	x			LC
ASTERACEAE	*Dimorphotheca pinnata*		x			LC
ASTERACEAE	*Oedera glandulosa*	x	x			LC
ASTERACEAE	*Oedera humilis*	x	x			LC
ASTERACEAE	*Oedera* cf. *oppositifolia*		x			LC
ASTERACEAE	*Osteospermum sinuatum* var. *sinuatum*	x	x			LC
ASTERACEAE	*Osteospermum spinescens*	x	x			LC
ASTERACEAE	*Crassothonna protecta*		x			LC
ASTERACEAE	*Pegolettia retrofracta*		x			LC
ASTERACEAE	*Pentzia calcarea*	x	x			LC
ASTERACEAE	*Pentzia globosa*	x				LC
ASTERACEAE	*Pentzia incana*	x	x			LC
ASTERACEAE	*Pentzia lanata*	x				LC
ASTERACEAE	*Pentzia pinnatisecta*		x			LC
ASTERACEAE	*Pentzia quinquefida*		x			LC
ASTERACEAE	*Pentzia sphaerocephala*		x			LC
ASTERACEAE	*Pentzia spinescens*	x	x			LC
ASTERACEAE	*Pseudognaphalium undulatum*		cf.			LC
ASTERACEAE	*Pteronia acuminata*	x	x			LC
ASTERACEAE	*Pteronia adenocarpa*		x			LC
ASTERACEAE	*Pteronia erythrochaeta*	x	x			LC
ASTERACEAE	*Pteronia glauca*	x	x			LC
ASTERACEAE	*Pteronia glomerata*	x	x			LC
ASTERACEAE	*Pteronia leucoclada*		x			LC
ASTERACEAE	*Pteronia membranacea*		x			LC
ASTERACEAE	*Pteronia mucronata*		x			LC
ASTERACEAE	*Pteronia scariosa*		x			LC
ASTERACEAE	*Pteronia sordida*	x	x			LC
ASTERACEAE	*Pteronia tricephala*		x			LC
ASTERACEAE	*Pteronia viscosa*	x	x			LC
ASTERACEAE	*Senecio angustifolius*	x				LC
ASTERACEAE	*Senecio cardaminifolius*	x				LC
ASTERACEAE	*Senecio consanguineus*		x			LC
ASTERACEAE	*Senecio leptophyllus*	x				LC
ASTERACEAE	*Senecio niveus*	x	x			LC
ASTERACEAE	*Senecio* sp.		x			-
ASTERACEAE	*Tagetes minuta*		x			NE
ASTERACEAE	*Troglophyton capillaceum* subsp. *capillaceum*	x				LC
ASTERACEAE	*Ursinia nana*		x			LC
ASTERACEAE	*Xanthium strumarium*		x		**1b**	NE
BIGNONIACEAE	*Rhigozum obovatum*	x	x			LC
BIGNONIACEAE	*Rhigozum trichotomum*	x	x			LC
BORAGINACEAE	*Ehretia rigida* subsp. *rigida*	x	x			LC
BORAGINACEAE	*Trichodesma africanum*		x			LC
BRASSICACEAE	*Coronopus* sp.	B				-
BRASSICACEAE	*Heliophila deserticola*		x			LC
BRASSICACEAE	*Heliophila seselifolia* var. *seselifolia*	x	x			LC
BRASSICACEAE	*Heliophila trifurca*		x			LC
BRASSICACEAE	*Lepidium africanum* subsp. *africanum*	x	x			LC
BRASSICACEAE	*Lepidium coronopus*	B				NE
BRASSICACEAE	*Lepidium desertorum*		x			LC
BRASSICACEAE	*Lepidium* sp.	x				-
CACTACEAE	*Opuntia ficus-indica*		x		**1b**	NE
CAMPANULACEAE	*Wahlenbergia nodosa*	x	x			LC
CAPPARACEAE	*Boscia albitrunca*	x	x	**x**		LC
CAPPARACEAE	*Cleome angustifolia*		x			LC
CAPPARACEAE	*Cleome gynandra*		x			LC
CARYOPHYLLACEAE	cf. *Corrigiola capensis*		x			-
CARYOPHYLLACEAE	*Dianthus micropetalus*	x	x	**x**		LC
CARYOPHYLLACEAE	*Pollichia campestris*	x				LC
COLCHICACEAE	*Colchicum albomarginatum*	x	x	**x**		LC
COLCHICACEAE	*Colchicum praeiiroratum*	B				LC
COLCHICACEAE	*Colchicum volutare*		x	**x**		LC
CONVOLVULACEAE	*Convolvulus sagittatus*	x	x			LC
CRASSULACEAE	*Cotyledon orbiculata*		x	**x**		LC
CRASSULACEAE	*Crassula capitella* subsp. *thyrsiflora*	x		**x**		LC
CRASSULACEAE	*Crassula corallina*		x	**x**		LC
CRASSULACEAE	*Crassula deltoidea*		x	**x**		LC
CRASSULACEAE	*Crassula hemisphaerica*		x	**x**		LC
CRASSULACEAE	*Crassula muscosa* var. *muscosa*	x	x	**x**		LC

CRASSULACEAE	*Tylecodon wallichii*	x		**x**			LC
CUCURBITACEAE	*Citrullus lanatus*	x	x				LC
CUCURBITACEAE	*Cucumis africanus*	x	x				LC
CUCURBITACEAE	*Cucumis myriocarpus* subsp. *leptodermis*	x	x				LC
CUCURBITACEAE	*Cucumis zeyheri*	x	x				LC
CUCURBITACEAE	*Kedrostis africana*	x	x				LC
CYPERACEAE	*Afroscirpoides dioeca*		x				LC
CYPERACEAE	*Cyperus indecorus* var. *namaquensis*	x	x				LC
CYPERACEAE	*Cyperus involucratus*		x				LC
CYPERACEAE	*Cyperus* cf. *rubicundus*		x				-
CYPERACEAE	*Isolepis* sp.		x				-
CYPERACEAE	*Schoenoplectus leucanthus*	B					
CYPERACEAE	*Schoenoplectus muricinux*	x					LC
CYPERACEAE	*Schoenoplectus* sp.		x				-
EBENACEAE	*Diospyros austro-africana* var. *microphylla*	x	x				LC
ERIOSPERMACEAE	*Eriospermum porphyrium*		x				LC
EUPHORBIACEAE	*Euphorbia braunsii*		x	**x**	**x**		LC
EUPHORBIACEAE	*Euphorbia inaequilatera* var. *inaequilatera*	x	x	**x**			LC
EUPHORBIACEAE	*Euphorbia* cf. *spartaria*		x		**x**		-
EUPHORBIACEAE	*Euphorbia stellispina* var. *stellispina*	x		**x**	**x**		LC
FABACEAE	*Argyrolobium argenteum*	x					LC
FABACEAE	*Argyrolobium pauciflorum*	x					LC
FABACEAE	*Calobota linearifolia*	x					LC
FABACEAE	*Calobota spinescens*	x	x				LC
FABACEAE	*Cullen tomentosum*	x	x				LC
FABACEAE	*Indigastrum argyraeum*	x	x				LC
FABACEAE	*Indigastrum niveum*	B					-
FABACEAE	*Indigofera alternans* var. *alternans*	x					LC
FABACEAE	*Indigofera charleriana*		x				LC
FABACEAE	*Indigofera meyeriana*		x				LC
FABACEAE	*Lessertia annularis*	x	x	**x**			LC
FABACEAE	*Lessertia frutescens*	x	x	**x**			LC
FABACEAE	*Lessertia inflata*		x	**x**			LC
FABACEAE	*Lessertia pauciflora* var. *pauciflora*	x	x	**x**			LC
FABACEAE	*Lotononis falcata*	B					LC
FABACEAE	*Lotononis laxa*	x	x				LC
FABACEAE	*Lotononis leptoloba*		x				LC
FABACEAE	*Lotononis rabenaviana*		x				LC
FABACEAE	*Leobordea platycarpa*	B	cf.				LC
FABACEAE	*Lotononis* sp.	x					-
FABACEAE	*Medicago laciniata*	B	x				NE
FABACEAE	*Melolobium calycinum*		x				LC
FABACEAE	*Melolobium candicans*	x	x				LC
FABACEAE	*Melolobium canescens*	x	cf.				LC
FABACEAE	*Melolobium microphyllum*	x	x				LC
FABACEAE	*Pomaria lactea*		x				LC
FABACEAE	*Prosopis glandulosa*		x			**3**	NE
FABACEAE	*Prosopis pubescens*	B					NE
FABACEAE	*Prosopis velutina*	B				**3**	NE
FABACEAE	*Rhynchosia totta*	x					LC
FABACEAE	*Senegalia mellifera* subsp. *detinens*	x					LC
FABACEAE	*Trifolium* sp.		x				-
FABACEAE	*Trigonella anguina*	x					LC
FABACEAE	*Vachellia erioloba*	x		**x**			LC
FABACEAE	*Vachellia karroo*		x				LC
FABACEAE	*Xerocladia viridiramis*	x					LC
GERANIACEAE	*Erodium cicutarium*	B					NE
GERANIACEAE	*Monsonia crassicaulis*		x				LC
GERANIACEAE	*Monsonia glauca*		x				LC
GERANIACEAE	*Monsonia luederitziana*	B					LC
GERANIACEAE	*Monsonia salmoniflora*	x	x				LC
GERANIACEAE	*Monsonia umbellata*		x				LC
GERANIACEAE	*Pelargonium minimum*		x	**x**			LC
GERANIACEAE	*Pelargonium* cf. *ramosissimum*		x	**x**			-
GERANIACEAE	*Pelargonium* sp.		x	**x**			-
GISEKIACEAE	*Gisekia pharnaceoides* var. *pharnaceoides*	x	x				LC
HYACINTHACEAE	*Albuca cooperi*	x					LC
HYACINTHACEAE	*Albuca spiralis*	x	x				LC
HYACINTHACEAE	*Albuca virens*	x					LC
HYACINTHACEAE	*Albuca* sp.		x				-
HYACINTHACEAE	*Daubenya marginata*		x				LC

HYACINTHACEAE	*Dipcadi bakerianum*		x		LC
HYACINTHACEAE	*Dipcadi crispum*		x		LC
HYACINTHACEAE	*Dipcadi gracillimum*	x	x		LC
HYACINTHACEAE	*Dipcadi viride*		?		LC
HYACINTHACEAE	*Drimia intricata*		x		LC
HYACINTHACEAE	*Lachenalia maughanii*	x		**x**	LC
HYACINTHACEAE	*Ledebouria* sp.		x		-
HYACINTHACEAE	*Ledebouria ensifolia*		cf.		LC
HYACINTHACEAE	*Massonia depressa*	x	x		LC
HYACINTHACEAE	*Massonia echinata*		x		LC
HYACINTHACEAE	*Ornithogalum* sp.	x			-
HYACINTHACEAE	*Ornithoglossum undulatum*	x	x		LC
IRIDACEAE	*Babiana bainesii*	x		**x**	LC
IRIDACEAE	*Babiana hypogaea*		x	**x**	LC
IRIDACEAE	*Freesia andersoniae*	x		**x**	LC
IRIDACEAE	*Lapeirousia plicata* subsp. *plicata*	B	x	**x**	LC
IRIDACEAE	*Moraea cookii*	x		**x**	LC
IRIDACEAE	*Moraea falcifolia*		x	**x**	LC
IRIDACEAE	*Moraea venenata*		x	**x**	LC
IRIDACEAE	*Syringodea concolor*		x	**x**	LC
IRIDACEAE	*Tritonia karooica*	x	x	**x**	LC
JUNCACEAE	*Juncus dregeanus*	x			LC
JUNCACEAE	*Juncus exsertus*	x			LC
JUNCACEAE	*Juncus* sp.		x		-
KEWACEAE	*Kewa salsoloides*	x	x		LC
LIMIACEAE	*Limeum aethiopicum*	x	x		LC
LIMIACEAE	*Limeum arenicolum*	x			LC
LIMIACEAE	*Limeum argute-carinatum* var. *argute-carinatum*	x	x		LC
LIMIACEAE	*Limeum fenestratum*		x		LC
LIMIACEAE	*Limeum viscosum*		x		LC
LAMIACEAE	*Salvia disermas*	x	x		LC
LAMIACEAE	*Salvia verbenaca*	x	x		LC
LAMIACEAE	*Stachys cuneata*	x	x		LC
LORANTHACEAE	*Helixanthera garciana*	B			LC
LORANTHACEAE	*Septulina glauca*	x	x		LC
MALVACEAE	*Hermannia cernua*		x		LC
MALVACEAE	*Hermannia coccocarpa*	x	x		LC
MALVACEAE	*Hermannia desertorum*	x	x		LC
MALVACEAE	*Hermannia erodioides*	B	x		LC
MALVACEAE	*Hermannia filifolia*		x		LC
MALVACEAE	*Hermannia gariepina*	B	x		LC
MALVACEAE	*Hermannia grandiflora*	x	x		LC
MALVACEAE	*Hermannia jacobeifolia*		x		LC
MALVACEAE	*Hermannia linearifolia*		x		LC
MALVACEAE	*Hermannia marginata*	x			LC
MALVACEAE	*Hermannia minutiflora*	x			LC
MALVACEAE	*Hermannia pulchella*	x	x		LC
MALVACEAE	*Hermannia spinosa*	x	x		LC
MALVACEAE	*Hermannia* cf. *vestita*		x		-
MALVACEAE	*Hibiscus trionum*		x		NE
MALVACEAE	*Malva aegyptia*	B	x		NE
MALVACEAE	*Malva parviflora*		x		NE
MALVACEAE	*Radyera urens*	x	x		LC
MARSILEACEAE	*Marsilea capensis*	B			LC
MELIANTHACEAE	*Melianthus comosus*	x	x		LC
MENISPERMACEAE	*Antizoma miersiana*		x		LC
MENISPERMACEAE	*Cissampelos capensis*	x			LC
MOLLUGINACEAE	*Hypertelis cerviana*	x	x		LC
MOLLUGINACEAE	*Pharnaceum subtile*	B			LC
NEURADACEAE	*Grielum humifusum* var. *humifusum*	x	x		LC
NEURADACEAE	*Grielum humifusum* var. *parviflorum*	x			LC
NYCTAGINACEAE	*Boerhavia repens* subsp. *repens*		x		LC
NYCTAGINACEAE	*Phaeoptilum spinosum*	x	x		LC
OPHIOGLOSSACEAE	*Ophioglossum polyphyllum*		x		LC
OXALIDACEAE	*Oxalis annae*	x		**x**	LC
OXALIDACEAE	*Oxalis depressa*	x		**x**	LC
OXALIDACEAE	*Oxalis grammopetala*	x	cf.	**x**	LC
OXALIDACEAE	*Oxalis haedulipes*		x	**x**	LC
OXALIDACEAE	*Oxalis hirsuta*	x	x	**x**	LC
OXALIDACEAE	*Oxalis pocockiae*		x	**x**	LC
OXALIDACEAE	*Oxalis primuloides*	x	x	**x**	LC

OXALIDACEAE	*Oxalis* sp.	x		**x**		-
PEDALIACEAE	*Argemone ochroleuca*	B	x		**1b**	NE
PEDALIACEAE	*Sesamum capense*	x	x			LC
PHYLLANTHACEAE	*Phyllanthus maderaspatensis*		x			LC
PLUMBAGINACEAE	*Dyerophytum africanum*	x	x			LC
PLUMBAGINACEAE	*Plumbago auriculata*		x			LC
POACEAE	*Agrostis lachnantha* var. *lachnantha*	x				LC
POACEAE	*Aristida adscensionis*	x	x			LC
POACEAE	*Aristida congesta* subsp. *barbicollis*	1	x			LC
POACEAE	*Aristida congesta* subsp. *congesta*	x	x			LC
POACEAE	*Aristida diffusa* subsp. *burkei*	x				LC
POACEAE	*Aristida diffusa*		x			LC
POACEAE	*Bromus pectinatus*	x				LC
POACEAE	*Bromus* sp.		x			-
POACEAE	*Cenchrus ciliaris*	x	x			LC
POACEAE	*Cenchrus geniculatus*	B				NE
POACEAE	*Cenchrus setaceus*		x		**1b**	NE
POACEAE	*Chloris virgata*	x	x			LC
POACEAE	*Cladoraphis spinosa*	x				LC
POACEAE	*Cynodon dactylon*	x				LC
POACEAE	*Cynodon incompletus*	x	x			LC
POACEAE	*Ehrharta calycina*	x				LC
POACEAE	*Eleusine coracana*		x			LC
POACEAE	*Enneapogon cenchroides*		x			LC
POACEAE	*Enneapogon desvauxii*	x	x			LC
POACEAE	*Enneapogon scaber*	x	x			LC
POACEAE	*Enneapogon scoparius*	x				LC
POACEAE	*Eragrostis bergiana*	x				LC
POACEAE	*Eragrostis bicolor*	B	x			LC
POACEAE	*Eragrostis brizantha*	x	x			LC
POACEAE	*Eragrostis chloromelas*	x				LC
POACEAE	*Eragrostis curvula*	x	x			LC
POACEAE	*Eragrostis echinochloidea*	x	x			LC
POACEAE	*Eragrostis homomalla*	x				LC
POACEAE	*Eragrostis lehmanniana*	x	x			LC
POACEAE	*Eragrostis nindensis*	x	x			LC
POACEAE	*Eragrostis obtusa*	x	x			LC
POACEAE	*Eragrostis porosa*	x	x			LC
POACEAE	*Eragrostis procumbens*	x	?			LC
POACEAE	*Eragrostis rigidior*		x			LC
POACEAE	*Eragrostis rotifer*		x			LC
POACEAE	*Eragrostis trichophora*		x			LC
POACEAE	*Fingerhuthia africana*	x	x			LC
POACEAE	*Heteropogon contortus*	x	x			LC
POACEAE	*Leptochloa fusca*	x	x			LC
POACEAE	*Melinis repens* subsp. *repens*	x	x			LC
POACEAE	*Oropetium capense*	x	x			LC
POACEAE	*Panicum coloratum* var. *coloratum*	x	x			LC
POACEAE	*Panicum impeditum*	x				LC
POACEAE	*Panicum lanipes*	x	x			LC
POACEAE	*Panicum maximum*	x				LC
POACEAE	*Paspalum distichum*	x				LC
POACEAE	*Pennisetum thunbergii*	x				LC
POACEAE	*Pentameris airoides* subsp. *airoides*	x	x			LC
POACEAE	*Phragmites australis*	x	x			LC
POACEAE	*Schismus barbatus*	B				LC
POACEAE	*Schismus inermis*		x			LC
POACEAE	*Schmidtia kalahariensis*	x	x			LC
POACEAE	*Schmidtia pappophoroides*	x				LC
POACEAE	*Setaria verticillata*	x	x			LC
POACEAE	*Sporobolus coromandelianus*	x				LC
POACEAE	*Sporobolus fimbriatus*	x	x			LC
POACEAE	*Sporobolus ioclados*	x	x			LC
POACEAE	*Sporobolus nervosus*		x			LC
POACEAE	*Stipagrostis amabilis*	x	x			LC
POACEAE	*Stipagrostis anomala*	x	x			LC
POACEAE	*Stipagrostis brevifolia*	x				LC
POACEAE	*Stipagrostis ciliata*	x	x			LC
POACEAE	*Stipagrostis hirtigluma*		x			LC
POACEAE	*Stipagrostis namaquensis*	x	x			LC
POACEAE	*Stipagrostis obtusa*	x	x			LC

POACEAE	*Stipagrostis uniplumis*	x	x				LC
POACEAE	*Themeda triandra*	x					LC
POACEAE	*Tragus berteronianus*	x	x				LC
POACEAE	*Tragus koelerioides*	x					LC
POACEAE	*Tragus racemosus*	x	x				LC
POACEAE	*Tricholaena capensis*	x	x				LC
POLYGALACEAE	*Polygala leptophylla*	x	x				LC
POLYGALACEAE	*Polygala pungens*	x					LC
POLYGALACEAE	*Polygala seminuda*	x					LC
POLYGALACEAE	*Polygala* sp.	x					-
POLYGONACEAE	*Polygonum bellardii*	B					NE
ANACAMPSEROTACEAE	*Anacampseros albidiflora*		x		**x**		LC
PORTULACACEAE	*Portulaca oleracea*		x				NE
PORTULACACEAE	*Talinum arnotii*		x				LC
PORTULACACEAE	*Talinum caffrum*	x	x				LC
PTERIDACEAE	*Cheilanthes eckloniana*	B					LC
PTERIDACEAE	*Pellaea calomelanos*		x				LC
RHAMNACEAE	*Ziziphus mucronata* subsp. *mucronata*	x					LC
RUBIACEAE	*Anthospermum rigidum* subsp. *rigidum*	x					LC
RUBIACEAE	*Kohautia cynanchica*	x	x				LC
RUBIACEAE	*Nenax cinerea*	x					LC
RUBIACEAE	*Nenax microphylla*		x				LC
SANTALACEAE	*Lacomucinaea lineata*	x	x				LC
SANTALACEAE	*Thesium hystrix*	x	x				LC
SANTALACEAE	*Thesium scandens*	B					LC
SANTALACEAE	*Thesium* sp.	x					-
SANTALACEAE	*Viscum capense*	x					LC
SCROPHULARIACEAE	*Aptosimum albomarginatum*	x					LC
SCROPHULARIACEAE	*Aptosimum indivisum*	x	x				LC
SCROPHULARIACEAE	*Aptosimum marlothii*	x					LC
SCROPHULARIACEAE	*Aptosimum procumbens*		x				LC
SCROPHULARIACEAE	*Aptosimum spinescens*	x	x				LC
SCROPHULARIACEAE	*Chaenostoma halimifolium*		x				LC
SCROPHULARIACEAE	*Cromidon minutum*		x				LC
SCROPHULARIACEAE	*Diascia engleri*		x	**x**			LC
SCROPHULARIACEAE	*Diascia integerrima*	B					LC
SCROPHULARIACEAE	*Jamesbrittenia atropurpurea* subsp. *atropurpurea*	x	x	**x**			LC
SCROPHULARIACEAE	*Jamesbrittenia filicaulis*	x		**x**			LC
SCROPHULARIACEAE	*Jamesbrittenia fruticosa*		x	**x**			LC
SCROPHULARIACEAE	*Jamesbrittenia tysonii*	x	x	**x**			LC
SCROPHULARIACEAE	*Limosella grandiflora*	x		**x**			LC
SCROPHULARIACEAE	*Lyperia tristis*		x				LC
SCROPHULARIACEAE	*Manulea cheiranthus*	x	x	**x**			LC
SCROPHULARIACEAE	*Manulea fragrans*		x	**x**			LC
SCROPHULARIACEAE	*Manulea gariepina*	B					LC
SCROPHULARIACEAE	*Nemesia fruticans*	x		**x**			LC
SCROPHULARIACEAE	*Nemesia karroensis*		x	**x**			LC
SCROPHULARIACEAE	*Peliostomum leucorrhizum*	x	x				LC
SCROPHULARIACEAE	*Selago albida*		x				LC
SCROPHULARIACEAE	*Selago centralis*	B					LC
SCROPHULARIACEAE	*Selago divaricata*		x				LC
SCROPHULARIACEAE	*Selago paniculata*	x					LC
SCROPHULARIACEAE	*Selago* sp.	x					-
SCROPHULARIACEAE	*Zaluzianskya benthamiana*	B					LC
SCROPHULARIACEAE	*Zaluzianskya peduncularis*		x				LC
SCROPHULARIACEAE	*Zaluzianskya pilosissima*		x				LC
SOLANACEAE	*Datura ferox*		x			**1b**	NE
SOLANACEAE	*Lycium bosciifolium*	x	x				LC
SOLANACEAE	*Lycium cinereum*	x	x				LC
SOLANACEAE	*Lycium horridum*	x	x				LC
SOLANACEAE	*Lycium oxycarpum*	x					LC
SOLANACEAE	*Lycium pilifolium*		x				LC
SOLANACEAE	*Lycium pumilum*	x	x				LC
SOLANACEAE	*Solanum burchellii*		x				LC
SOLANACEAE	*Solanum capense*	x	x				LC
SOLANACEAE	*Solanum* sp.	x					-
SOLANACEAE	*Solanum tomentosum*	x	x				LC
TAMARICACEAE	*Tamarix usneoides*	x	x				LC
TECOPHILAEACEAE	*Cyanella hyacinthoides*		cf.				LC
THYMELAEACEAE	*Lasiosiphon polycephalus*	x	x				LC
URTICACEAE	*Forsskaolea candida*		x				LC

VAHLIACEAE	*Vahlia capensis* subsp. *vulgaris* var. *vulgaris*		x					LC
VERBENACEAE	*Chascanum pinnatifidum*		x	x				LC
VERBENACEAE	*Chascanum pumilum*			x				LC
ZYGOPHYLLACEAE	*Augea capensis*		x	x				LC
ZYGOPHYLLACEAE	*Roepera divaricata*		B					EN
ZYGOPHYLLACEAE	*Roepera flexuosa*		x	x				LC
ZYGOPHYLLACEAE	*Roepera incrustata*			x				LC
ZYGOPHYLLACEAE	*Roepera lichtensteiniana*		x	x				LC
ZYGOPHYLLACEAE	*Roepera maculata*		x	x				LC
ZYGOPHYLLACEAE	*Roepera microphyllum*		B					LC
ZYGOPHYLLACEAE	*Tetraena chrysopteron*		x	x				LC
ZYGOPHYLLACEAE	*Tetraena microcarpa*		x	x				LC
ZYGOPHYLLACEAE	*Tetraena tenuis*			cf.				LC
ZYGOPHYLLACEAE	*Tetraena retrofracta*		x	x				LC
ZYGOPHYLLACEAE	*Tetraena simplex*		x	x				LC
ZYGOPHYLLACEAE	*Tribulus cristatus*		x	x				LC
ZYGOPHYLLACEAE	*Tribulus terrestris*		x	x				LC
ZYGOPHYLLACEAE	*Tribulus zeyheri* subsp. *zeyheri*		x	x				LC
TOTAL		**563**	**367**	**416**	**124**	**8**	**10**	

APPENDIX C: COORDINATES OF SURVEY SITES

Number	Latitude	Longitude
MK1	-30.69052798	21.56062704
MK2	-30.70761097	21.56202799
MK3	-30.71583303	21.56022202
MK4	-30.72000001	21.55941702
MK5	-30.72303426	21.56294555
MK6	-30.71436108	21.61683331
MK7	-30.70272222	21.59769441
MK8	-30.69569441	21.58455553
MK9	-30.67707997	21.54398703
MK10	-30.67591664	21.54441669
MK11	-30.66141671	21.51691667
MK12	-30.66083333	21.51663889
MK13	-30.65448973	21.49527728
MK14	-30.64725003	21.47816663
MK15	-30.64636113	21.47402781
MK16	-30.63858331	21.45622222
MK17	-30.62811096	21.42805601
MK18	-30.62761098	21.42852799
MK19	-30.61949998	21.41544401
MK20	-30.61527802	21.40927803
MK21	-30.58969402	21.37299998
MK22	-30.57477800	21.35263899
MK23	-30.56302490	21.34638970
MK24	-30.55672204	21.34302797
MK25	-30.54091704	21.34136098
MK26	-30.53077804	21.33119398
MK27	-30.51463902	21.32424999
MK28	-30.50733302	21.32194396
MK29	-30.49988897	21.31769400
MK30	-30.54569397	21.25686100
MK31	-30.53580601	21.30019401
MK32	-30.59307746	21.36752056
MK33	-30.59393384	21.36646771
MK34	-30.61108304	21.35450003
MK35	-30.62872351	21.36058353
MK36	-30.63100004	21.37413899
MK37	-30.65302801	21.33191700
MK38	-30.67361103	21.32186098
MK39	-30.67775002	21.31699998
MK40	-30.69050878	21.31313651
MK41	-30.70411756	21.30828255
MK42	-30.72249999	21.29805604
MK43	-30.74294404	21.29505498
MK44	-30.74838901	21.29566703
MK45	-30.75536099	21.30447197
MK46	-30.77538896	21.29919397
MK47	-30.63228800	21.43746796
MK48	-30.63394401	21.44191699
MK49	-30.61572201	21.31502797
MK50	-30.62338902	21.30611097
MK51	-30.62588900	21.29874998
MK52	-30.63336097	21.28758302
MK53	-30.64363902	21.27738903
MK54	-30.64349997	21.27477799
MK55	-30.66931129	21.29818286
MK56	-30.66391703	21.28697198
MK57	-30.65789279	21.27624180
MK58	-30.65128810	21.26636197
MK59	-30.62861103	21.26325002
MK60	-30.65221162	21.25042554
MK61	-30.65019401	21.23136098

MK62	-30.64769419	21.22267155
MK63	-30.63864056	21.20530726
MK64	-30.62524267	21.18761323
MK65	-30.62053657	21.17742931
MK66	-30.59055601	21.20377799
MK67	-30.57781158	21.20775118
MK68	-30.76665988	21.25744890
MK69	-30.76906624	21.24997283
MK70	-30.77561100	21.23999996
MK71	-30.77634601	21.24140301
MK72	-30.77833302	21.24375002
MK73	-30.77563900	21.23886103
MK74	-30.75605602	21.23019397
MK75	-30.74786103	21.21433298
MK76	-30.74661104	21.21758298
MK77	-30.72799207	21.20416934
MK78	-30.71177803	21.20316703
MK79	-30.69270828	21.19443459
MK80	-30.69803783	21.15848805
MK81	-30.69699998	21.16844399
MK82	-30.69299997	21.20086100
MK83	-30.59072197	21.36808299
MK84	-30.68536104	21.11358301
MK85	-30.71908303	21.11536098
MK86	-30.72038901	21.11547204
MK87	-30.71422203	21.11313902
MK88	-30.72361889	21.10712509
MK89	-30.73936421	21.11154805
MK90	-30.73890774	21.11298965
MK91	-30.74791702	21.11338897
MK92	-30.76013901	21.11374998
MK93	-30.77047197	21.11544404
MK94	-30.78434989	21.11680132
MK95	-30.79651463	21.12062666
MK96	-30.81378764	21.12471828
MK97	-30.82188900	21.12605603
MK98	-30.82188900	21.12605603
MK98	-30.84433330	21.27383335
MK99	-30.76500001	21.28558301
MK100	-30.66447199	21.53105602
MK101	-30.65444397	21.72502801
MK102	-30.64584975	21.72181187
MK103	-30.61472037	21.72314426
MK104	-30.55918900	21.73407116
MK105	-30.55216698	21.71172199
MK106	-30.54419403	21.69472198
MK107	-30.55358302	21.72763897
MK108	-30.57694397	21.70655496
MK109	-30.57186102	21.69236097
MK110	-30.56972204	21.68327800
MK111	-30.66285378	21.59112107
MK112	-30.64799996	21.57591697
MK113	-30.64441703	21.56761101
MK114	-30.64097199	21.56244398
MK115	-30.63855498	21.55999999
MK116	-30.62602798	21.55775003
MK117	-30.62463901	21.55633299
MK118	-30.62413903	21.55358297
MK119	-30.62272198	21.55266699
MK120	-30.60824996	21.56044398
MK121	-30.59988272	21.56299719
MK122	-30.57638062	21.57100894
MK123	-30.56972204	21.55358297
MK124	-30.53787173	21.52317929
MK125	-30.52510533	21.52466884
MK126	-30.51165959	21.52697713
MK127	-30.56944401	21.50774997
MK128	-30.56919398	21.50827803
MK129	-30.56969396	21.50952802
MK130	-30.57105602	21.51213898
MK131	-30.57197199	21.51380497

MK132	-30.57063902	21.51216698
MK133	-30.55127800	21.49747199
MK134	-30.55077801	21.49611102
MK135	-30.60597201	21.75394398
MK136	-30.60774998	21.76166698
MK137	-30.60833302	21.76222203
MK138	-30.60991704	21.76258304
MK139	-30.60550002	21.76647199
MK140	-30.60402799	21.74580499
MK141	-30.56917948	21.66758867
MK142	-30.56733303	21.66802797
MK143	-30.55076703	21.64210081
MK144	-30.54014641	21.65028892
MK145	-30.52441768	21.64679593
MK146	-30.52474977	21.63354498
MK147	-30.52379969	21.63364959
MK148	-30.52247199	21.63274996
MK149	-30.50855602	21.62663897
MK150	-30.48234832	21.62054943
MK151	-30.47881954	21.61939147
MK152	-30.54891698	21.64375003
MK153	-30.56874999	21.63472197
MK154	-30.57846939	21.58632293
MK155	-30.67680596	21.49702800
MK156	-30.70652802	21.47408296
MK157	-30.70705500	21.47311100
MK158	-30.74772198	21.42483300
MK159	-30.74458304	21.42352802
MK160	-30.74042302	21.42056803
MK161	-30.73997383	21.42105343
MK162	-30.75002801	21.42552802
MK163	-30.75174998	21.42705596
MK164	-30.67844404	21.46116704
MK165	-30.65789279	21.27624180
MK166	-30.76588900	21.41930496
MK167	-30.78324356	21.36514110
MK168	-30.76066104	21.35849635
MK169	-30.76086103	21.35650003
MK170	-30.74488571	21.35880849
MK171	-30.73999998	21.36105602
MK172	-30.74241699	21.36280498
MK173	-30.75766702	21.35936103
MK174	-30.77537019	21.34186674
MK175	-30.77691698	21.34075002
MK176	-30.84624999	21.62663897
MK177	-30.84480504	21.61347200
MK178	-30.84300058	21.59944975
MK179	-30.84341699	21.59130497
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MK181	-30.82551509	21.58585489
MK182	-30.81708298	21.58366696
MK183	-30.80481187	21.58274001
MK184	-30.84633582	21.56709284
MK185	-30.85898671	21.52845562
MK186	-30.87236096	21.50341703
MK187	-30.87830499	21.49691703
MK188	-30.88122415	21.48771160
MK189	-30.89675381	21.47217985
MK190	-30.91188901	21.44744402
MK191	-30.90846836	21.41865604
MK192	-30.90741701	21.39036099
MK193	-30.90499448	21.38123981
MK194	-30.87359092	21.34845701
MK195	-30.76408882	21.46558665
MK196	-30.76811104	21.46683304
MK197	-30.89675381	21.47217985
MK198	-30.77947204	21.48811100
MK199	-30.76676130	21.49479381
MK200	-30.76836568	21.48905698
MK201	-30.81219398	21.50255604
MK202	-30.81624253	21.50414122

MK203	-30.81824999	21.50833301
MK204	-30.82474999	21.52869400
MK205	-30.86680602	21.52141700
MK206	-30.84158303	21.35436097
MK207	-30.83691834	21.36354905
MK208	-30.84629333	21.37196682
MK209	-30.82205596	21.37800003
MK210	-30.82172354	21.37914333
MK211	-30.80452798	21.38308299
MK212	-30.79642352	21.38821070
MK213	-30.58211099	21.42627804
MK214	-30.56830340	21.42706409
MK215	-30.55391704	21.42711103
MK216	-30.56144449	21.42362282
MK217	-30.57769398	21.43099998
MK218	-30.57750002	21.43311096
MK219	-30.56069397	21.45377797
MK220	-30.56094401	21.45291698
MK221	-30.55019254	21.37221526
MK222	-30.54847190	21.38513136
MK223	-30.53177800	21.40158302
MK224	-30.53311097	21.40325001
MK225	-30.53938902	21.39211097
MK226	-30.78218635	21.29993794
MK227	-30.77897198	21.29349997
MK228	-30.77925000	21.29213297
MK229	-30.78641569	21.31988654
MK230	-30.78074542	21.32046171
MK231	-30.80791703	21.29222198
MK232	-30.70386099	21.33825003

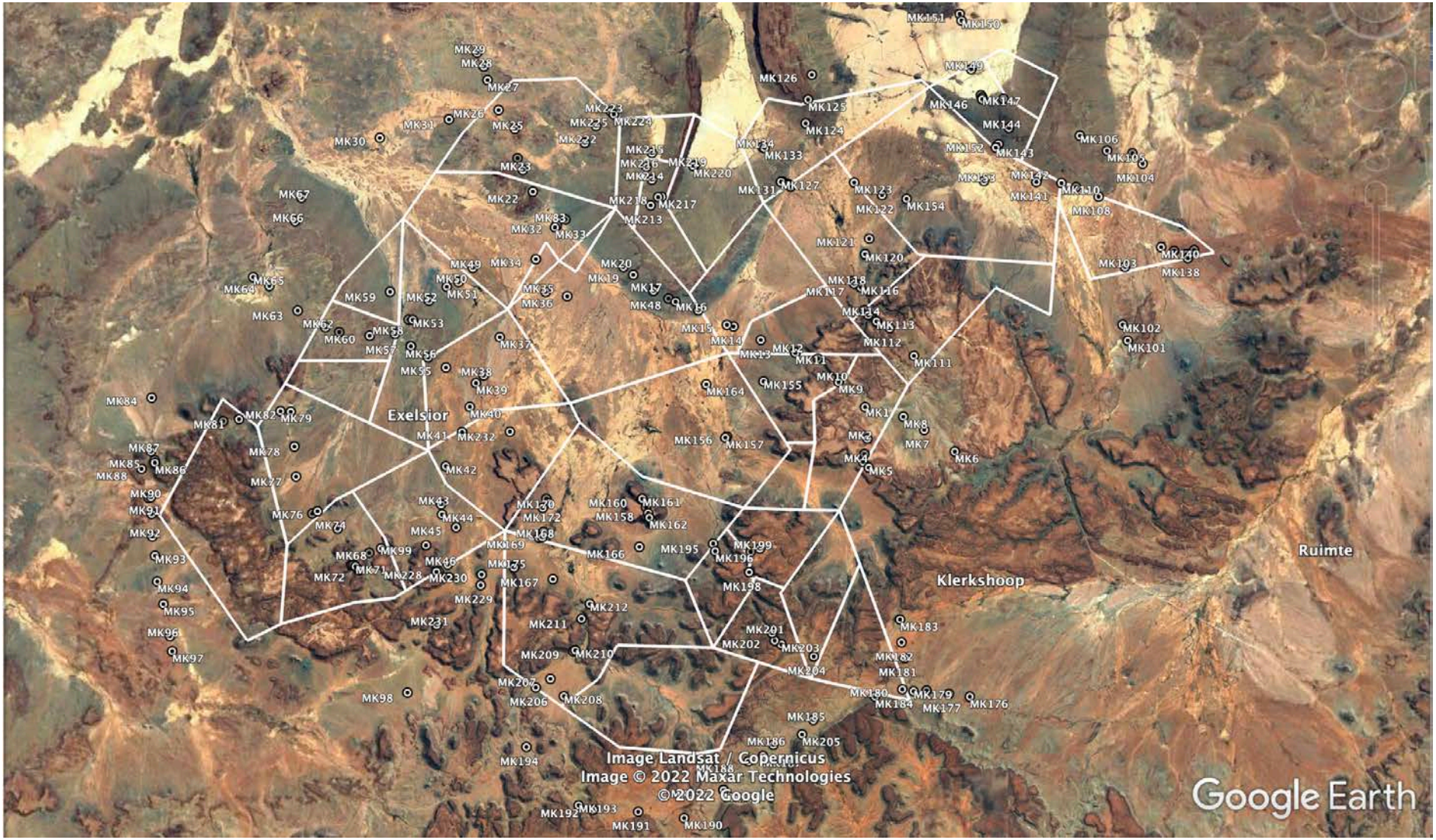

Figure C1: Locations of Braun-Blanquet survey sites. Note roads have been indicated on the vegetation map.

APPENDIX D: TERMS OF REFERENCE

The work should include the following:

1. The necessary preparation, namely GIS work and stratification of potential vegetation units, detailed plan for fieldwork and reporting, presented and agreed in an inception report, by 30 September 2020.
2. Extensive field work using Braun Blanquet survey methodology in order to gather floristic data across the entire study area.
3. Species that cannot be identified in the field are to be collected as voucher specimens for identification by experts at herbaria. An additional specimen is to be collected for lodging at the SANParks herbarium in Kimberley.
4. Initial classification of the collected floristic data using modified TWINSPAN with subsequent refinement using accepted classification techniques.
5. Compilation of a vegetation map of the study area.
6. IUCN, TOPS, NCNCA, CITES, Alien classification of floral species.
7. Report including description of vegetation units using both the refined phytosociological table and vegetation map.
8. A categorised species list of the flora.
9. Diversity analysis per association.
10. Recommendations for long-term observations.
11. The floristic data, herbarium specimens and accompanying data must be supplied to SAEON for archiving.
12. The map should be presented visually as map (overview), including maps with finer resolution of various parts of the study area. A separate map should show the location of each sample site, and roads/routes how to get there, as well as property boundaries.
13. The report should also be of use to the wider researcher community wanting to conduct studies in the SKA area.