

ECOLOGY AND BIODIVERSITY ASSESSMENT OF THE SKA PHASE 1 IN SOUTH AFRICA

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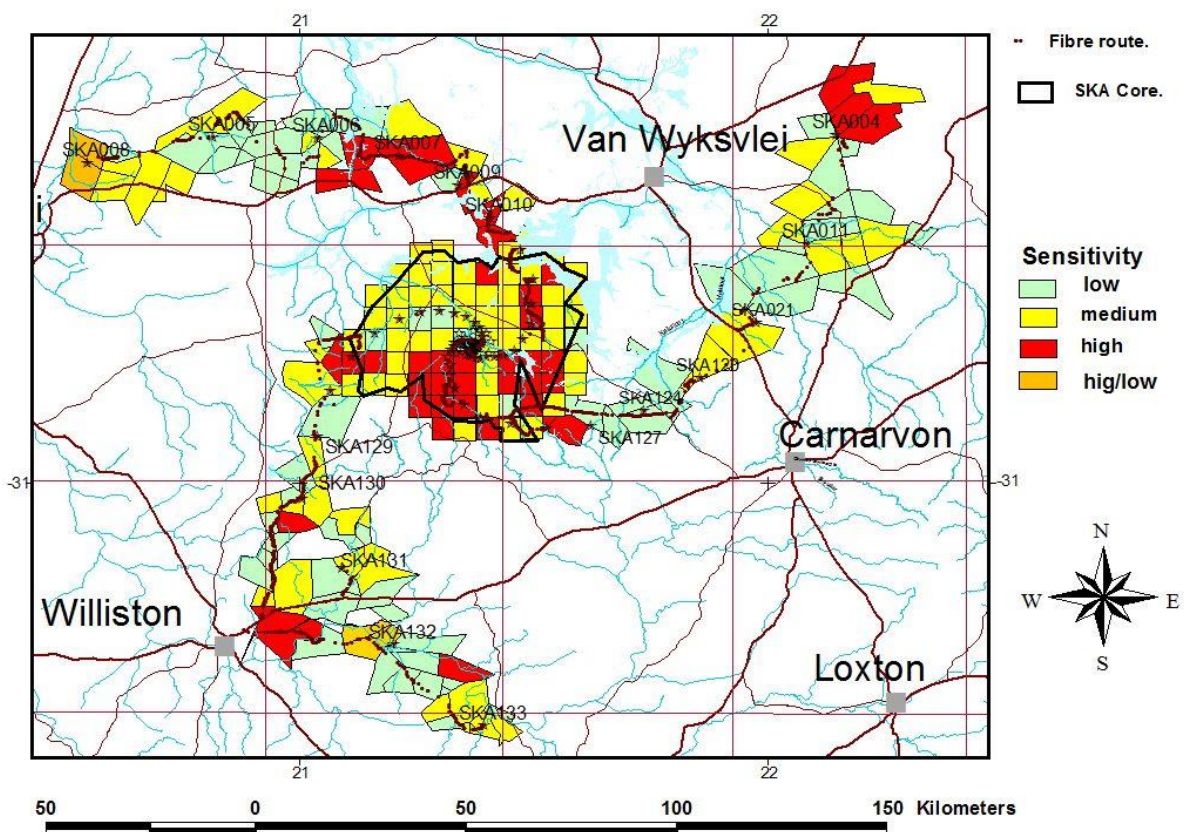


SAEON
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Observation Network

Summary

This Biodiversity and Ecology Specialist Report is largely based on desktop studies and field research conducted for other projects within the KCAA1 area, supplemented by a short data collection visit to the core area and sites of eight proposed radio telescope receivers to verify desktop assessments. The vegetation, flora and smaller fauna of the project area are poorly documented. All available records obtained from SABIF and other sources were at a quarter degree or degree scale so that plant and animals species records could not be assigned to particular land parcels, but only to a 50 km radius of the proposed SKA infrastructure in most cases.

In the absence of accurate species distribution data, the specialist assumed that plant and animal species richness is correlated with habitat heterogeneity and therefore used habitat heterogeneity as the major surrogate used to generate sensitivity scores for quantifying likely response of the SKA Phase 1 environment and biota to physical disturbance. The sensitivity map of the SKA Phase 1 area, including the core area is shown in the map below. Sensitivity was scored on the basis the number of habitat types in each land parcel (in the spiral arms) or 25 square kilometre block (core area) based on the number of habitat types recorded in the block in fine scale maps prepared by Simon Todd (2016) for SAEON. This score increased by 1 if rare species, water features or steep topographic gradient were present. Scored values were then classified as follows 1-2 =low sensitivity, 3-4 medium sensitivity, 5-6 high sensitivity.



Summary-Map: Sensitivity map for the SKA Phase 1 study area based on habitat heterogeneity, rarity, steepness and water features

Because of the uncertainty around the distribution of species of conservation concern and the coarse nature of the sensitivity mapping, the final selection of sites for telescopes, cable trenching and roads must be inspected by a field ecologist before construction, and where found to impact sensitive habitats, an acceptable alternative should be approved.

For the purpose of this assessment for SKA Phase 1, the specialist considered that the sites that are impossible to restore once they have been destroyed and the habitats that are essential for the survival of rare plant or animal species should be no-go areas. These include:

- Aloe dichotoma populations (a slow-growing, range-restricted plant species),
- exposed mudstone rock sheets that are home to rare succulents and reptiles,
- koppies and steep slopes that cannot be restored once destroyed by blasting, trenching or road building,
- pans and wetlands where development may change drainage patterns and affect the wildlife (especially birds, amphibians and fish) that use the pans after rain, and
- red sanddunes which are habitat of the narrow range endemic and substrate-restricted Red Lark.

Negative impacts associated with the SKA Phase 1 development are related to construction and operation of the road network, trenching for installation of optic fibre and electrical cables, installation of telescope installations, associated construction camps and borrow pits, overhead electrical infrastructure, and people on site during the construction and operational phases. Unmitigated construction phase impacts will include removal of vegetation, damage to sensitive habitats, displacement of fauna and destruction of rare plants, increased risk of soil erosion through road construction on inclines or poor management of runoff from telescopes, roads or other hardened surfaces, alteration of drainage patterns and acceleration of the spread of invasive alien plant species. Unmitigated operational phase impacts include ongoing bird mortality caused by strikes or electrocution on overhead electrical or cable infrastructure, failure to restore areas damaged during construction, failure to control invasive alien plant species, failure to maintain drainage works and control accelerated erosion, roadkill, and reinforced or electrical fencing that might genetically isolate or reduce populations of some reptiles (tortoises, snakes, monitor lizards) and mammals (Aardvark, Pangolin).

Positive impacts associated with the SKA Phase 1 development include:

- Exclusion of the area from prospecting and mining;
- Release of the Core area from its current grazing regimes (livestock ranching),
- Initiation of programmes to control invasive alien plant species, particularly *Prosopis* that has invaded drainage lines and pans, and is posing a threat to water resources and biodiversity,
- Stimulating research on ecology, biodiversity and ecological restoration in the Central Karoo, and
- Declaration of the Core area as a protected area has potential for ecosystem conservation, and presents opportunities for long-term monitoring of predator and other wildlife populations, vegetation dynamics, and ground and surface water responses to cessation of livestock farming.

The specialists identified the following key mitigation measures and management actions:

During pre-construction:

- Complete avoidance of No-Go areas;
- Preconstruction verification of site sensitivity for roads, telescopes and trenches and allocation of activities to approved less sensitive sites; and
- Minimisation of the size of the damage footprint.

During construction:

- Management of machinery and people on site to minimise damaging activities such as spills, roadkill, hunting and littering,
- Management of invasive alien plants during preparation for construction, as well as during the operational phase on all sites disturbed by construction;
- Protection and/or translocation of red Listed and protected plant species prior to and during the construction phase as recommended in the plant rescue and protection plan; and
- Post construction compliance with the revegetation and habitat restoration plan.

During operation:

- Development of detailed management plans for ongoing control of established populations of invasive alien plants in the SKA Core and land parcels;
- Monitoring and ongoing restoration and runoff management from of damaged and disturbed sites;
- Monitoring of animal populations likely to be affected by cessation of predator control and water supplementation;
- Monitoring of bird, mammal and reptile mortality associated with boundary fences, roads and overhead infrastructure;
- Development of a policy for response to locust outbreaks within the SKA Core; and
- Monitoring and management of human activities on site including off-road driving, waste disposal and removal of plants or animals.

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I. Introduction

The study area of the Strategic Environmental Assessment (SEA) for the first phase of the SKA project (SKA1_MID) is located within the Karoo Central Astronomy Advantage Area 1 (KCAAA1). The study area is characterised by an arid climate and receives in average less than 200 mm annual rainfall with a mean annual rainfall at Fraserburg is 182 mm, Brandvlei 127 mm, and Carnavon 209 mm. The study area lies mainly within the Karoo Basin where geology is dominated by mudstone and sandstone rocks derived from marine sediments (Figure 2). These relatively soft sediments weather to form stony plains and flat or rounded hills. Dolerite has intruded through the sedimentary strata as dykes and pipes that weather to form hills and ridges characterised by round brown or black boulders (Figure 1 C & D). Where dolerite intrusions overlies softer sediments, the hard capping results in formation of flat-topped ridges and mesas (Figure 1 B). The landscape thus comprises abrupt ridges and conical hills scattered across extensive sandy and silty plains. Within the study area, the altitude ranges from 1500 m a.s.l. on the escarpment in the South (Fraserburg) to 900 m a.s.l. on the pans between Brandvlei and Van Wyksvlei. There is thus a gentle gradient of 0.6 km over a distance of 300 km. Drainage is mostly endorheic Rivers arising on the escarpment (e.g. Sakrivier) and off ridges and hills, flowing northwards and discharging into the pans (Brandvlei, Verneukpan, VanWyksvlei) where the water evaporates.

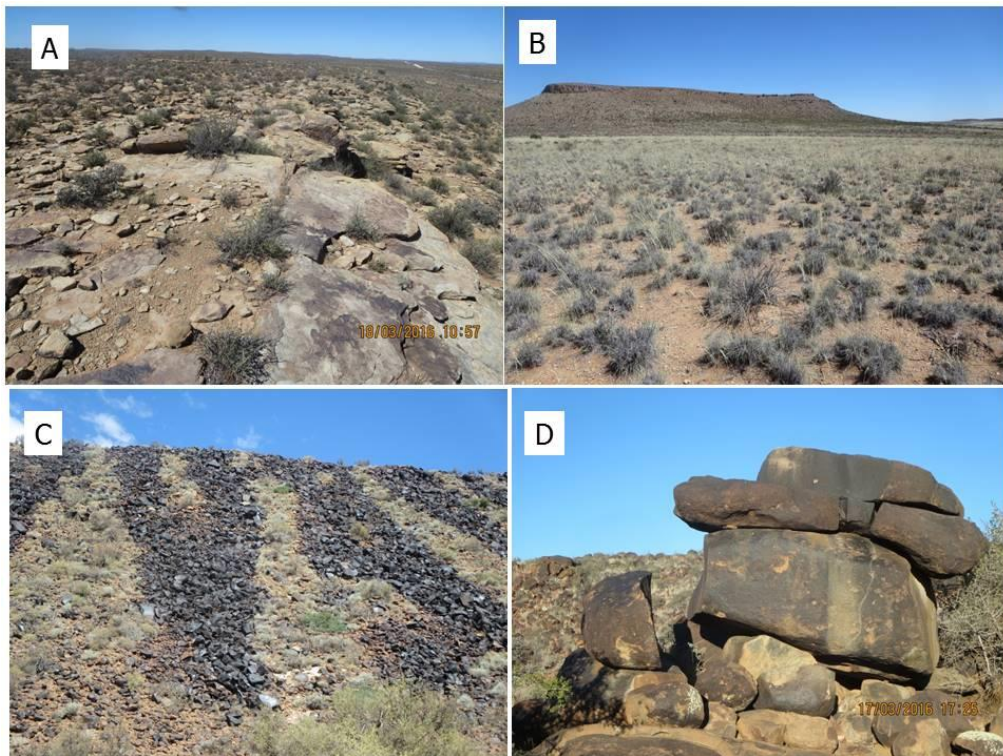


Figure 1. Typical rock formations of the KCAAA1 area. (A) Sedimentary rock of the Beaufort Series 10 km north of Fraserburg, (B) Ecca mudstone ridge capped by Dolerite 30 km south of Williston, (C) Dolerite scree forming stripes on a ridge in the SKA SKA core area, (D) stacked Dolerite boulders near Van Wyksvlei

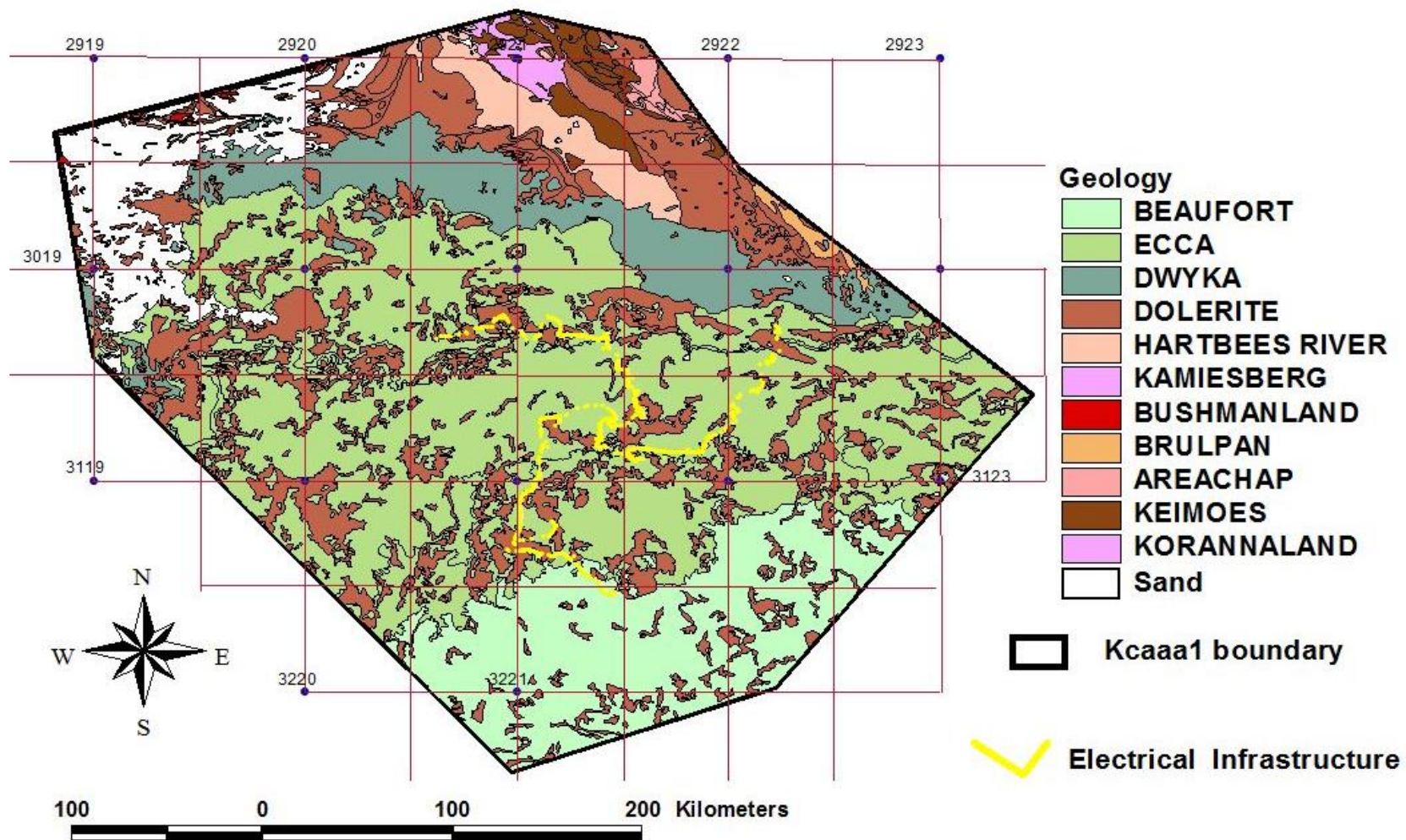


Figure 2. Geology of KCAAA1 area showing the sedimentary rocks in greens and the igneous rocks in pinks and browns

Although the soils of the plains are generally shallow to skeletal, wind and water-borne sediments have accumulated in parts of the landscape (Figure 3). In the Van Wyksvlei area, many stony plains are devoid of soil (habitat for Sclater's Lark) whereas wind-blown sand has elsewhere accumulated to form dunes that overlie the mudstone plains and dolerite outcrops in some places. These orange sand dunes are habitat for the endemic Red Lark. Silt and clay has accumulated in shallow valleys to form extensive level pans (vloëre) between Brandvlei and Van Wyksvlei. Deep silty friable alluvium flanks the Sakrivier and its tributaries creating a suitable habitat for the Critically Endangered Riverine Rabbit.

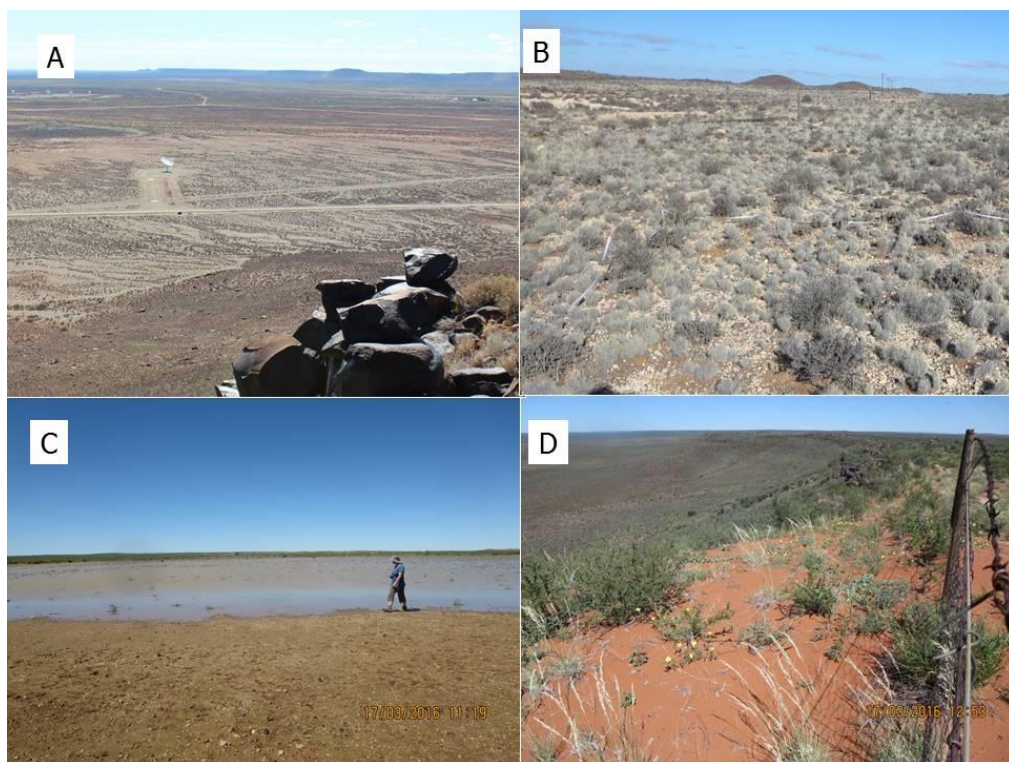


Figure 3. Substrates in KCAA1. (A) Sandy and silty plains in SKA Core area, (B) calcrete plains south of Williston, (C) clay and silt accumulated in pans in the Brandvlei-Van Wyksvlei area, red sand dunes north of Van Wyksvlei

According to Mucina & Rutherford (2006), the KCAA1 contains 23 vegetation types (Figure 4) among which ten vegetation types form part of the Nama-Karoo Biome. Of these the four Upper Karoo types (NKu 1-4) make up the majority of the area together with Bushmanland Arid Grassland (NKb3). The pans classified as azonal vegetation known as Bushmanland Vloëre (AZi5) follow drainage features through the Upper Karoo vegetation types. Relatively small portions of eight Succulent Karoo Biome vegetation types are included along the western boundary of the KCAA1 area (not located within the SKA1_MID SEA study area). A small area of Renosterveld occurs in the southern edge of the KCAA1 on the escarpment. It is significant that the majority of the listed (rare, vulnerable, endangered) flora of the area was limited to half degree squares classified as Hantam Succulent Karoo or Roggeveld Succulent Karoo that lie beyond the boundaries of the SKA1_MID SEA study area (Figure 4).

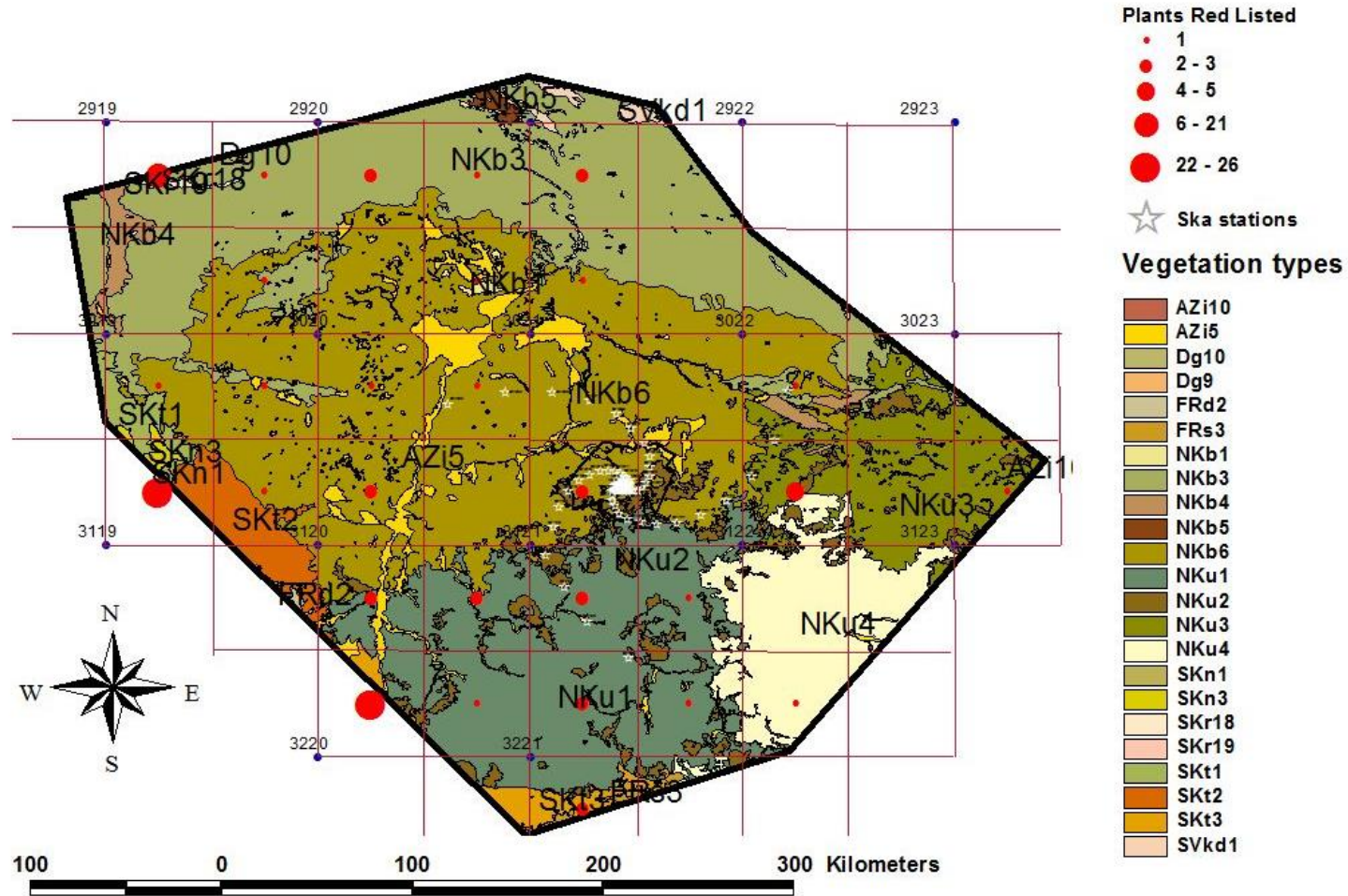


Figure 4. Vegetation map for the KCAAA1 area from Mucina & Rutherford (2006). The major types indicated in the abbreviated key to the right of the map are: AZ = azonal vegetation of drainage lines and pans, DG = Desert Grassland, FR = Fynbos of the Renosterveld type, NKb = Nama Karoo bushmanland types, NKu = Nama Karoo high altitude types, SK = Succulent Karoo

The Succulent Karoo vegetation types are made up of low-growing (<0.3 m) succulent and non-succulent shrubs, particularly *Mesembryanthemaceae* and *Asteraceae* usually on skeletal soils on sedimentary rock. The most commonly encountered genera are *Ruschia*, *Pteronia*. They contain a high diversity of spring-flowering bulbs and annual plants, and include endemic species in the *Mesembryanthemaceae*, *Colchicaceae*, *Asphodelaceae* and *Oxalidaceae*. All of the Succulent Karoo vegetation types included in the KCAAA1 have Least Threatened Status, but all are poorly conserved (Rouget et al. 2004¹). No Succulent Karoo vegetation has been mapped within the SKA1_MID SEA study area.

The Upper Karoo vegetation types are made up of succulent and non-succulent shrubs up to 0.5 m high on stony ground and patches of grasses on sandy soil. This vegetation type occurs on sedimentary and dolerite rock and on calcrete. The dominant plant families are *Asteraceae*, *Chenopodiaceae*, *Fabaceae*, *Poaceae*, and *Scrophulariaceae*. The most commonly encountered species are *Pentzia incana*, *Eriocephalus ericoides*, *Rhigozum obovatum* and *Lycium* spp. Endemic species occur within the *Amarylidaceae*, *Asphodelaceae*, *Crassulaceae*, *Fabaceae* and *Malvaceae*. All of the Upper Karoo vegetation types included in the study area have Least Threatened Status, but all are poorly conserved (Rouget et al. 2004²).

The Bushmanland Arid Grassland types are dominated by desert grasses, with karoooid and woody shrubs in the *Asteraceae*, *Bignoniaceae*, *Fabaceae*, *Scrophulariaceae* and *Zygophyllaceae* with abundant annual forbs and grasses after rain. The vegetation occurs on Kalahari Sands on plains, dunes and outcrops of calcrete and dolerite. The most abundant species are *Rhigozum trichotomum* and *Stipagrostis ciliata*. The few endemic species are in the *Mesembryanthemaceae*, *Fabaceae* and *Scrophulariaceae*. All of the Arid Grassland vegetation types included in the study area, have Least Threatened Status, but all are poorly conserved (Rouget et al. 2004).

Azonal vegetation on deep silty to sandy soils in dry river beds and pans is characterised by taller, woodier vegetation including trees (*Rhus lancea*), tall shrubs (*Salsola*, *Lycium*, *Tripteris*), and tall grasses (*Stipagrostis namaquensis*). *Xerocladia viridiramis* is a spiny legume shrub characteristic of deeper channels in endorheic drainage features. Azonal habitats are severely threatened by invasion by *Prosopis glandulosa* and its hybrids. The Karoo Azonal vegetation has Least Threatened Status.

The only existing detailed (plant community level) studies for the study area are the unpublished botanical³ and faunal⁴ reports prepared as part of the impact assessment for the Meerkat development in the SKA core area. The habitats described in these reports are dolerite hills and poorly-drained plains characterised by silt, gravel, calcrete and sand substrates. The South African Environmental Observation Network (SAEON) and the South African National Biodiversity Institute (SANBI) are currently preparing a fine-scale vegetation map for the KCAAA1. There are no other detailed studies of the vegetation within the KCAAA1 area, although fine scale vegetation maps have been published for some sites on the periphery of the study area. These are the Alkantpan area near Copperton to the northeast^{5,6}, the Vaalputs Nuclear Waste Facility⁷ to the northwest of the study area, the Tanqua Karoo⁸ to the southwest and for the Karoo National Park to the southeast⁹.

² Rouget, M., Reyers, B., Jonas, Z., Desmet, P., Driver, A., Maze, K., Egoh, B. & Cowling, R.M. 2004. South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 1: Terrestrial Component APPENDIX A. Pretoria: South African National Biodiversity Institute

³ McDonald, D.J. 2008. Botanical Assessment of proposed site for the MeerKAT radio astronomy facilities on the farms Losberg and Mey's Dam near Carnarvon, Northern Cape

⁴ Strategic Environmental Focus 2007. The proposed Karoo array telescope (KAT), Northern Cape Faunal assessment report. Prepared for Northern Cape Department of Education.

⁵ Lloyd, J.W. & le Roux, A. 1985. A conservation assessment of the Verneukpan-Copperton area. Report, Cape Department of Nature and Environmental Conservation.

Descriptions of plant communities in the unpublished botanical and faunal report prepared for MeerKat in 2008 are integrated and summarised below:

- Dolerite hills, inselbergs and pediments of exposed dolerite sills and dykes have sparse vegetation cover. Vegetation include a number of protected plant species (*Aloe dichotoma*, *Boscia albitrunca*) as well as *Rhigozum obovatum*
- Silt plains characterised by *Salsola aphylla* with *Lycium cinereum*, *L. oxycarpum* and an understorey of succulents, forbs and a few grasses (*Drosanthemum sp.*, *Malephora crocea*, *Ornithogalum sp.*, *Setaria verticillata*, *Stipagrostis ciliata*, *S. obtusa*, *Mesembryanthemum guerichianum*). Invasive alien species present were *Prosopis glandulosa* var. *torreyana* (mesquite), and *Atriplex lindleyi* subsp. *inflata* (spongefruit saltbush);
- Gravel plains below the flat-tipped hills were dominated by *Rhigozum trichotomum* with *Lycium* species, *Salsola aphylla*, and a grassy understorey of *Stipagrostis obtusa* with *Aridaria noctiflora*, *Asparagus retrofractus*, *Drosanthemum sp.*, *Lebeckia*, *Leysera sp.*, *Lycium cinereum*, *Malephora crocea*, *Osteospermum scariosum*, *Pentzia incana*, *Pteronia sp.*, *Ruschia spinescens*, *Salsola tuberculata*, *Zygophyllum microphyllum* and invasive alien *Atriplex lindleyi*;
- Calcrete plains with lower, sparser vegetation similar in composition to gravel plains but with a greater abundance of *Salsola tuberculata*;
- Sand Washes or larger drainage lines are dominated by *Stipagrostis namaquensis* with *Lebeckia spinescens*, *Cenchrus ciliaris* and scattered *Searsia (Rhus) lancea* trees;
- Disturbed areas associated with farm dams and boreholes are characterised by large tree species (mainly invasive alien *Prosopis glandulosa*) and herbaceous indigenous and alien plants.

Gibbs Russel (1987) estimated that 2,147 species occurred in a central area of the Nama Karoo (198,000 km²), of which 377 (16 %) are endemic¹⁰. Within the KCAAA1 area, 35 (1.8%) of the 1952 plant species on record are endemic to the vegetation types shown in Figure 4 and within the parts of those vegetation types included within the KCAAA1 boundary. Of the 35 endemics 23 species are in the Renosterveld and Succulent Karoo types on the western boundary of the study area.

Amongst the 1899 species of higher plants and 51 species of mosses and lichens known to occur in the KCAAA1, the higher plants belong to 101 families (Table 1), the most speciose of which are *Asteraceae* (326 species), *Mesembryanthemaceae* (156), *Poaceae* (147), *Fabaceae* (99) and *Iridaceae* (73). The mosses and lichens belong to 21 families, the most speciose being *Parmeliaceae* (11), *Ricciaceae* (10) and *Pottiaceae* (7). Data indicate that species densities are greater in the western edge of the study area (Succulent Karoo vegetation types) than in the Nama Karoo vegetation types that cover the rest of the area. Within the Nama Karoo, species richness (mapped per 50 x 50 km block) appears greater at higher altitudes and where there are closely-spaced contours (broken terrain), than in the northern central region around the pans, where topography is flat (Figure 5). Additional factors that may affect species numbers reported per unit area is the accessibility of an area and its proximity to towns. Within the SKA1_MID SEA study area, there are records of only 1257 higher plant species in 93 families. These low numbers probably reflect under-collecting and are likely to increase during the SANBI and SAEON studies.

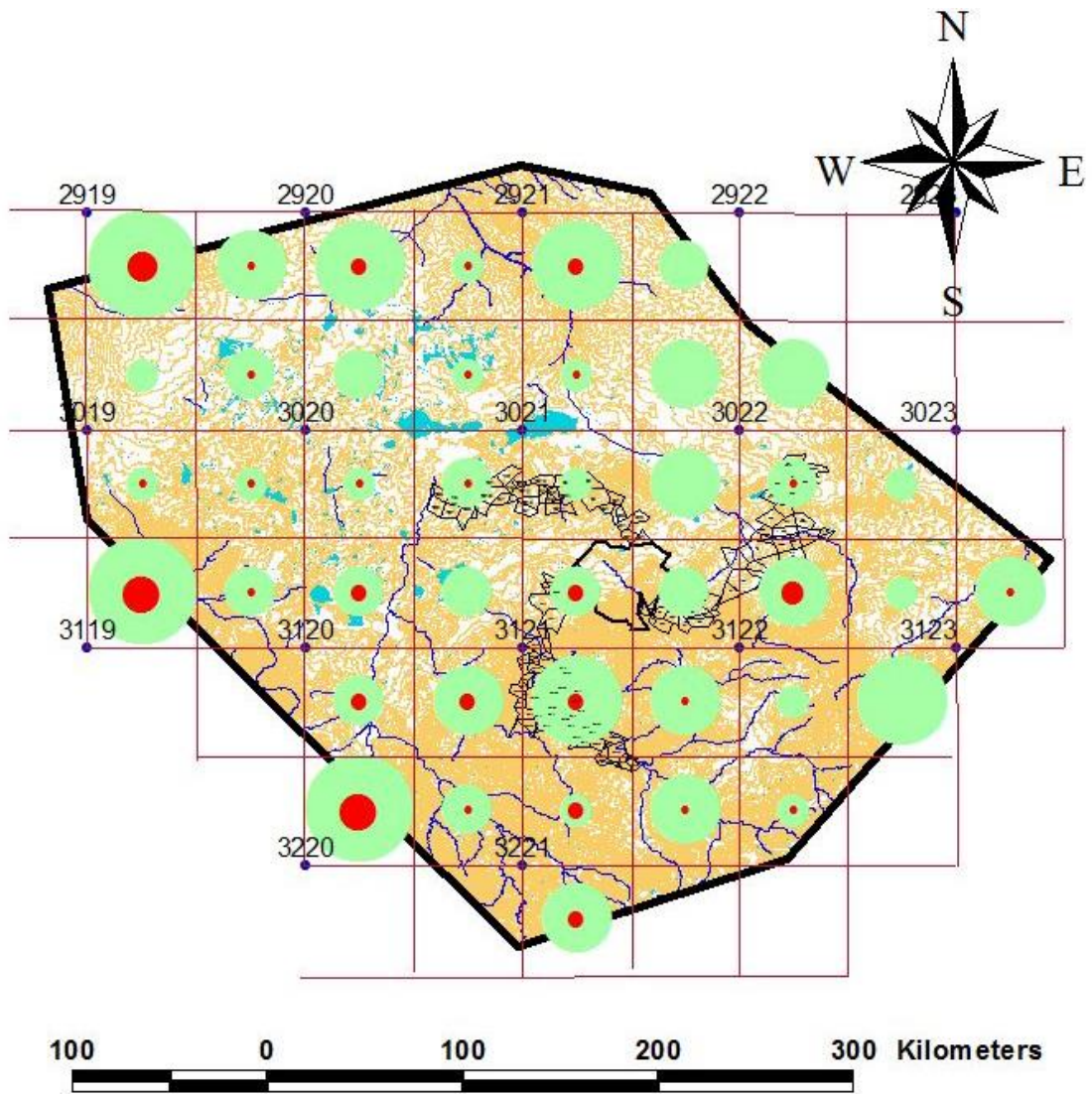
⁶ McDonald, D. 2011. Botanical Assessment for a proposed wind energy facility at Copperton, Northern Cape. Prepared for Aurecon SA (Pty) Ltd.

⁷ Lloyd, J. W. 1989. Phytosociology of the Vaalputs radioactive waste disposal site, Bushmanland, South Africa. *South African Journal of Botany*, 55, 372-382.

⁸ vd Merwe, H., van Rooyen, M.W. & van Rooyen, N. 2008. Vegetation of the Hantam-Tanqua-Roggeveld subregion, South Africa. Part 2: Succulent Karoo Biome related vegetation. *Koedoe* 50: 160-183

⁹ Rubin, F. and Palmer, A.R. 1996. The physical environment and major plant communities of the Karoo National Park, South Africa. *Koedoe* 39:25-52

¹⁰ Gibbs Russel, G.E. 1987. Preliminary floristic analysis of the major biomes in southern Africa. *Bothalia* 17: 213-227.



Plant Species of Conservation Concern

- 1
- 2 - 3
- 4 - 5
- 6 - 21
- 22 - 26

Plant Species per Half Degree

- | | |
|------------|-------------|
| • 7 - 50 | • 147 - 234 |
| • 51 - 92 | • 235 - 433 |
| • 93 - 146 | |

Figure 5. Plant species densities per half degree square (ca. 50 x 50 km) plotted against relief and drainage features

In the KCAAA1 area there are 135 records of 91 plant species of conservation concern (listed as declining, vulnerable, threatened, endangered or critically endangered in the Threatened Species Programme¹¹). Most records are from species-rich half degree squares in Succulent Karoo vegetation and in areas with broken topography (Figure 5). The plant families with the most species of conservation concern (Table 1) are Mesembryanthemaceae (18), Iridaceae (13), Amaryllidaceae (9) and Asphodelaceae (8). Within the SKA1_MID SEA study area there are only 89 records of 47 plant species of conservation concern (Table 1). The plant families with the most species of conservation concern are Iridaceae (12), Amaryllidaceae (6) and Apocynaceae (5), all of which are geophytes or small shade succulents that are difficult to detect in field surveys during dry periods. Three plant species of conservation concern occur within the SKA core area, namely *Acacia erioloba* (declining), *Aloe dichotoma* (VU) and *Hoodia gordonii* (Data deficient, declining) (Figure 6).

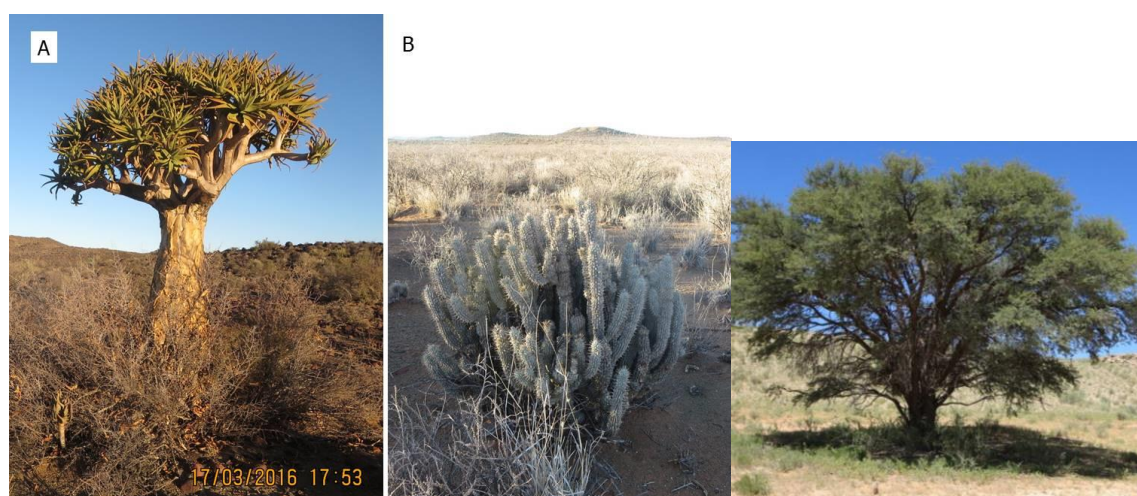


Figure 6. Listed plant species that occur in the SKA Core area. (A) *Aloe dichotoma*, (B) *Hoodia gordonii*, (C), *Acacia erioloba*

In addition to Red Listed threatened species, the Northern Cape Nature Conservation Act¹², makes provision for Specially Protected and Protected species of fauna and flora. There are 44 (25) "Specially Protected" and 589 (337) "Protected" plant species in the KCAAA1 area, (and SKA1_MID SEA study area) respectively. In terms of Section 49 of the Act, no person may, without a permit (a) pick; (b) import; (c) export; (d) transport; (e) possess; (f) cultivate; or (g) trade in, a specimen of a "specially protected plant". All these restrictions (with the exception of possession) also apply to "protected plants". The Specially Protected and Protected plant species present in the SKA1_MID SEA study area include slow-growing trees (*Boscia* spp, *Acacia erioloba*), geophytes in the Amaryllidaceae, Hyacinthaceae, Iridaceae, Oxalidaceae, most succulent plants in the Apocynaceae, Asphodelaceae, Crassulaceae, Euphorbiaceae, Geraniaceae, Portulacaceae, and certain medicinal plant species (*Harpagophytum*, *Sutherlandia*) (Figure 7).

¹¹ Threatened Species Programme Red List of South African Plants Online provides up to date information on the national conservation status of South Africa's indigenous plants on the SANBI website <http://redlist.sanbi.org/>

¹² Northern Cape Nature Conservation Act 9/2009 (Provincial Gazette 1566 dated 19 December 2011)

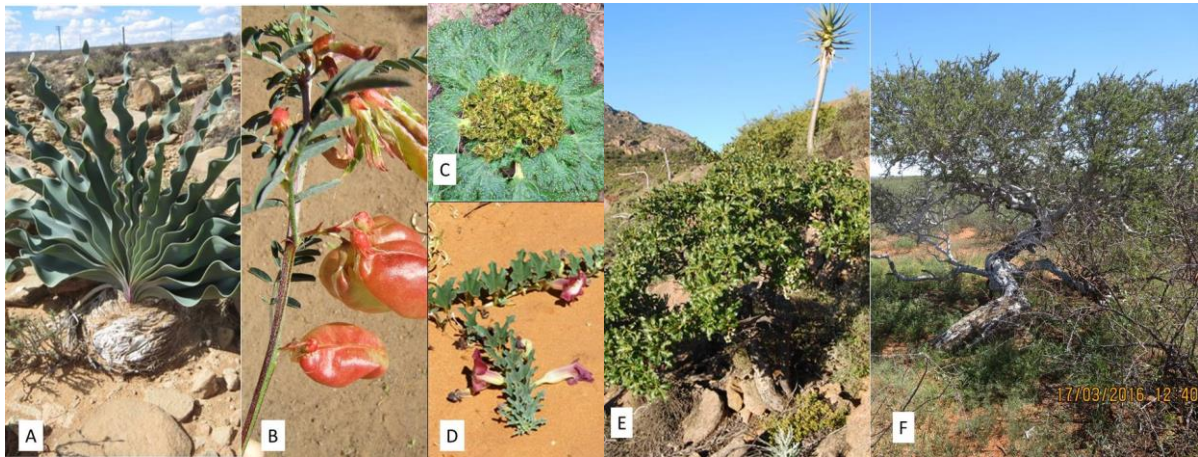


Figure 7: Medicinal plants (A) *Boophane distichya*, (B) *Lessertia (Sutherlandia) frutescens*, (C) *Arctopus echinatus*, (D) *Harpagophyton* spp, and slow-growing trees (E) *Ozoroa dispar* (photo Senckenberg Research Institute) and (F) *Boscia albitrunca* protected under Northern Cape Nature Conservation Act

Table 1: Species richness and Red Listed species in plant families of the KCAA1 and SKA1_MID SEA study area- the species occurring within the SKA1_MID SEA study area are indicated in brackets (i.e."()")

Family	spp/fam	Listed spp	Family	spp/fam	Listed spp	Family	spp/fam	Listed spp
ACANTHACEAE	20 (7)	1 (0)	LAMIACEAE	13 (13)		RUBIACEAE	11 (8)	
AIZOACEAE	38 (25)		LOASACEAE	1 (1)		RUTACEAE	5 (3)	
AMARANTHACEAE	13 (8)		LOBELIACEAE	4 (4)		SALICACEAE	2 (0)	
AMARYLLIDACEAE	29 (14)	9 (6)	LOPHIOPHYLLACEAE	1 (1)		SALVADORACEAE	1 (0)	
ANACARDIACEAE	7 (4)		LORANTHACEAE	5 (5)		SANTALACEAE	9 (7)	2 (2)
APIACEAE	10 (6)	1 (0)	MALVACEAE	49 (42)		SAPINDACEAE	1 (0)	
APOCYNACEAE	56 (40)	5 (5)	MARSILEACEAE	3 (3)		SCROPHULARIACEAE	106 (68)	6 (4)
ARALIACEAE	1 (0)		MELIACEAE	1 (1)		SINOPTERIDACEAE	7 (6)	
ASPARAGACEAE	18 (15)		MELIANTHACEAE	1 (1)		SOLANACEAE	20 (16)	
ASPHODELACEAE	42 (24)	8 (3)	MENISPERMACEAE	3 (2)		TAMARICACEAE	3 (3)	
ASPLENIACEAE	1 (1)		MESEMBRYANTHEACEAE	156 (75)	18 (3)	TECOPHILAEACEAE	1 (1)	
ASTERACEAE	326 (234)	5 (3)	MOLLUGINACEAE	27 (19)		THYMELAEACEAE	6 (6)	
BIGNONIACEAE	3 (3)		MONTINIACEAE	1 (1)		URTICACEAE	2 (1)	
BORAGINACEAE	19 (15)		MORACEAE	2 (0)		VAHLIACEAE	1 (1)	
BRASSICACEAE	39 (29)		MYRTACEAE	1 (1)		VERBENACEAE	3 (3)	
BUDDLEJACEAE	4 (2)		NEURADACEAE	3 (3)		VISCACEAE	1 (0)	

Family	spp/fam	Listed spp	Family	spp/fam	Listed spp	Family	spp/fam	Listed spp
BURSERACEAE	2 (0)		NYCTAGINACEAE	3 (2)		ZYGOPHYLLACEAE	20 (20)	
CACTACEAE	3 (3)		OLEACEAE	1 (1)				
CAMPANULACEAE	10 (5)	1 (0)	ONAGRACEAE	2 (2)				
CAPPARACEAE	11 (5)		OPHIOGLOSSACEAE	2 (2)	1 (1)	BRYOPHYTES		
CARYOPHYLLACEAE	15 (99)		ORCHIDACEAE	4 (2)		Family	mosses /lichens	
CELASTRACEAE	6 (3)		OROBANCHACEAE	2 (1)		AYTONIACEAE	1	
CHENOPODIACEAE	46 (37)		OXALIDACEAE	30 (15)	3 (2)	BACIDIACEAE	1	
COLCHICACEAE	13 (8)		PAPAVERACEAE	2 (1)		BARTRAMIACEAE	1	
CONVOLVULACEAE	3 (3)		PASSIFLORACEAE	1 (0)		BRYACEAE	1	
CRASSULACEAE	53 (26)	5 (2)	PEDALIACEAE	5 (4)		BRYACEAE	1	
CUCURBITACEAE	12 (5)		PEGANACEAE	1 (0)		FABRONIACEAE	1	
CYPERACEAE	21 (13)		PHYLLANTHACEAE	3 (3)		FISSIDENTACEAE	1	
EBENACEAE	11 (4)		PLANTAGINACEAE	4 (1)		FUNARIACEAE	2	
ELATINACEAE	1 (0)		PLUMBAGINACEAE	3 (3)		GIGASPERMACEAE	1	
ERICACEAE	2 (0)		POACEAE	147 (108)	1 (0)	GRIMMIACEAE	2	
ERIOSPERMACEAE	7 (2)		POLYGALACEAE	13 (12)		HYMENELIACEAE	1	
EUPHORBIACEAE	33 (33)		POLYGONACEAE	4 (4)		LECANORACEAE	2	
FABACEAE	99 (62)	6 (3)	PORTULACACEAE	24 (1)	1 (0)	LECIDEACEAE	1	
FRANKENIACEAE	1 (1)		POTAMOGETONACEAE	1 (0)		PARMELIACEAE	11	
FUMARIACEAE	3 (2)		PROTEACEAE	5 (5)		PERTUSARIACEAE	2	
GENTIANACEAE	3 (2)		PTERIDACEAE	6 (6)		PERTUSARIACEAE	1	
GERANIACEAE	34 (16)		RANUNCULACEAE	3 (1)		PHYSICIACEAE	1	
GISEKIACEAE	2 (1)		RESEDACEAE	1 (1)		POTTIACEAE	7	
HYACINTHACEAE	43 (27)	2 (1)	RESTIONACEAE	1 (1)		PSORACEAE	2	
HYPOXIDACEAE	5 (3)		RHAMNACEAE	3 (3)		RICCIACEAE	10	
IRIDACEAE	73 (58)	13 (12)	ROSACEAE	2 (1)		TELOSCHISTACEAE	2	

Family	spp/fam	Listed spp	Family	spp/fam	Listed spp	Family	spp/fam	Listed spp
JUNCAEAE	3 (3)							

The KCAAA1 area overlaps the distributions of 90 mammals species according to 2016 IUCN records¹³. The list includes only two invasive alien mammal species, the House Mouse and the Black Rat. With the exception of the Black Rhinoceros (that no longer freely occurs in the areas) all species are listed in the Appendices. There are no endemic mammals in the region except perhaps the uncertain record of *Chrysochloris visagiei* (Visagie's Golden Mole). Six small mammal species are near-endemic. These are Grant's rock mouse (*Aethomys granti*), Shortridge's tree Rat (*Thallomys shortridgei*), Karoo Rock Elephant-shrew (*Elephantulus pilicaudus*), Brush-tailed Hairy-footed gerbil (*Gerbillurus vullinus*), Brukkaros Pygmy Rock Mouse (*Petromyscus monticularis*) and the Riverine Rabbit (*Bunolagus monticularis*) (Hilton-Taylor 2000)

Two species are rated as Vulnerable. The Blackfooted Cat (*Felis nigripes*) is population is declining in response to habitat degradation of predator control by poisoning¹⁴, whereas the Ground Pangolin (*Smutsia temminckii*) population is declining as a result of the value of its scales in traditional medicine, and through electrocution on the lowest strands of electric fences¹⁵. These two Vulnerable species may well benefit from the SKA development.

Nine Near Threatened mammal species that may occur within the KCAAA1 area include Leopard, Brown Hyaena, Honey Badger, Litledale's Whistling Rate, Lesueur's Hairy Bat, Straw-coloured Fruit Bat and three species of Horseshoe Bat. The carnivore populations are declining in response to predator control (Leopard, Brown Hyaena, Honey Badger). The Whistling Rat is threatened by land transformation and the bats by wind farms and, in the case of the migratory Fruit Bat, by bush meat hunting elsewhere in Africa¹⁶.

The three remaining listed species are Data Deficient and all occur on the KCAAA1 periphery outside of the SKA1_MID SEA study area. These are the once collected *Chrysochloris visagiei* (Visagie's Golden Mole) on the Nuweveld escarpment, and the recently recognised and poorly documented *Elephantulus pilicaudus* (Karoo Rock Elephant-shrew¹⁷) that occurs in rocky outcrops east of Calvinia, and *Thallomys shortridgei* (Shortridge's Tree Rat¹⁸) recorded from the northern arid savanna margins of the KCAAA1.

¹³ The IUCN Red List of Threatened Species. Version 2015-4. <www.iucnredlist.org>. Downloaded on 10 April 2016

¹⁴ Sliwa, A. 2008. *Felis nigripes*. The IUCN Red List of Threatened Species 2008: e.T8542A12917449. <http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8542A12917449.en>. Downloaded on 11 April 2016.

¹⁵ Pietersen, D., Waterman, C., Hywood, L., Rankin, P. & Soewu, D. 2014. *Smutsia temminckii*. The IUCN Red List of Threatened Species 2014: e.T12765A45222717. <http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T12765A45222717.en>. Downloaded on 11 April 2016.

¹⁶ Mickleburgh, S., Hutson, A.M., Bergmans, W., Fahr, J. & Racey, P.A. 2008. *Eidolon helvum*. The IUCN Red List of Threatened Species 2008: e.T7084A12824968. <http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T7084A12824968.en>. Downloaded on 11 April 2016.

¹⁷ Smit-Robinson, H. & Rathbun, G. 2015. *Elephantulus pilicaudus*. The IUCN Red List of Threatened Species 2015: e.T165924A21291059. <http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T165924A21291059.en>. Downloaded on 11 April 2016.

¹⁸ Boitani, L. & Taylor, P.J. 2008. *Thallomys shortridgei*. The IUCN Red List of Threatened Species 2008: e.T21693A9309334. <http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T21693A9309334.en>. Downloaded on 11 April 2016.

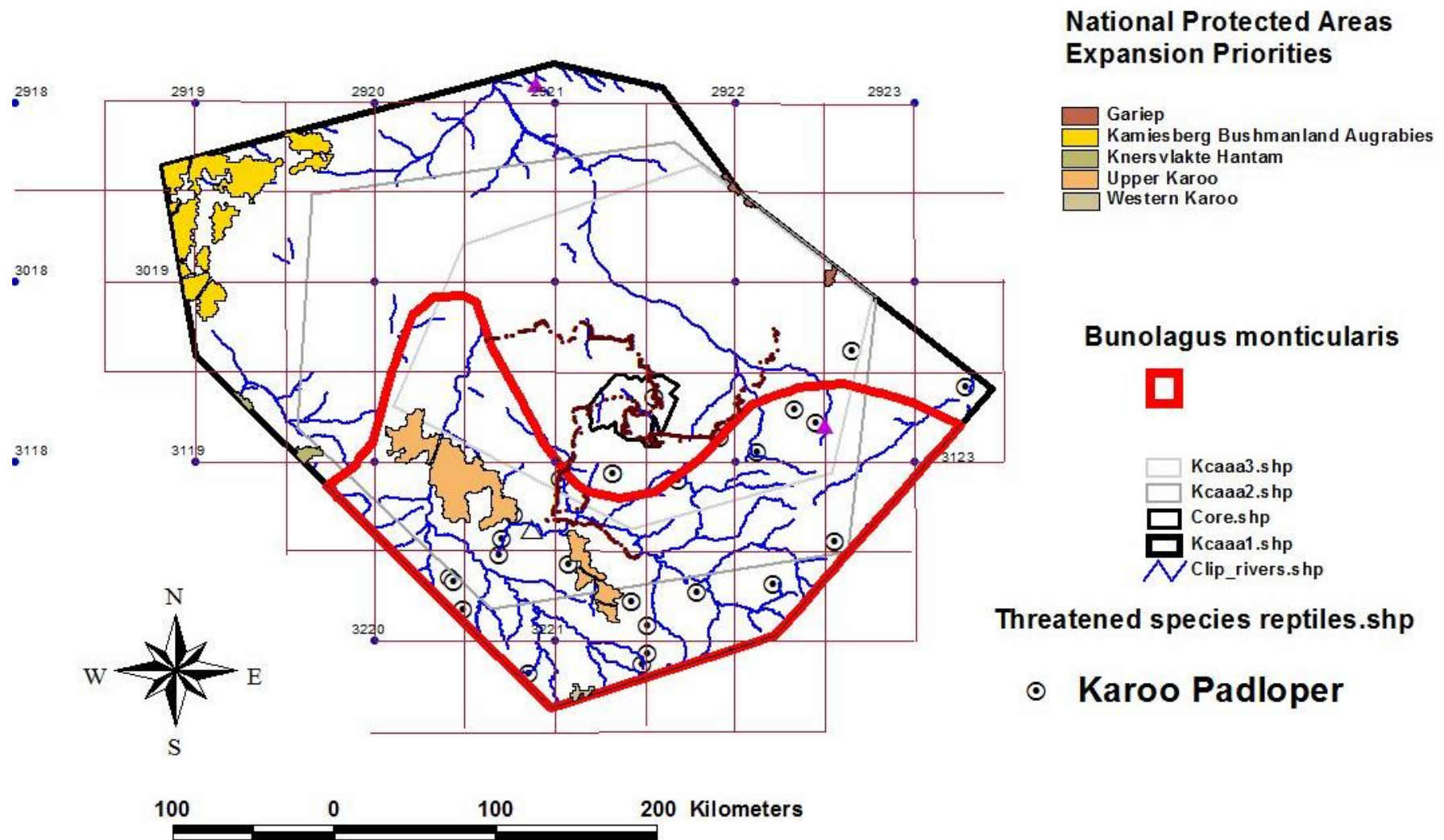


Figure 8: Known distribution of the Riverine Rabbit (*Bunolagus monticularis*) in the KCAA1 (red polygon) and of the Karoo Padloper Tortoise (*Homopus boulengeri*) plotted against KCAA1, 2 and 3 outlines, and National Protected Areas expansion priorities

According to maps in Minter et al. (2004)¹⁹ only 16 species of amphibians, all with Least Concern status, have been recorded from KCAAA1 (see Appendices). Of these the Giant Bullfrog has special protection status (Schedule 1) in the Northern Cape (Act 9 of 2009)²⁰, and all other species are protected under Schedule 2. The most common species are the Karoo Toad (*Vandijkophrynus garipeensis*) and the Common Caco (*Cacosternum boettgeri*) recorded from 11 of the 13 degree squares in the KCAAA1 area. Six of the amphibian species are unlikely to occur within the three spiral arms of the SKA1_MID or within the SKA core area because they have been recorded from only one degree square towards the margins of the KCAAA1.

The study area is fairly rich in tortoises and lizards, but snake diversity is low in comparison with higher rainfall areas. The most recent reptile atlas (Bates et al. 2014)²¹ shows that 54 species may occur in the KCAAA1 (see Appendices). The most widespread of these Common Sand Lizard, Common Ground Agama, Southern Rock Agama, Spotted Desert Lizard, Namaqua Sandlizard, Tent Tortoise, Southern Karusa Lizard and Western Three-striped Skink. Cordylid lizards (3 species) and the Namaqua Chamaeleon (Figure 9) are Specially Protected under Northern Cape Nature Conservation Act (9/2009).

The only reptile species of conservation concern is the Karoo Padloper (*Homopus boulengeri*) tortoise that is Near Threatened according to the assessment by Bates et al. (2014). This species would probably benefit from reduced grazing by domestic livestock and a reduction in the populations of Pied Crows that appear to be increasing in response to increased traffic and associated roadkill (Dean et al. 2005)^{22,23}. The Karoo Padloper, as indicated in Figure 8 should be present in the SKA Core and in the southern part of the KCAAA1 including the Williston spiral arm and the southern part of the Van Wyksvlei/Carnavon spiral arm.



Figure 9: Namaqua Chamaeleon, a low density species Specially Protected, in the Northern Cape

¹⁹ Minter, L.R., Burger, M., Harrison, J.A., Braack, H.H., Bishop, P.J. & Klopfer, D. (eds) 2004. Atlas and red data book of the frogs of South Africa, Lesotho and Swaziland. SI/MAB series 9. Smithsonian Institution, Washington DC.

²⁰ Northern Cape Nature Conservation Act, 2009 (ACT No. 9 of 2009)

²¹ Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J., & de Villiers, M.S. 2014. Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. Suricata 1. South African National Biodiversity Institute

²² 119. Dean, W.R.J., Milton, S.J. and Anderson, M.D. 2005. Use of road kills and roadside vegetation by Pied and Cape Crows in semi-arid South Africa. Ostrich 77: 102-104

²³ Dean, W.R.J. & Milton, S.J. 2003. The importance of roads and road verges for raptors and crows in Succulent and Nama Karoo, South Africa. Ostrich 74:181-186.

Arthropods communities differ among closed and open shrubland, grassland, and rock outcrops at Vaalputs (-30.1, 18.5 on the western edge of the Study area (Benade et al. 2016²⁴). Although the diversity in all communities sampled at this site was similar, differences in species composition among habitats indicates that arthropod diversity is likely to be greater in heterogeneous (complex) landscapes than in homogeneous landscapes within the SKA.

Scorpions that occur in the KCAAA1 belong to the Buthidae (Genera *Parabuthus* and *Uroplectes*), Ischinuridae (Genus *Hadogenes*), and Scorpionidae (Genus *Opisthophthalmus*) (Figure 10 A-D). The genus *Opisthophthalmus* is endemic to southern Africa, and contains 59 species, many of which have very small distribution ranges confined to the Northern Cape. (Lemmer 2003). Atlasing has not been intensive enough to assign any species to particular areas of the SKA1_MID study area.

Spider diversity is high in the Nama Karoo. 464 species from 50 families have been recorded of which 74 species are Nama Karoo endemics and an additional 77 species near endemics. The most diverse spider family in the Nama Karoo is the Gnaphosidae or burrowing spiders, but other endemic ground dwelling spider families including Ammoxenidae and trapdoor spiders in the Cyrtachenidae, Ctenizidae (trapdoor spiders, Figure 10 D), Ioiopidae and Nemesiidae occur in Nama Karoo (Dippenaar-Schoeman 2002²⁵, Foord et al. 2011²⁶).



Figure 10: Arachnid species of the study area. Scorpions (A) *Hadogenes phyllodes*²⁷ (Rock Scorpion), (B) *Parabuthus schlechteri*, (C) *Opisthophthalmus carinatus*, (D) *Uroplectes carinatus*, (E) Trapdoor spider (*Stazimopus*) retreat

The Brown Locust is a Karoo species and the KCAAA1 contains the locust outbreak 'cradle, in that swarming events originate on the sandy plains in the northern part of KCAAA1, and spread from there

²⁴ Benade, P.C., Dreyer, L.L. & Roets, F. 2016. The importance of maintaining a mosaic of different plant communities for arthropod biodiversity conservation at the Vaalputs radioactive waste disposal site, Bushmanland, South Africa. *African Entomology* 24: 1-15.

²⁵ Dippenaar-Schoeman AS 2002. Baboon and trapdoor spiders of southern Africa - an identification Manual. PPRI Handbook13. ARC, Pretoria

²⁶ Foord, S.H. Anna S. Dippenaar-Schoeman, A.S & Haddad, C.R. 2011. South African Spider Diversity: African Perspectives on the Conservation of a Mega-Diverse Group. In Grillo, O. & Venora, G. (eds) *Changing Diversity in Changing Environment*. ISBN 978-953-307-796-3. <http://www.intechopen.com/books/changing-diversity-in-changing-environment/south-african-spider-diversity-african-perspectives-on-the-conservation-of-a-mega-diverse-group>

²⁷ Photos reproduced from Lemmer, J. 2003. *Scorpions of southern Africa*. Struik

to other parts of the Karoo and elsewhere in southern Africa²⁸. If the SKA core area is declared a National Park or specially protected area, the SKA Organisation could motivate to obtain permission from DAFF to exclude chemical control of locust swarms. Should no exception be granted then, in the case of a locust outbreak, SKA may need to allow spraying teams to enter and kill locust swarms without an EIA as prescribed by the 1998 policy and actively practised. Spraying of locust hoppers kills most other arthropods and consumption of poisoned locusts leads to mortality of some avian and mammalian predators of locusts. To avoid disruption of SKA activities it is strongly advised that application is made to DAFF to exempt the SKA from locust spraying and that the area is maintained as a control to understand locust and locust predator dynamics in the absence of chemical control. Alternative less disruptive locust control measures that could be applied in the SKA area are myco-insecticides (pathogenic fungi), barriers and baits.

II. Study methodology

1) Baseline description of the study area

The baseline description of the study area of the strategic environmental assessment (SEA) for the first phase of the SKA project (SKA1_MID) includes geographic information system (GIS)-based maps and text descriptions of terrestrial ecology features of interest including biodiversity hotspots, and habitats critical for persistence of threatened, rare and locally endemic plant and animal species. The maps combine coverages for vegetation types (Mucina & Rutherford 2006²⁹), Critical Biodiversity Areas for the Namaqua District (critical biodiversity areas coverages), geology, rainfall and landcover, distribution data for mammal species of Conservation Concern obtained from the International Union for Conservation of Nature (IUCN) website³⁰ bird distribution and species richness data based on the Bird Atlas³¹ and supplemented from our own sources, and information on amphibian³² and reptile distributions³³.

Baseline descriptions of the vegetation were based on checklists available from SANBI's biodiversity information website, SANBI red data list, surveys recently conducted by SAEON and SANBI, data collected during impact assessments carried out by myself for private clients or as academic research. The plant species checklist compiled for the KCAAA1 (and included in the Appendices) was derived from data downloaded from the SANBI SABIF³⁴ and Plants of southern Africa (POSA) websites, combined with the consultant's own data obtained from vegetation surveys conducted in the Northern Cape, Western and Eastern Cape portions of the KCAAA1 in between 1988 and 2015 for other clients, and the records obtained during fieldwork carried out in March 2016 for the SKA SEA. In total 7119 records were combined to produce a list of 1899 species of higher plants and 51 species mosses and lichens known to occur in the area. Additional information was extracted from publications dealing

²⁸ Henschel, J.R. 2015. Locust times – monitoring populations and outbreak controls in relation to Karoo natural capital, *Transactions of the Royal Society of South Africa*, 70:2, 135-143.

²⁹ Mucina, L & Rutherford, M.C. (eds). 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19, South African National Biodiversity Institute, Pretoria

³⁰ The IUCN Red List of Threatened Species. Version 2015-4. <www.iucnredlist.org>. Downloaded on 10 April 2016

³¹ Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V. & Brown, C.J. 1997. The Atlas of southern African Birds, Vols 1 & 2. *Birdlife South Africa*, Johannesburg.

³² Minter, L.R., Burger, M., Harrison, J.A., Braack, H.H., Bishop, P.J. & Klopfer, D. (eds) 2004. Atlas and red data book of the frogs of South Africa, Lesotho and Swaziland. SI/MAB series 9. Smithsonian Institution, Washington DC.

³³ Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J., & de Villiers, M.S. 2014. Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. *Suricata* 1. South African National Biodiversity Institute

³⁴ SABIF is the South African node of the Global Biodiversity Information Facility (GBIF).

with the climate, geology, fauna and flora of the Karoo including Dean & Milton (1999)³⁵ and other more specific works cited in the relevant sections of the baseline description.

2) Habitat sensitivity map for the study area

The habitat sensitivity map for the SKA1_MID SEA study area was based on using available GIS coverages including various terrestrial ecosystems and biodiversity data, surveys recently carried out by SAEON staff in the SKA area³⁶, and the expert's mapping from Google Earth satellite imagery (altitude 1 to 2 km). Sensitivity to physical disturbance (roads, radio telescope installations, trenches and powerlines) was prioritized using a method modified from that used in South African conservation plans (Skowno et al. 2009³⁷). Sensitivity prioritization scores consider components of functionality (water provision, dispersal corridor function, climate change resilience) and pattern (uniqueness, rare species, complexity, restoration potential). Nine criteria were taken into consideration when assessing habitat sensitivity and conservation importance as follows:

1. Structural complexity. Heterogeneous topography (rough surfaces with rocks and boulders, variation in slope and aspect) or multilayered vegetation (moss, grass, shrub, tree) offers a greater range of shelter sites and microhabitats, leading to more biodiverse communities. Complex habitats have greater conservation value. Coverages: Geology, Topocadastral maps, Google Earth imagery;
2. Key Resource Areas. These are habitats with higher than average productivity and that serve as refuges for plant and animal populations during severe droughts. They include drainage lines, run-on and pan areas, all of which are of high conservation importance because water is a scarce resource in the Karoo and because damage to such habitats has downstream implications (reduced quality of ground water, siltation of dams, loss of key resources for wildlife both on and off site). Mapping from Google Earth imagery;
3. Climate change refuges. Steep environmental gradients such as south-facing kloofs in arid mountains, and steep slopes of escarpments and mountains offer potential refuges for plant and animal species during global warming. Landscapes with such features have high conservation value. Coverages: topo-cadastral, relief;
4. Disturbance sensitivity. Habitats with stable substrates (bedrock, quartz patches, lichen fields) and other functional attributes that are difficult or impossible to reconstruct after disturbance are substrates that are more sensitive than less stable ones (loose sand or gravel). Coverages: relief, geology, mapping from Google Earth imagery;
5. Rare taxa. The number of threatened Red Data species or legally protected species present. Habitats with many species have high conservation value. Coverages: POSA plant species records per half degree, SANBI Red Data point distribution; bird, reptile and amphibian atlas data;
6. Size of the habitat within the prospecting area. Habitats found in a small part of the area are relatively more important than communities that cover most of the area because of their under-representation in the landscape. Data source: Google Earth, Landcover, CBA
7. Fragmentation. A high degree of natural fragmentation makes a community more susceptible to disruptions by development because plants and animals in the remaining (undeveloped) fragments cannot easily recolonize the disturbed fragment. Habitats that are naturally fragmented have greater conservation value scores because they have less resilience to disturbance. Data source: Google Earth, Landcover, CBA

³⁵ Dean, W.R.J. & Milton, S.J. 1999. The Karoo – ecological patterns and processes. Cambridge University Press

³⁶ Todd, S & Henschel, J. 2016. Background document SAEON@SKA - ecological research and monitoring framework. Unpublished document produced for a SAEON workshop held at Kirstenbosch on 16 January 2016.

³⁷ Skowno, A., Holness, S. & Desmet, P. 2009. Biodiversity Assessment of the Central Karoo District Municipality. DEAP Report EADP05/2008, 52 pages

8. Corridor function. Linear features such as rivers and long ridges provide corridors for the movement of plant seeds and animals between biomes and habitats. This may facilitate recovery of populations after disturbances such as droughts, floods and overgrazing. Functional corridors have greater conservation value. Coverages: Geology, Topocadastral maps, Google Earth imagery
9. Health. Habitat health is the degree to which a habitat has escaped past degradation by land management (e.g. grazing, ploughing, prospecting, invasion by alien organisms). Healthy habitats have greater conservation value. Coverages: Land Cover, CBA

The key assumption for the sensitivity analysis was that plant and animal species richness is correlated with habitat heterogeneity, based on the fact that vegetation associations and plant species are limited to a subset of substrates and habitats within Nama Karoo vegetation types (Lloyd 1989³⁸, Rubin & Palmer 1996³⁹, van der Merwe et al. 2008⁴⁰). Similarly, invertebrate species and some birds, reptile, amphibians and mammals may be habitat-specific. We therefore argue that land parcels within the SKA spiral arms that comprise four or more distinct habitats as defined by geology, topography and substrate, are likely to be more species rich than land parcels comprising two or three habitats. Habitat heterogeneity was the major surrogate used to generate sensitivity scores for quantifying likely response of the environment and biota to physical disturbance. Sensitivity was scored on the basis the number of habitat types (within each farm for the spiral arms and for a 25 square kilometer block for the SKA core area) was quantified and the score increased by 1 if rare species, water features or steep topographic gradient were present. Scored values were then classified as follows 1-2 =low sensitivity, 3-4 medium sensitivity, 5-6 high sensitivity.

The resolution of the sensitivity mapping was necessarily very coarse. For each of the 130 land parcels making up the three spiral arms, ten broad habitat features were mapped on Google Earth images from an altitude of 1-2 km. These were rivers and pans, alluvium, sand plains, sand dunes, dolerite outcrops and capping, mudstone plains, mudstone slopes, calcrete plains and disturbed areas (including ploughed lands, homesteads, water point piospheres, weirs, airstrips and cropfield dams (saaidamme) which are fields behind man-made dykes that trap occasional flood waters so that short-lived subsistence crops can be grown on unirrigated land). Sensitivity mapping of the SKA core area was based on the number of habitat units mapped by Simon Todd that occurred within 25 square kilometer grid blocks together with coverages of rivers, wetlands, topographical relief and red-listed plant and animal species.

3) Field survey

A field survey was carried out from the 14 to the 19th March 2016. Although Dr Sue Milton initially planned to sample 45 plots within 100 m from an existing vehicle track and within the areas to be affected by access roads, radio receptors or other infrastructure (offices, workshops, construction camps, laydown yards or refueling facilities) forming part of the SKA1_MID, this proved impossible for the following reasons: (1) some land-owners denied permission to visit the sites or could not be contacted, (2) many sites were remote, being far from public and farm roads, (3) in some cases accessing a single site by vehicle and foot took six hours. To assess the potential effects of the SKA infrastructure on the receiving environment, Dr Sue Milton observed the effects of new and old roads and of receptor dishes and trenching infrastructure on drainage, soil stability and invasive alien plants

³⁸ Lloyd, J. W. 1989. Phytosociology of the Vaalputs radioactive waste disposal site, Bushmanland, South Africa. *South African Journal of Botany*, 55, 372-382.

³⁹ Rubin, F. and Palmer, A.R. 1996. The physical environment and major plant communities of the Karoo National Park, South Africa. *Koedoe* 39:25-52

⁴⁰ vd Merwe, H., van Rooyen, M.W. & van Rooyen, N. 2008. Vegetation of the Hantam-Tanqua-Roggeveld subregion, South Africa. Part 2: Succulent Karoo Biome related vegetation. *Koedoe* 50: 160-183

within the KCAAA1 area and particularly in the SKA core area, described typical topographic and soil features and collected information on the vegetation in various habitat types. Dr Sue Milton then considered how the various features (e.g. rock sheets, pans, drainage lines, slopes), sensitive flora (e.g. *Aloe dichotoma* populations) might be impacted during the construction, operational and decommissioning phases of the project. Additional issues considered were interactions between physical disturbance and invasive alien plants, arid conditions, flash floods, skeletal soils and other characteristics of the Nama Karoo⁴¹.

During the field trip conducted in the SKA spiral arms from the 14 to the 19th March 2016, Dr Sue Milton collected vegetation data at nine sites along the spiral arms where radio receptors were to be installed. Dr Sue Milton also visited two sites in the SKA core area but did not collect structured data at those sites. Vegetation data collected from the 9 sample plots in the spiral arms were from sites identified by the preliminary mapping as being of high (2 plots), medium (3 plots) or low (4 plots) sensitivity. In addition, Dr Sue Milton recorded the presence of any animal species or its signs (tracks, eggs, dung, burrows, bones), and the nearby presence of habitat features that might sustain populations of plants or animals not recorded on the site (termitaria, cliffs, rock-pools, caves, rocky hills, river courses, springs). At each vegetation sample site (approximately 2500 m²) Dr Sue Milton photographed the area, numbered the photographs to match plot numbers and electronically archived them as JPGs. Dr Sue Milton recorded the following environmental data:

- Co-ordinates and altitude;
- Rock type (dolerite, mudstone, calcrete, tillite) and bedrock cover (%);
- Soil texture (cl = clay, si = silt, lm = loam, sa = sand), colour (brown, buff, grey) and depth (none, skeletal, shallow, deep);
- Drainage features (pan, rill, river bed);
- Total vegetation canopy spread cover (%);
- Estimated cover of the tree, shrub, succulent and grass components;
- List of all plant species encountered, including alien plant species and their abundance and distribution; and
- Existing disturbance or degradation features including roads, water points, ploughed land and erosion features.

Spiral arm parcels marked as heterogeneous on the basis of desktop studies were confirmed to be heterogeneous and those mapped as low habitat diversity were confirmed in the field to be homogenous plains. The areas mapped as having medium heterogeneity had low rocky features, the sensitivity of which would need to be evaluated in the field along paths of electrical infrastructure and on as yet unassessed receptor sites. Following the field trip, the preliminary habitat and sensitivity maps were revised. All produced spatial data were documented for submission in Shapefile format on a CD using Albers equal-area conic projection (Central Meridian: 24, Upper Parallel: -24, Lower Parallel: -33, Datum WGS 1984, Prime meridian Greenwich). The sensitivity of only one mapped unit was changed following the field trip, namely the dolerite hills within the SKA core area was in a square mapped as medium sensitivity prior to the field trip. A visit to this site revealed a population of *Aloe dichotoma* on the top of this hill. The sensitivity of the square was therefore changed from medium to high. During the survey all parts of the survey area with the exception of a few farms to the north and east of Van Wyksvlei were in a state of severe drought. No geophytes or annual plants were present, shrubs were brown and leafless or semi-leafless, and grasses were absent or reduced to tussock bases. This state of the vegetation meant that it is likely that many plant species were overlooked, many animal populations were reduced or aestivating and that nomadic birds and animals had left the area. The surveys thus underestimated the species richness of all areas.

⁴¹ Milton, S.J. & Dean, W.R.J. 2015. Guidelines for NAMA KAROO ECOSYSTEMS (draft chapter for Fynbos Forum Ecosystem Guideline Series)

4) Data sources

The following data sources were used during the Ecology and Biodiversity assessment:

Data title	Source and date of publication	Data Description
Topography, soil & water		
Geology of South Africa	Council for Geoscience	shapefiles
Rivers, Inland Water, Relief, Roads, Rail	Chief Directorate : National Geo-spatial Information coverages for all the degree squares in the KCAAA1 area (mostly 2007-2009)	shapefiles
Rainfall and temperature	National Department of Agriculture	shapefiles
Land parcels	The Council for Scientific and Industrial Research (CSIR) outlines of all landparcels in the SKA1_MID development including the Spiral Arms	shapefiles
Conservation status		
National Spatial Biodiversity Assessment (NSBA) 2004	South African National Biodiversity Spatial Assessment 2004: Technical Report s forming part of the National Spatial Biodiversity Assessment (NSBA) of the National Biodiversity Institute (2004)	Vegetation type conservation status
Critical Biodiversity areas for Central Karoo & Namaqua District	SANBI BiodiversityGIS (BGIS) spatial data website (2009)	shapfiles
Freshwater Ecosystem Priority Areas (FEPA)	SANBI BGIS spatial data website	shapfiles
Landscape heterogeneity	An index developed by SJM that includes the presence of various types of geology, waterbodies, soil types, and slopes within a land parcel. Mapping of diversity was carried out using Google Earth imagery to create polygons that were then classified and converted to Shapefiles	shapefiles
Vegetation & flora		
Vegmap	Mucina, L & Rutherford, M.C. (eds). 2006. The vegetation of South Africa, Lesotho and Swaziland. <i>Strelitzia 19</i> , South African National Biodiversity Institute, Pretoria.	Shape files obtained from CSIR
POSA	Plants of South Africa Database on the SANBI website (2006)	Plant species lists for quarter degree squares
SANBI	SABIF South African Biodiversity Information Facility (2005 & 2006)	Plant and animal species lists for quarter degree squares
SJ Milton vegetation data	SJ Milton vegetation surveys relevant to KCAAA1 but carried out for other clients (1988-2016)	Plant Species lists
Fine scale vegetation map (S. Todd)	Draft shapefiles for fine scale map of vegetation in the SKA1_MID project area produced by Simon Todd (SAEON) and made available to SJM (2016.03)	Shapefile
Alien vegetation Prosopis	WfW map Obtained from CSIR (2007)	shapefile
Fieldwork for SKA	Fieldwork conducted for the CSIR SKA SEA project in the SAK Phase 1 area (March 2016)	Species lists, photographs, observations
Fauna		
Bat roosts clip	CSIR	shapefile

Data title	Source and date of publication	Data Description
Bird Atlas	South African Birds Atlas Project, Avian Demography Unit, University of Cape Town	Bird species lists and spatial distribution data (point data text file)
WRJ Dean avifaunal data	Own data transcribed from field observations and museum records (1960-2016)	Georeferenced species occurrence records
Important Bird Areas (IBA)	Map showing important bird areas. Birdlife South Africa and CSIR	Shape file
SKEP expert maps for birds, reptiles, invertebrates, processes	Succulent Karoo Ecosystem Programme (SKEP) maps and information (Archived: 2003)	Shape files
NC Ramsar sites	DEA State of the Environment website (2008)	shapefile
WRJ Dean PhD thesis	Printed copy of Where birds are rare or fill the air: the protection of the endemic and the nomadic avifaunas of the Karoo. Zoology Dept., University of Cape Town (1995)	Bird protection priority areas
Reptile atlas	Maps and descriptions of South African Reptiles	Reptile lists for study area
IUCN mammals	The IUCN Red List of Threatened Species CSIR and IUCN website (various dates, downloaded 2016)	Shape files and species descriptions
Development		
Mining rights clip	CSIR	Shape file
Petroleum exploration areas	http://www.petroleumagencyrsa.com/images/pdfs/Hubmap0216a.pdf	Location of gas application areas
SKA Electricity and optic fibre infrastructure	CSIR	Kml file
NPAES	National Protected Area Expansion Strategy 2008 (NPAES) SANBI, BGIS website http://bgis.sanbi.org/protectedareas/NPAES.asp	Shape files

III. Sensitivity assessment

1) Key sensitive ecology and biodiversity features

The following ecology and biodiversity features present within the study area are sensitive and their integrity is essential for the conservation of endemic plant and animal species of the area:

- The temporary shallow waterbodies existing in the centre and north of the SKA1_MID SEA study area are important for ephemeral aquatic fauna (crustaceans, worms) and algae that are the staple food of large water birds and waders including Flamingos, Pochard, Avocet, Shelduck. Figure 11 illustrates an ephemeral pan within the Brandvlei spiral arm of the SKA1_MID SEA study area;
- The dolerite ridges occurring within the SKA1_MID SEA study area represent boulder-strewn habitats and offer sheltered establishment sites for a wider diversity of plants than found on the plains. The vulnerable Aloe dichotoma populations are largely restricted to these habitats.
- The exposed sandstone bedrock sheets occur in Ecca and Beaufort sedimentary deposits, mainly in the south of the study area, and particularly on the rims of ridges and hills. They provide specialised habitat for dwarf succulents endemic in the Nama Karoo (Chasmatophyllum, Deilanthus, Stomatium). Horizontal fracturing associated with such rock

sheets provides shelter of vulnerable species of reptile (Karoo Padloper Tortoise, Karoo Sandlizard), as well as some endemic invertebrates (Rock Scorpions);

- The Red sand dunes are the habitat of the Red Lark which is endemic to the northern part of the Nama Karoo. The Red Lark was seen on the red sand dunes within the SKA1_MID SEA study area;
- The deep alluvial silty soils are the habitat of the Critically Endangered Riverine Rabbit. These habitats are threatened by soil erosion and denudation caused by past ploughing, by alteration of drainage patterns and by invasion by alien *Prosopis* hybrids. Figure 12 illustrates the deep eroded alluvial soil with Ganna (*Salsola*) and Inkbos (*Bassia*) shrubs within the SKA1_MID SEA study area, which constitute possible Riverine Rabbit habitat;
- The Sclater's Lark habitat typically comprises sparsely-vegetated stony plains. This open ground nesting bird species is vulnerable to disturbance from off-road vehicles, livestock grazing and climate change;
- There are 91 plant species of conservation concern in the KCAAA1 area including *Aloe dichotoma*, *Hoodia gordonii* and *Acacia erioloba*. The lists of all plant species of conservation concern occurring in the KCAAA1 (and 47 species in the SKA1_MID SEA study area) are included in the Appendices. The Williston area has more listed species than the Brandvlei, Van Wyksvlei or SKA core area. There is an important *Aloe dichotoma* "forest" in the SKA core area; and
- Animals with listed conservation status (i.e. vulnerable, threatened, endangered) include 9 bird species, of which 5 are endemics, 9 mammal species, and one reptile species. The list of all animals occurring in the KCAAA1 with listed conservation status is included in the Appendices.



Figure 11: Pan within the Brandvlei spiral arm of the SKA1_MID SEA study area, Photo SJM



Figure 12: Deep eroded alluvial soil with Ganna (*Salsola*) and Inkbos (*Bassia*) shrubs

Based on the above, the following habitat types and plant species populations were identified as no-go areas for the final design phase of the SKA1_MID. These features are classified as no-go areas because damage to these habitats and populations is difficult to mitigate and impossible to repair:

- Red dunes – that are habitat for the narrow range endemic and substrate-restricted Red Lark (no go for receptor dishes, roads);
- Aloe dichotoma populations (no go for receptor dishes, roads, powerline servitudes);
- Ephemeral pans and wetlands where development may change drainage patterns and affect the wildlife (especially birds, amphibians and fish) that use the pans after rain (no-go for power lines, trenches and roads);
- Hills and steep slopes that cannot be restored once destroyed by blasting, trenching or road building (no go for roads because damage cannot be repaired); and
- Sandstone/mudstone rock sheets that are home to rare succulents and reptiles (no go for receptor dishes, roads and cable trenches because the damage cannot be repaired).

2) Key heterogeneous areas

Based on the assumption that plant and animal species richness is correlated with habitat heterogeneity, the most heterogeneous (and therefore sensitive) areas were identified as

- The southern mountainous third of the SKA core area where steep dolerite boulder hills and scree provide a range of aspects and protection from frost and sun. This area supports a large population of Aloe dichotoma;
- The eastern extreme of the Brandvlei Arm are in the East, and the adjacent northern edge of the SKA core area comprising ephemeral pans, dolerite and Ecca outcrops and outwash fans;
- The northern part of the Van Wyksvlei arm is heterogeneous, comprising dolerite outcrops, broken topography, and red dunes, whereas the areas in the centre of the arm are relatively level sand plains; and
- The heterogeneous topography near Williston where the broken topography comprises dolerite and mudstone hills, calcrete and sand plains and alluvium along the course of the Sakrivier.

3) Conservation priority areas of the KCAAA1

The western area of the KCAAA1 is highly sensitive as it includes a high density of plant and animal species richness, listed plant and animal species, protected area expansion priorities, bird protection priorities, Critical Biodiversity Areas, FEPA wetlands and rivers. This area should be prioritised for conservation purpose. The central and southern parts of the KCAAA1 include the habitat for endemic Karoo avifauna, bat roosts, Ecological Support Areas along major endorheic river systems, and much of the known distribution of the Riverine Rabbit. This area includes the SKA core area and should be the next focus for conservation of ecology and biodiversity within the KCAAA1. The third area of interest for conservation purpose within the KCAAA1 is the area south of Kenhardt which includes riparian corridors, habitat of Red Lark and Sclaters Lark and a large population (forest) of the Vulnerable Aloe dichotoma. These three parts of the KCAAA1 are illustrated in Figure 13 with a progressive order of priority in terms of conservation activities.

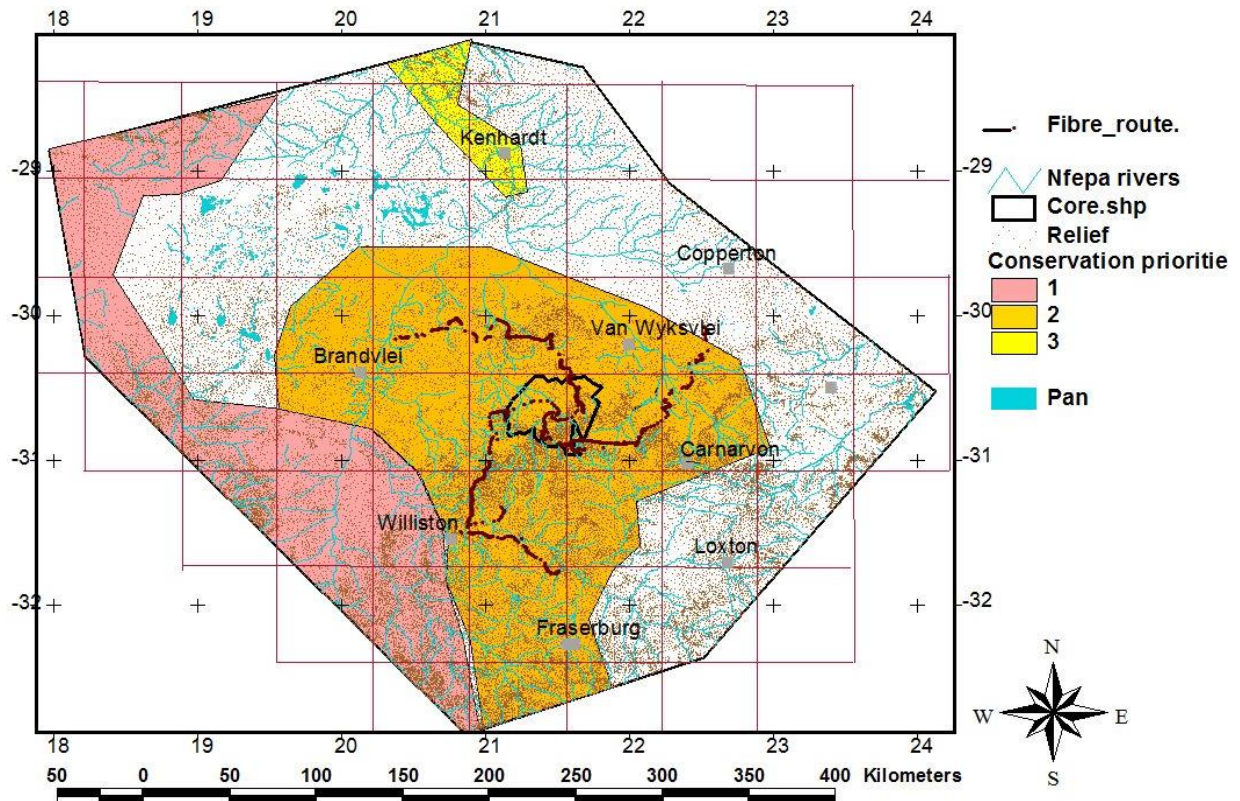


Figure 13: Conservation priority areas of the KCAA1

4) Detailed description of the sensitivities associated with the preliminary configuration of SKA1 MID

The sensitivity of the preliminary configuration of SKA1_MID's spiral arms i.e. the 21 SKA dish-antenna sites was evaluated on the basis of a desktop study that involved mapping on Google earth imagery and reference to the mapped conservation priorities including distribution of listed plant and animal species, critical biodiversity areas and wetland features. The sensitivity to physical disturbance (based on habitat heterogeneity), for the 21 SKA dish-antenna and their preliminary configuration is illustrated in Figure 14. Vegetation, geological, topographical, geological and land use data collected at nine sites and the sensitivity score derived from the desktop study was reconsidered after this ground-truthing activities. Classification of the footprint site as acceptable does not imply that the landscape in the two kilometres between the powerlines and the receptor footprint is acceptable for trenching to install cables, and it is recommended that all cable routes must be inspected by a botanist prior to finalisation of the infrastructure plans.

In the Brandvlei spiral arm:

- SKA005 dish-antenna, is placed on gentle sandy slop with some minor drainage on the ZOUT POORT farm. The site consists of alluvial delta, mudstone & dolerite, on a flat area with some drainage features. There are a few tracks or disturbance. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure, and the heterogeneity of the site was scored 3.
- SKA 006 dish-antenna, is placed on sandy gentle slope at base of dolerite outcrop among massive scattered dolerite boulders & near calcrete outcrop on the JAN LOUWS KOLK farm.

The site consists of Dolerite, calcrete, sloping northwards 50 m fall over 9 km, much exposed rock, minor drainage, no habitation, minor disturbance. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity but further field research is required prior to construction, as the access to the site was refused by the land owner during the fieldwork, and the heterogeneity of the site was scored 3.

- SKA 007 dish-antenna, is placed 300 m from farm track in gap in low dolerite ridge, on the RIET KOPS KOLK farm. The site consists of large area of broken topography, dolerite & mudstone, rocky outcrops drainage towards Verneukpan, silty plains. There are water points, grazing scars, numerous roads, some with berms. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure, and the heterogeneity of the site was scored 4.
- SKA 008 dish-antenna, is placed on mudstone outcrop elevated 2 m on the RIET KOLK farm. The site consists of Mudstone & dolerite plains bounded by Sakrivier alluvium to west. E-W drainage toward Sak. Not much disturbed, 1 farmstead, few tracks. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity but further field research is required prior to construction, as the access to the site was refused by the land owner during the fieldwork, and the heterogeneity of the site was scored 3.
- SKA009 dish-antenna, is placed on level mudstone gravel plains on the MOFFYS DAM farm. The site consists of large property split by R357. Includes mudstone plans, a scarp to the S, rocky outcrops, a large pan, small dunefields mostly ripped, drainage, farmstead & lands. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity but further field research is required prior to construction, and the heterogeneity of the site was scored 5.
- SKA010 dish-antenna, is placed on outwash fan below dolerite ridge 400 m from access road. Slope gentle to moderate. Road downslope may erode on the GROOTKOLK A farm. The site consists of Part of large pan, outwash fans, and small steep hill 75 m high to east. Steep dolerite scarps on either side of pan & drainage feature. Mudstone slopes. Farmstead, much disturbance of sandy areas by ripping & pan by dykes. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity but further field research is required prior to construction, and the heterogeneity of the site was scored 5.
- SKA012 dish-antenna, is placed on the DUBBELDE VLEI NOORD farm. The site consists of Mostly a pan with some gentle shale foot slopes up dolerite hills. Farmstead, dykes, lands & ripping, *Prosopis* invasion. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure, and the heterogeneity of the site was scored 3. At existing water point accessed by farm track on flat ground. Damaged veld adjacent to pan. Farmer would need to relocate water point. Access from Meerkat 19 km, flat but may flood after rain. Vegetation cover is dominated (at approximately 25%) by with salt-tolerant non-succulent shrubs *Lycium pumilum* and *Salsola calluna*. Common succulents are *Psilocaulon utile*, *Mesembryanthemum tetragona*.

In the Van Wyksvlei/Carnarvon spiral arm:

- SKA004 dish-antenna, is placed on the KLEIN MARKT farm. The site consists of complex landscape including dolerite mesa, scarp, mudstone slopes, drainage valley, farmstead, old lands. The dish-antenna site has been inspected and found unacceptable for the receptor dish infrastructure. Siting of dish is on dolerite ridge, species rich and impossible to restore. Large dolerite boulders make building impractical. Heritage material present on ridge. The specialist recommended the dish-antenna to be moved to sand plains near access roads on 36/1 (Leeukolk) or 37/2 (Fortuinskolk). A botanist must inspect the alternative site prior to construction. The heterogeneity of the site was scored 4.
- SKA011 dish-antenna, is placed on situated in an ephemeral floodplain or pan possibly ploughed in past. About 20 km farm tracks from Carnarvon-Prieska road on the BOTTEL PUT farm. The site consists of Dolerite-capped mudstone hills and broad silty drainage feature with

many dykes, farmstead (ruined) & watering points. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity but further field research is required prior to construction as the access to the site was refused by the land owner during the fieldwork, and the heterogeneity of the site was scored 3.

- SKA021 dish-antenna, is placed on sandy plain behind a dolerite ridge, on the GARST KOLK farm. The site consists of Dolerite-capped mudstone hills, drainage and silty alluvium ploughed in places. Access road will need to be extended around dolerite ridge 2.6 km. Needs careful planning to avoid exacerbating soil erosion and spread of *Prosopis* (see suggested route). Marked *Aloe dichotoma* must be avoided by minimum of 30 m. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure, and the heterogeneity of the site was scored 4.
- SKA120 dish-antenna, is placed on Sandy or gravel plain, gentle slope, on the VILLIERS RUST farm. The site consists of Mudstone plains and gentle slopes with low dolerite outcrops. Minor drainage, farmstead, four or more water point, grazing scars. Site not sensitive but ACCESS ROUTE needs field check. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure, and the heterogeneity of the site was scored 3.
- SKA124 dish-antenna, is placed on level sandy and silty plain, on the WIT GRAS A farm. The site consists of Silty floodplain split by main road. Ploughing and dykes along all drainage features. Possible *Prosopis* invasion. Heuweltjies to east. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity but further field research is required prior to construction as the access to the site was refused by the land owner during the fieldwork, and the heterogeneity of the site was scored 2.
- SKA127 dish-antenna, is placed on level gravel plains, on the UITSPAN-KOLK farm. The site consists of Gently sloping mudstone plains with a farmstead, main road and a few water points and grazing scars.. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure, and the heterogeneity of the site was scored 2.
- SKA128 dish-antenna, is placed in a sandy valley 700 m from nearest track, on the STUURMANS FONTEIN farm. The site consists of Rugged landscape with extensive dolerite capping, mudstone hills and slopes, minor drainage in valleys, farmstead with corbelled houses, roads, fences, water points, livestock tracks.. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity but further field research is required prior to construction as the access to the site was refused by the land owner during the fieldwork,, and the heterogeneity of the site was scored 4.

In the Williston spiral arm:

- SKA112 dish-antenna, is placed on gently-sloping sandy plain below dolerite mountain, on the WATERKLOOF farm. The site consists of Dolerite-dominated table land 50 m above surrounding plains. Roads, waterpoints, minor drainage. Calcrete patches in dolerite. Small area of ploughing. Uninhabited. Scattered dolerite boulders may have heritage value. Veg dominated by *Rhigozum trichotomus* and *Stipagrostis* spp. Site best accessed from the SKA core area to avoid rocky ground & rivers to west. Sheet erosion evident at boulder base 100 mm. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure, and the heterogeneity of the site was scored 4.
- SKA122 dish-antenna, is placed on on flat silty to sandy plains, on the ZAND PUTS farm. The site consists of Silty and sandy plains, dunes, dolerite outcrops and dykes, pan and minor drainage. Numerous small ploughed patches and ripping. Farmstead, roads, waterpoints and grazing scars. Access would need to cross silty drainage dammed by a crop field weir

(saaidam). Vegetation dominated by *Rhigozum trichotomum* & *Stipagrostis* spp on site. Main risk is erosion of deep silty soils or changing flow regime. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure,, and the heterogeneity of the site was scored 4.

- SKA129 dish-antenna, is placed on dolerite outcrops on gently sloping grounds with scattered dolerite rocks, on the BISSIES EN ANTEEL KOLK farm. The site consists of Silty and stony plains with dolerite outcrops to north and south. Heuweltjies on mudstone in SW. Farmstead, ploughed alluvium, many waterpoints, roads, fences. Veld condition seems poor. No track from road. Access route from public road (0.6 km) would cross three sandy river beds. No sensitive plants species - mainly *Pentzia incana*, *Phaeoptilon spinosum*, *Ruschia spinosa*, *Salsola aphylla* and other non-succulent shrubs. Main risk is soil erosion. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure,, and the heterogeneity of the site was scored 3.
- SKA130 dish-antenna, is placed on Sandy plains dominated by *Rhigozum trichotomum* and *Stipagrostis* spp., on the KOEGA farm. The site consists of Rocky landscape with dolerite capping and mudstone hills and plains. Incised drainage. Not much recent land use. A few roads, water points and old lands. No habitation. No sensitive plant species. New access track required 0.5 km from public road to site, will cross minor dry drainage lines. Main risks soil erosion and *Prosopis* invasion. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure,, and the heterogeneity of the site was scored 4.
- SKA131 dish-antenna, is placed on gentle sandy slope below dolerite spitzkop and is affected by drainage from the hill above, on the BANKSFONTEIN farm. The site consists of Dolerite, mudstone slopes and plains, very steep inselberg, incised drainage, farmstead, roads, water points, ploughed sandy alluvium. No sensitive plant species. Site is. Access would require crossing a broad drainage line 3 x on the farm track to the water point and making a new track from watering point and along hillside. Main risk is soil erosion. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure,, and the heterogeneity of the site was scored 4.
- SKA132 dish-antenna, is placed on sandy plain adjacent to an existing well-graded game farm road, on the VLOKS WERVEN farm. The site consists of Mudstone plains, small area of dolerite, water points and grazing scars, saaidamme on sandy alluvium, erosion works on minor drainage, two farmsteads (one perhaps associated with RE168). Main risk is interference with the game farm operation, visual impact, and proximity to farm house (1km).The dish-antenna position was assessed to be "acceptable" in terms of biodiversity i.e. the site is not expected to be highly sensitive to the dish-antenna infrastructure,, and the heterogeneity of the site was scored 5.
- SKA133 dish-antenna, is placed on mudstone table <200m from tributary of Sakrivier, on the KORFSPLAATS farm. The site consists of Dolerite, mudstone, sand, incised drainage lines. Sandy and silty alluvium ploughed in places, perennial river, farmstead, water points, roads. *Prosopis* present in river bed. The dish-antenna position was assessed to be "acceptable" in terms of biodiversity but further field research is required prior to construction as the access to the site was refused by the land owner during the fieldwork, and the heterogeneity of the site was scored 4.

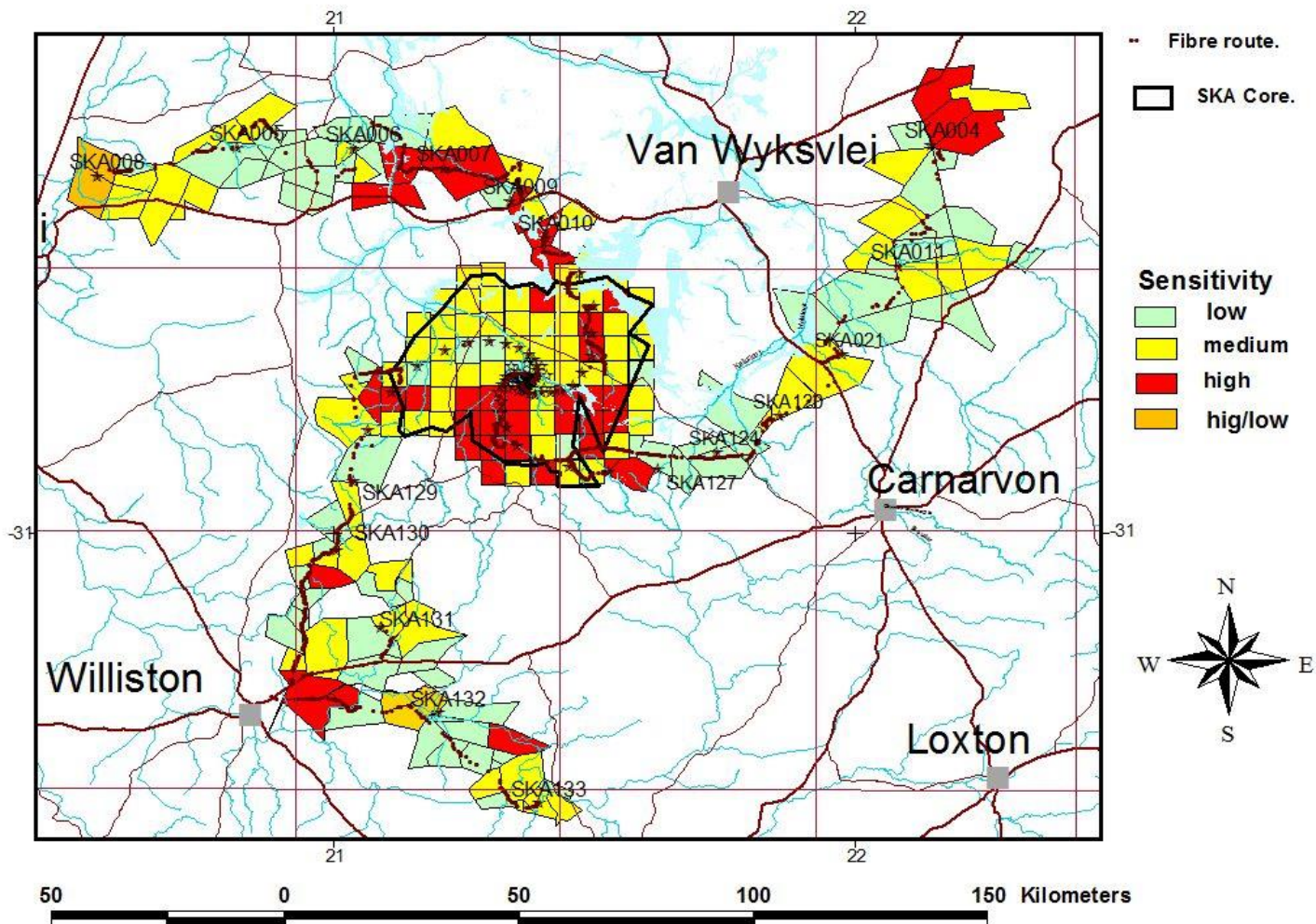


Figure 14: Sensitivity to physical disturbance (based on habitat heterogeneity), within the SKA1_MID Core and spiral arm development areas. Receptor stations (star symbol) on the spiral arms are numbered. Rivers and pans (blue) and major roads (brown) are indicated

IV. Potential impacts of SKA1_MID on ecology and biodiversity within the SKA1_MID SEA study area

1) Impacts related to the SKA core area land acquisition

The removal of livestock from the SKA core area is likely to have a positive effect on flora and fauna because the populations of palatable plants are likely to increase; grass cover important for some endemic bird species is likely to increase. The resulting denser vegetation cover may also benefit listed species including Riverine Rabbit and Karoo Padloper tortoise. These changes need to be monitored but are provisionally assessed as positive, local, long-term, highly reversible (when land use changes again), of medium intensity (in that cover changes will be slow and rainfall-limited), and highly probable. The significance is medium and positive. No mitigation is required but monitoring of vegetation and animals inside and outside the livestock removal area would be of interest to SAEON, ecologists and agricultural scientists.

The cessation of any on-going predator control activities (e.g. gin trapping, hunting and poisoning) is likely to lead to a change in the age structure and a stabilization of the jackal and caracal populations in the area (Minnie et al. 2016)⁴². Variations in the distribution and abundance of other fauna such as Bat-eared Fox, Cape Fox, Aardwolf, Aardvark, Porcupine, vultures and raptors are likely to be observed as resulting consequence of the increase, stabilisation or change in age structure of the predator population. Densities of meso-predators (mainly mustellids such as mongooses, polecats and suricates), and their impacts on ground-nesting birds, are expected to decrease as larger predators (Leopard, Black-backed Jackal and Lynx) return (Lloyd 2007). These changes are assessed as positive or neutral, local in extent, long term (in that they will last for the duration of the predator control amnesty), highly reversible, of medium impact (no major change in ecosystem functioning) and probable. The overall significance may be medium and neutral. No mitigation (such as continued predator control) is required, but monitoring of predators both inside and outside SKA management area through use of trap cameras or tracks is recommended. The results would be of interest to SAEON, ecologists and agricultural scientists.

The potential termination of ground water supply to livestock drinking facilities within the SKA core area should limit increases in any surface water-dependent wildlife present in the area. This will keep wildlife populations at densities that are sustainable and do not require culling or any other type of management. In terms of conservation of the original flora and fauna of the area this impact can be seen as neutral to positive. Closure of water points during the operational phase should limit increases in any surface water-dependent wildlife present in the area. This will keep wildlife populations at densities that are sustainable and do not require culling or any other type of management. In terms of conservation of the original flora and fauna of the area this impact can be seen as neutral to positive, local in extent, long-term (throughout the operational phase), highly reversible (following change of land use), of medium intensity for the species affected, and highly probable (for water-dependent animals species). The unmitigated significance is assessed as medium. It is uncertain whether any mitigation should be implemented as reduced input into wildlife management could be considered positive for the environment. It is recommended that populations of surface water-dependent species

⁴² Minnie, L., Gaylard, A. and Graham I. H. Kerley, G.I.H. 2016. Compensatory life-history responses of a mesopredator may undermine carnivore management efforts. *Journal of Applied Ecology* 53, 379–387,

be monitored using methods that do not conflict with SKA activities (spoor counts, approved trap and cameras web-cameras).

The effects of internal stock fencing and boundary fencing on the movement of wildlife have apparently never been quantified in the Karoo. However fences restrict the movement of animals that are unable to jump or fly over, squeeze through, or burrow under fences⁴³. Removal of internal fencing on farms within the SKA core area is likely to have little if any effect. However, removal of fences between boundaries of farms within the SKA core area may facilitate movement of mammals and reptiles, and in this way facilitate seed dispersal. Reducing of the permeability of fences on the boundary between the SKA core area and neighbours may restrict movement of animals such as Black-backed Jackal, Lynx, Leopard, Riverine Rabbit, Aardwolf, Bat-eared Fox, and Leopard tortoise between the SKA core area and surrounding farms. In the long-term this could influence the genetic makeup of the isolated populations⁴⁴. Low electric cables on fences kill medium-sized animals, particularly Leopard Tortoise (*Stigmochelys pardalis*), Rock Monitor (*Varanus albigularis*), Pangolin (*Manis temminckii*), and Porcupine (*Hystrix africae australis*)⁴⁵ as well as restricting movement. Increasing the height of boundary fences is likely to lead to mortality of large birds such as Kori Bustard (*Ardeotis kori*, Ludwigs Bustard (*Neotis ludwigii*), Blue Crane (*Grus paradiseus*) and Flamingos (*Phoenicopterus* spp.) that need long runways to take off and clear high fences⁴⁶. All these species are Red Listed as Vulnerable, Near Threatened or Endangered. The unmitigated re-enforcement of boundary fencing through increasing height, use of wire mesh or electric cables lower than 0.2 m from the ground is assessed as being of medium and negative significance for some wildlife populations, including population of threatened mammals. With mitigation (no electric fencing) the significance would be negative but low. The significance of removal of internal fencing within the SKA core area farms is likely to be low and positive.

Furthermore, the potential exclusion of mining activities within the SKA core area (and potentially some parts of the KCAA1 based on the Astronomy Geographical Advantage Act represent a positive regional impact. There are currently a number of applications for shale gas prospecting, and licenses for mining of uranium within the KCAA1 area which have the potential to negatively affect the ecology and the biodiversity of the Central Karoo as a result of the following activities:

- groundwater extraction may result in reduced surface water and mortality of aquifer-dependent trees;
- heavy traffic on gravel roads will increase dust and roadkill;
- night light and noise may disrupt faunal activity; and
- hard rock habitats will be destroyed permanently by mining and blasting.

2) Impacts related to the extraction of material with borrow pits and quarries

Construction of roads and pedestals for the receptor dishes will require construction materials, including crushed rock, gravel and sand. Rock suitable for construction of hard surfaces and concrete is usually quarried from exposed bedrock, often dolerite. Gravel is usually excavated from so-called "borrow-pits" in soft rock (typically mudstone or calcrete). Sand suitable for concrete making is usually mined from Aeolian sand deposits or from river beds. All these types of mining are listed activities that

⁴³ Lindsey PA, Masterson CI, Beck AL & Romanach S. 2012. Ecological, social and financial issues related to fencing as a conservation tool in Africa. pp 215-233 in Somers M J & Haywood M 2012 Fencing for Conservation: Restriction of Evolutionary Potential or a Riposte to threatening processes? Springer, New York

⁴⁴ Miller SM, Harper CK, Bloomer P, Hofmeyr J, Funston PJ. Fenced and Fragmented: Conservation Value of Managed Metapopulations. Roca AL, ed. PLoS ONE. 2015;10(12):e0144605. doi:10.1371/journal.pone.0144605.

⁴⁵ Beck, A. 2010. Electric fence induced mortality in South Africa. MSc thesis, University of the Witwatersrand

⁴⁶ Prof. Peter G. Ryan, Percy FitzPatrick Institute for African Ornithology (personal communication 2016.10.10)

potentially have negative, local, irreversible, long term, high intensity impacts on the environment, and consequently have high significance without mitigation. Mitigation includes inspection of selected and alternative quarry or borrow pit sites by a qualified ecologist, avoidance of sensitive habitats and listed species, minimisation of damage, and post damage rehabilitation. With mitigation the effect remains negative, site specific, long term, but should have a lower impact, and be of medium significance.

3) Impacts related to the construction and upgrading of access roads

In poorly-drained plains, pans, floodplains and across drainage lines, access roads that carry heavy construction vehicles – such as those required to transport cranes, concrete stone and telescopes – need to be built up above the flood line. The process of construction of heavy duty roads involves vegetation clearing, cutting and filling of ground, soil disturbance, use of heavy machinery, mining, quarrying or import of stone and sand from other areas.

During the construction of larger roads, additional, parallel, temporary service roads are constructed in order to transport materials to the road construction site or to allow alternative access. All these road-construction activities, in combination, increase the risk of importation and dispersal of seeds of invasive alien plants. Invasive alien plants such as *Prosopis* sp., but also such herbaceous weeds as *Xanthium* spp., *Datura* spp., *Pennisetum setaceum*, *Salsola kali* and *Atriplex nummularia* are likely to establish on disturbed ground adjacent to new roads following completion of road building activities.

During the construction phase, the road-construction activities, i.e. clearing, filling, compacting, spills, topsoil loss, can damage indigenous vegetation and soil fauna, and can disperse seeds of invasive alien plants. This has a negative, local (e.g. could affect drainage or weed invasion at some distance from the road), high, long-term impact with low reversibility in an arid environment where compaction reduces infiltration of water and vegetation recovery is gradual and linked to episodic (possibly once decadal) effective rainfall events, with flash-flooding probable. Without mitigation the impact will definitely take place and significance will be high. With mitigation, especially avoidance of sensitive areas, vegetation loss can be reduced, sensitive areas avoided, topsoil saved, rehabilitation initiated and weeds controlled. The impacts with mitigation will be site specific and long term with low reversibility, but of medium intensity and probability and therefore the overall significance with mitigation will be medium.

The construction of roads (and other infrastructure) on top of rocky hills to enable access for the installation of web cameras, satellite dishes, or electrical infrastructure, are indelible. Rocky hills (hills) generally support more species of plants and animals than flat areas, and many of the listed invertebrates, reptiles, small mammals and plants are restricted to hills. Construction activity on tops and slopes of hills therefore has a greater impact than on flat areas. Hills cannot be rehabilitated so that the road scar disappears. Impacts of road construction on hills are therefore negative, regional or national (in that they affect listed species), permanent and irreversible with a potentially high intensity. Negative impacts will definitely occur in that the construction process will remove plants and animals and create a permanent scar that initiates soil erosion. The significance of construction on hills is therefore high. With mitigation that involves avoidance of hills and substitution of roads with mule trails or paths for installation of light equipment on hills, the significance of the impact can be reduced to medium or low.

Built up roads in endorrheic drainage areas disrupt water flow and concentrate water flow into culverts. Concentration of water flow on fine-textured soils can lead to gully erosion. Most of the roads in the poorly-drained SKA core area will be built up above the floodplain, disrupting water flow, damming up water in places and starving some ephemeral wetlands of water, possibly exacerbating

invasions by invasive alien plants, and causing soil erosion where water is concentrated by culverts and drainage ditches. This impact is expected to be local, affecting soil movement and water flow many meters from the roads. Figure 15 illustrates the ways in which built-up roads alter the landscape during the operational phase. The changes in the distribution of water, damming it on the upslope side of the road, can induce starving of the down-slope side of water. This over the long term will lead to vegetation change and may promote invasion of alien plants (*Datura* spp., *Nicotiana glauca*, *Prosopis* sp., *Xanthium* spp.), particularly along cleared and disturbed ground adjacent to roads, where water is dammed up, and in gullies formed by culvert discharge. Long term road impacts should be moderately reversible once decommissioned. The impact intensity is medium, and will probably take place in much of the SKA area. The overall significance is therefore medium without mitigation. Mitigation will involve keeping all culverts open; monitoring soil erosion associated with culverts, and reducing the force of runoff water where erosion is causing dongas (erosion gullies), monitoring and controlling woody and perennial invasive alien plant species along road side annually. With mitigation the effects of roads on water and plants will be local, temporary, moderately reversible, with low impacts and low probability of doing damage and therefore the overall impact of roads with mitigation will be low.

During the operation phase, road operation will result in roadkill of slow-moving, basking, scavenging, crepuscular and nocturnal animals that rest on roads, forage on roads, or cross roads. Roadkill caused by SKA roads is assessed as negative for biodiversity, regional or even national (depending on whether critically endangered animal species are victims). The impact will be long term (throughout the life of the SKA and may have long term effects on the demography of some species). After decommissioning the impact is moderate reversibility. The impact of road operation, although highly probable, is of medium significance without mitigation because most SKA roads will not be used very frequently or by very fast-moving vehicles. The most effective mitigation would be the imposition of a 60 km/hr speed limit on those roads likely to be driven daily at high speeds by SKA personnel or contractors (e.g. road between Carnarvon and the SKA). Mitigation should include monitoring to determine which road sections pose high risks to listed animal species. Use of underpasses in combination with fencing, and erection of signs at sites with higher collision probabilities may help to reduce the impacts. With mitigation we estimate with medium confidence that roadkill impacts will be lower and less likely although still long term and of regional and therefore the overall significance with mitigation could be low.

Finally, the roads up hills can accelerate water runoff and initiate soil erosion, as well as providing vehicle access to listed plants and animals confined to these relatively inaccessible areas. These impacts are assessed as negative for biodiversity and the environments, of local scale but permanent in duration (since road scars on steep, rocky hillsides cannot be obliterated). They have low reversibility. Impacts are of medium intensity by highly probable. The operation of hillside roads without mitigation therefore has medium significance. Careful management of soil erosion structures (berms, ditches) to shed and spread water will reduce soil erosion impacts to medium low. Strict supervision of visitors and work teams will reduce access to rare listed plants and animals during the operational phase. Roads no longer required for infrastructure must be closed and rehabilitated. These mitigation actions will reduce the significance of hills roads to low during the operational phase.

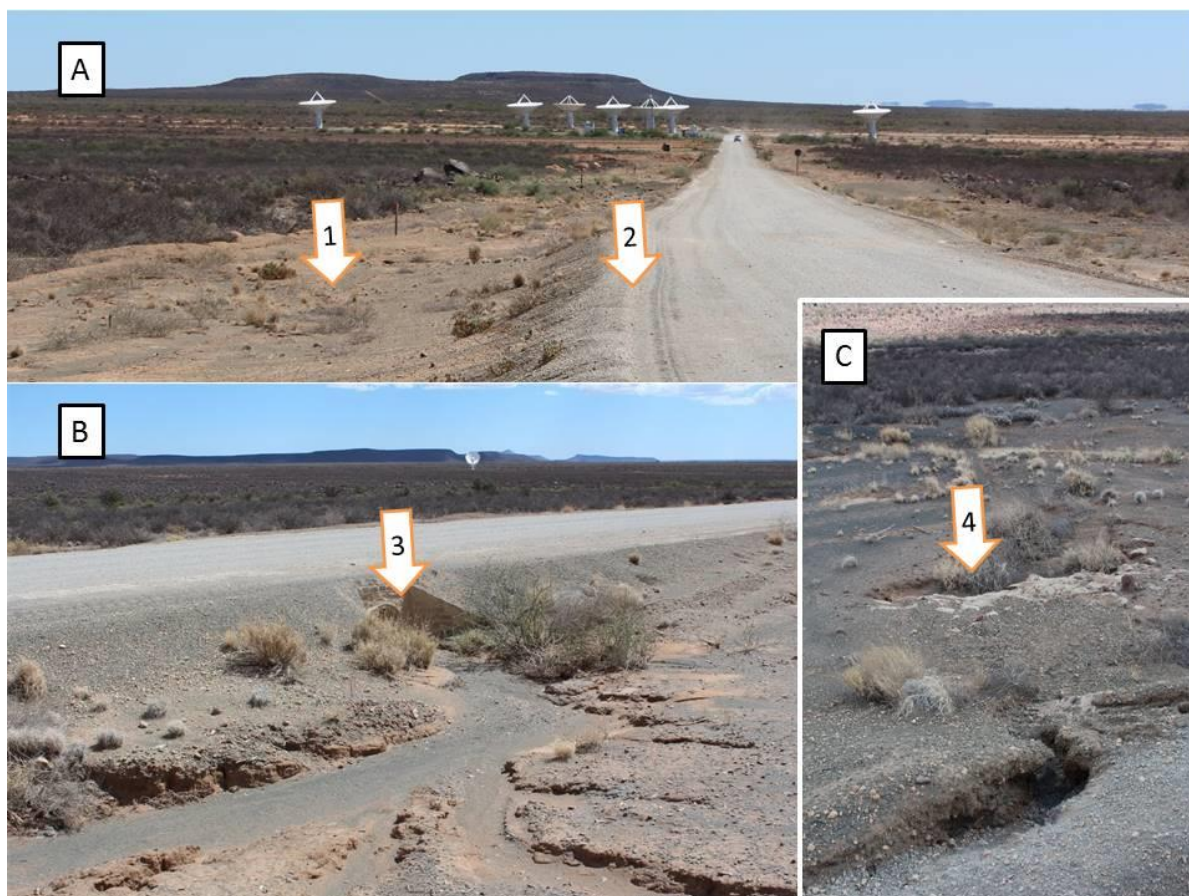


Figure 15: Disturbance to vegetation, soil structure, and water distribution caused by installation of built up roads across endorheic areas, poorly-drained plains and pans. Arrows indicate (1) bare soil adjacent to the road, (2) built up road surface, (3) a small culvert channelling water, and (4) rills resulting from water channelled by a culvert in the SKA Core area. Photography: Lydia Cape

Roads that are not built up significantly above the surrounding landscape, nevertheless shed water from their hardened bare surfaces. Runoff from both tarred and gravel roads results in increased growth of plants adjacent to roads, and to the establishment of weedy species adjacent to roads. In the SKA core area, runoff from roads is likely to increase the establishment of *Prosopis* near roads.

The green plant growth adjacent to roads in arid zones attracts animals (invertebrate and vertebrate herbivores and their predators), increasing the probability of roadkill (Lee et al. 2015⁴⁷). Birds and snakes may be more vulnerable to roadkill than mammals (Collinson et al. 2015). Slow-moving animals (tortoises, Chamaeleon), animals that bask on roads, i.e. as swallows, lizards, snakes (Lee et al. 2015), and nocturnal or crepuscular species, especially Bat-eared Foxes, Hares, Striped Polecat and Owls in the Karoo, suffer higher road mortality risks (Dean & Milton 2003)⁴⁸.

The roads constructed up hills accelerate water runoff and initiate soil erosion, the habitat cannot be rehabilitated. Roads up hills also provide vehicle access to listed plants and animals that were previously inaccessible to commercial collectors.

⁴⁷ Lee, E., Crost, D.B. & Achiron-Frumkin, T. 2015. Roads in the arid lands: Issues, challenges and potential solutions. Pp 382-390 in van der Ree, R., Smith, D.J. & Grilo, C. (eds) Handbook of Road Ecology. John Wiley & Sons, Sussex, UK.

⁴⁸ Dean, W.R.J. & Milton, S.J. 2003. The importance of roads and road verges for raptors and crows in Succulent and Nama Karoo, South Africa. Ostrich 74:181-186.

4) Impacts related to the construction of SKA dish-antennas

SKA1_MID comprises the construction of an additional 133 SKA dish-antennas with a footprint of 100 m x 100 m (1 ha). The area is initially cleared of vegetation. A concrete pedestal (5 x 5 m) is built to support the receptor. Each receptor is centred in on a slightly raised, gravel-surfaced circle with a diameter of approximately 50 m. This allows a large heavy vehicle to access the site and drive around the receptor pedestal (without sinking into mud after rain) so that the infrastructure can be installed and maintained. It is assumed that the gravel used for the turning circle is crushed dolerite which might be mined near Carnavon. The installation process results in soil compaction, alteration of habitats, and increased probability of soil erosion in the adjacent area. There is also the risk of lubricant and diesel spills. The impacts on vegetation, soil and rainfall infiltration is negative, local in that runoff may affect soil and vegetation within a few hundred metres of the site, long-term in that any soil erosion initiated during the construction process will remain active for decades, and have low reversibility, especially if the construction takes place in a sensitive environment such as on a hills, or dongas form around the footprint. The overall impact of construction is high and definite, and the significance is high without mitigation. With mitigation including the avoiding of sensitive sites, demarcation of the area used for construction vehicles and storage, cleaning up of pollution, control of weeds), the impact will be site specific, although long term. It will be moderately reversible and have a medium-low impact with a reduced probability therefore with mitigation the significance of this impact should be low.

During the operational phase there will be accelerated water shedding from the compacted, de-vegetated and built-up turning circle around the structure. The telescope dishes, pedestals, and the hardened gravel surrounds will shed water during rain. The water will run off the infrastructure faster than it would have run off natural vegetation. This in turn will cause soil erosion that may have a negative and local impact on the landscape (e.g. donga formation, sheet erosion, weed invasion). This might lead to gully formation around the telescopes, and increase the probability of establishment of invasive alien plant species in the receptor footprint runoff area. The impact will continue in the long term (throughout the life of the SKA and possibly after decommissioning). It will be moderate reversible over time and is of medium intensity, but highly probable. Without mitigation the radio telescope operation will be of medium negative significance for the environment. Mitigation involves managing the runoff from the structure to avoid concentrating runoff; sowing runoff areas with indigenous grasses to hold the soil in the erosion ditches or adding coarse gravel to the ditches, as well as monitoring and removing invasive alien plants from the surrounds of the receptor footprint annually. With mitigation the impact will be local or site specific with lower impacts and a low probability, so that the overall significance will be low.

The pedestals and antennas for the radio telescopes are large and substantial with an overall height of 19.5 m⁴⁹ and may be used by nesting birds during the operational phase. The sheer size and visibility (largely white) of the radio telescopes is unlikely to be a hazard to birds, and more likely to be a benefit and used as nest sites by some species, including the invasive alien House Sparrow. This impact could be seen as neutral or negative (if the structures facilitated invasion of the area by alien birds such as House Sparrows). The impact is site specific, short-term, highly reversible of low intensity but highly probable. The complex of struts and stays around the dish would be attractive to birds that build nests supported by a surrounding structure. The overall significance is low. Mitigation would involve monitoring and removal of bird nests at least twice annually. This mitigation would further reduce the significance of the impact to improbable and low.

⁴⁹ Technical Fact Sheet, South African MeerKAT Radio Telescope, March 2014

5) Impacts related to trenching for the construction of power and fibre-optic infrastructure for SKA1 MID

Within a 2 km radius of the dish-antennas, the fibre-optic cables and powerlines will be buried in 0.4m wide trenches at a depth of 800 mm with a footprint for the trenching machinery of 3.0 m wide. . The trenches will be backfilled with bedding sand and the original soil or rock material following the laying of the optic fibre and cables. A minimum of 42 km of trenches will be required to provide power and data transmission to the 21 receptors on the three spiral arms. The trenching activity will involve the movement of a large trenching machine or mechanical digger along new or existing roads, or into silty, sandy or rocky substrates in natural veld on a variety of inclines and in well and poorly-drained habitats. Trenching has potential to damage vegetation, alter drainage patterns, leave enduring scars on the landscape, kill or damage listed or protected plants or animals (Riverine Rabbit, Trap-door spiders, tortoises), particularly if this activity takes place across hard rock features such as dolerite hills, ridges, mudstone and sandstone rock sheets or through springs and seeps (fonteine). The activity is assessed as negative, of potentially regional magnitude (if listed species are affected), long-term, irreversible in hard rock substrates, and of high intensity. The unmitigated impact is of high significance. With mitigation including avoidance of sensitive habitats, salvaging of certain plants, acceptable topsoil management and rehabilitation, and weed management, although duration will remain long and reversibility low, the probability and intensity of the negative impact could be reduced so that mitigated significance is medium.

6) Impacts related to the Overhead electricity / optic cable operation

There will be a minimum of 392 km of overhead cables carrying optic fibre and Medium or low voltage electricity from the SKA core area to the 21 SKA dish-antennas in the three spiral arms. The paths of the overhead cables do not always follow existing roads therefore new access routes may be required to enable the installation team to install the poles using vehicle-mounted drill trucks, cable pullers and work teams. It is also envisaged that laydown areas will be required for storage of poles, fibre and cable. These activities have potential to damage vegetation, alter drainage patterns, leave enduring scars on the landscape, kill or damage listed or protected plants or animals (Riverine Rabbit, Trap-door spiders, tortoises). These activities have a negative impact in that they will damage and remove vegetation. The impact could be local, long term and of high intensity where the construction was carried out in sensitive habitats. Given that pole installation has a relatively small footprint, the impact should be moderate and reversible in most habitats although site specific impacts will be high and will definitely occur. Without mitigation the significance will be high. Mitigation including avoidance of sensitive habitats, cleaning up spills, rehabilitating camps & laydowns, monitoring weeds and removing new weed invasions reduces the extent, duration and intensity of the impact making it more reversible, so that the mitigated impact is low.

The infrastructure (illustrated in Figure 16) comprises steel or wooden monopoles each supporting 3 to 4 cables. The electricity/optic fibre overhead infrastructure is likely to remain in place for the duration of the SKA project. During that time fauna, particularly birds and bats, are likely to interact with the infrastructure resulting in some negative impacts on the fauna and vegetation.

Overhead cables and stay-wires on electrical infrastructure are hazardous for large flying birds, particularly those, such as large bustards, that have good downward vision in flight but that are almost

blind in the direction of travel (Martin & Shaw 2010⁵⁰). Ludwigs Bustard and Kori Bustard, both Red Listed, occur in the SKA Core and spiral arms land parcels. Overhead cables can kill large birds through collision with cables throughout the operational phase. The impact is assessed as negative of national extent (as large listed bird species are usually the victims), of long duration and low reversibility (since large bird populations have very slow growth). The significance of operating an infrastructure that will kill birds over many decades is seen as very high and highly probable. Bird unfriendly (Figure 17) overhead cable infrastructure is therefore of fatally flawed significance. The mitigation measures that could be implemented include markers and bird flappers visible to day- and night-flying species. With bird flappers as mitigation, the impact will remain negative, of national extent for listed bird species and long term. Intensity will be reduced to medium and the probability of the impact reduced. The mitigated significance will be medium.



Figure 16: Designs of overhead infrastructure carrying optic fibre and cables (A & B) steel monopoles, (C) wood monopoles (Photos by Lydia Cape)



Figure 17: Bird-friendly (✓) and bird un-friendly (X)

⁵⁰ Martin, G.R. & Shaw, J.M. 2010. Bird collisions with power lines: Failing to see the way ahead? *Biological Conservation* 143:2695-2702

Overhead infrastructure can cause kill large birds through electrification throughout its operational phase. This impact is assessed as negative, of national extent (as large listed bird species are usually the victims), of long duration and low reversibility (since large bird populations have very slow growth). The significance of operating an infrastructure that will electrocute birds over many decades is seen as very high and highly probable. There is a low likelihood of birds being killed by electrification along the steel monopole section of the electrical infrastructure route because the arrangement of the cables on the steel monopoles is bird friendly (Figure 17). However the arrangement of the cables on the wood pole sections of the line may be bird- unfriendly if the live cables are less than 2 m apart. In order for a power line to be designated 'bird friendly' it must not be possible for birds with large wingspans such as Cape Vulture and Martial Eagle (wingspan of 1.8 m–2.6 m) to breach the gap between 2 live conductors or between live and earth phases (ESKOM 2011⁵¹). Both species are Red Listed. Bird unfriendly overhead electricity infrastructure is therefore of fatally flawed significance. Given that the design of the steel monopoles in the SKA core area is bird friendly, mitigation efforts should focus on the wood pole section of line with the three Phase 1 arms of the SKA. Contracts must ensure that it is not be possible for birds with wingspans >2.0 m (vultures, martial eagles) to breach the gap between 2 live conductors or between live and earth phases. With this mitigation the impact of operating overhead electricity infrastructure is reduced to low significance.

It has been noted that power to the antennas in the field will be provided by a combination of medium voltage and low voltage underground cabling and overhead power lines, and that overhead power lines. The design of the poles and insulators does not offer any suitable sites for nests of large raptors, but it is likely that crows (both Cape and Pied) will nest on the insulator carriers (Figure 18). Similarly, Sociable Weavers are highly likely to build nests on the poles, using the insulator carriers as a starting (foundation) point (Figure 18). The crow nests are unlikely to cause any shorting-out problems, except where crows include conductive material such as wire that can cause faults. Nests of the Sociable Weaver could cover two or more cables and have a high probability of shorting-out if the nest becomes wet during rain. Large nest built on power line supports by Crows, Sociable Weaver and raptors that build on top of these nest, can cover two or more cables and have a high probability of shorting-out if the nest becomes wet during rain. Nest building will occur throughout the operational phase and may have a negative, local, temporary, highly reversible effect of medium intensity and high probable on the power supply of the SKA as well as on the birds themselves if the nests are set on fire during a short. The unmitigated impact is of medium significance. Mitigation involves patrols of the overhead electricity infrastructure and removal of nests of Sociable Weavers and Crows from poles. The significance of birds nesting on poles during the operational phase will be low with mitigation.

⁵¹ Eskom 2011. Land_and_Biodiversity_Standard. Ref 32-815. Report compiled by R. Kruger, Land and Biodiversity task team, ESKOM



Figure 18: Electrical overhead infrastructure that is attractive to some species of birds as perches or nest sites. (A) insulator carriers and cables that provide nesting sites for birds (photo supplied by CSIR), (B) Martial Eagle perched on a pole near Carnarvon, (C) Sociable Weaver nests on electrical infrastructure near the SKA Core area on the Carnarvon-Van Wyksvlei road (Photo SJ Milton)

Large raptors (such as Red Listed Marshall Eagle) frequently perch on poles and their excreta can cause "bird streamer faults" i.e. the shorting of electricity between a live and earth wire (Vosloo 2004:52). This impact is negative as it can kill listed bird species and cause temporary power outages. The extent may be regional where listed bird species are killed, short to medium terms (depending on the population dynamics of the species involved), but usually highly reversible, though with a high intensity and fairly probable over a long operational period. The overall significance without mitigation is medium. Mitigation involves the fitting of spikes or bird discouragers on vulnerable poles, especially in wetland areas where large water-birds are present at times. With mitigation the impact will be negative but site specific, temporary and of lower probability so that the mitigated significance is low.

Furthermore, the powerline poles are used as perches by many species of birds, some of which consume and defecate the viable seeds of invasive alien cactus species. This results in the spread of cactus along linear infrastructure routes into natural veld. The spread of Cactus below perches is assessed as negative, local (in that established cactus fruit and are further spread by birds), long term (throughout the life of the infrastructure), of moderate reversibility and high impact on local flora and fairly probable. Crows and Ravens perching and nesting on power line supports, frequently drop seeds of the fruits they feed on. The seeds sometimes germinate and in this way fleshy-fruited plants, particularly Cactaceae such as Prickly Pear, Imbricate Cactus and Myrtillo Cactus establish near of

⁵² Vosloo HF 2004 The need for and contents of a Life Cycle Management Plan for Eskom Transmission Line Servitudes. MSc University of Johannesburg

below transmission infrastructure as well as along fence-lines (Dean & Milton 2000)⁵³, Figure 19). Unmitigated perch dispersal of alien plants is of medium significance. Mitigation involves regular patrols of powerline infrastructure, recoding and removal of invasive alien plants at least once annually. Cactus dispersal by perching birds is improbable with mitigation and significance therefore low.

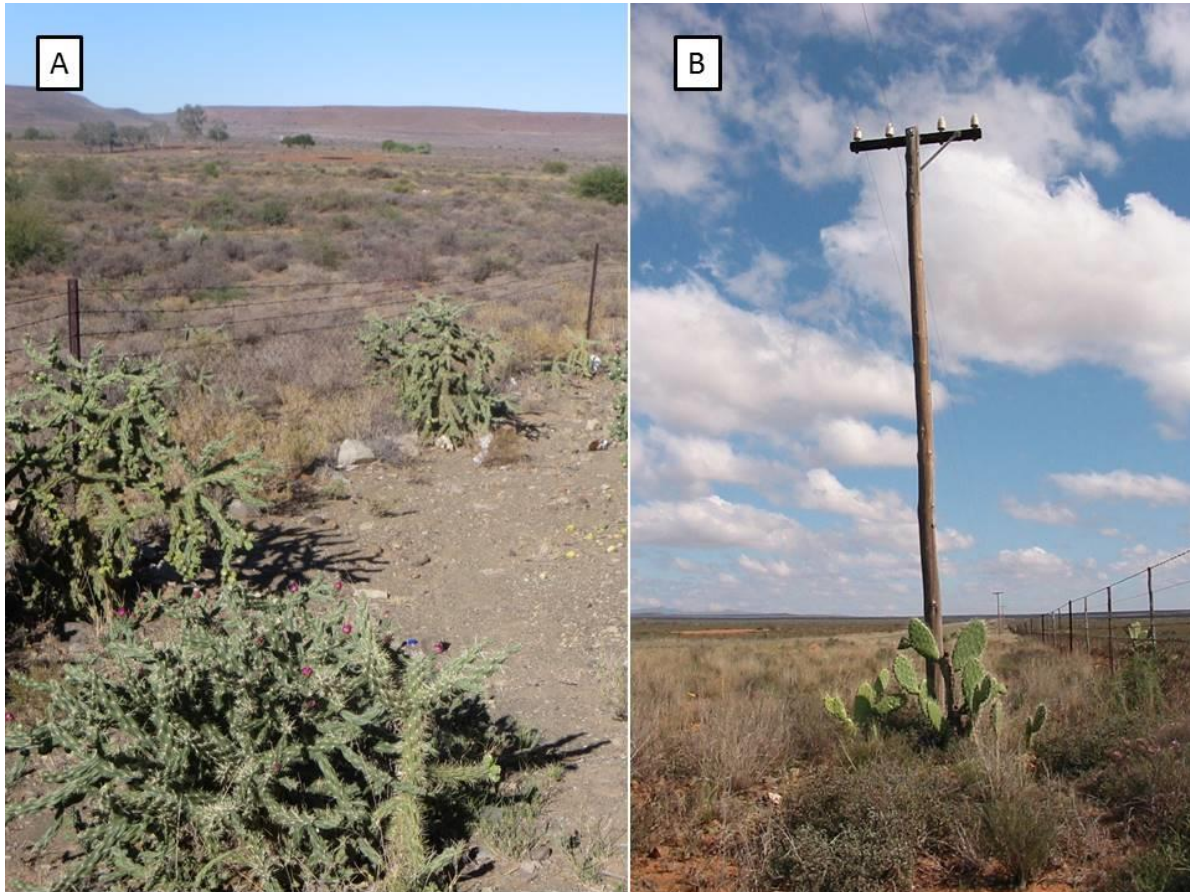


Figure 19: Alien invasive cactus likely to have been dispersed in Crow or Raven droppings. (A) *Opuntia fulgida* near Carnarvon, (B) *Opuntia ficus indica* near Beaufort West. Photos SJ Milton

7) Impacts related to the clearance of vegetation

The construction of the access roads and the dish-antennas platforms, and the maintenance of the servitude under powerlines on private land may involve vegetation clearing or reduction of the heights of plants. The impacts of the required construction and maintenance activities can be positive, for instance due to the associated invasive alien vegetation control, but can also be negative due to further damage or removal of listed plant species.

This operational impact is negative, may be of regional extent depending on the species removed, will be long term (throughout the life of the SKA), moderately reversible, of medium intensity, probable, and of medium significance without mitigation. The mitigation approach will depend on the vegetation in the servitude. On plains dominated by invasive alien *Prosopis* or species that have increased as a result of past grazing management (*Rhigozum trichotomum*), total clearing of woody vegetation would be acceptable provided that the cleared area is sown with seed of locally indigenous

⁵³ Dean, W.R.J. and Milton, S.J. 2000. Directed dispersal of *Opuntia* species in the Karoo, South Africa: are crows the responsible agents? *Journal of Arid Environments* 45(4): 305-314

grass species. Where the servitude crosses rocky ground with diverse vegetation and a higher probability of affecting listed plant species, little or no clearing should be permitted. Where listed tall succulent plant species (*Aloe chlorantha*, *A. dichotoma*) occur within the servitude these plants should be translocated to an adjacent site in the same habitat type. With mitigation the impact of servitude maintenance would be site specific, short term, highly reversible, of medium-low intensity and have a low significance.

On construction sites, as a result of seed introduction, the removal of indigenous vegetation and soil disturbance promote an increase in cover and density of alien plants, including *Prosopis* and other species already in the area (e.g. *Tamarix ramossissima*, *Cactaceae*, *Nicotiana glauca*, *Argemone ochroleuca*, *Atriplex lindleyi (inflata)*, *Atriplex nummularia*, *Salsola kali*). An increase in invasive alien species is viewed as negative because it is likely to retard the return of cover and diversity of indigenous plants to construction sites, to change habitat structure and food resource availability for fauna, as well as negatively affecting shallow aquifers. The impact will be local, because weeds can spread beyond the site of introduction, long-term in the case of perennial weeds such as *Prosopis*, moderately reversible and of medium intensity. The probability of weed invasion of construction sites is high and the significance of the impact therefore medium without mitigation. With mitigation, including removal of weeds from sites where materials are sourced, removing or killing weeds around the construction site, and post construction monitoring and removal, the impact is reduced to low.

Invasive alien *Prosopis glandulosa* and its hybrids are very abundant and even dominant in landscapes of the SKA core area, Van Wyksvlei and Brandvlei spiral arms and along the Sakriver and its tributaries in the Williston arm of the SKA1_MID development (Figure 20). In the absence of management to control this species, its cover is likely to increase in the project area as a result of population growth facilitated by soil disturbance, seed transport and disruption of drainage patterns along built up roads and around receivers. An increase in cover and density of invasive alien *Prosopis* and possibly in other invasive alien species is likely to lead to a reduction in the cover and diversity of indigenous plants, including listed species, to changes in habitat structure and food resource availability for fauna, as well as a possible increase in the depths of shallow aquifers.

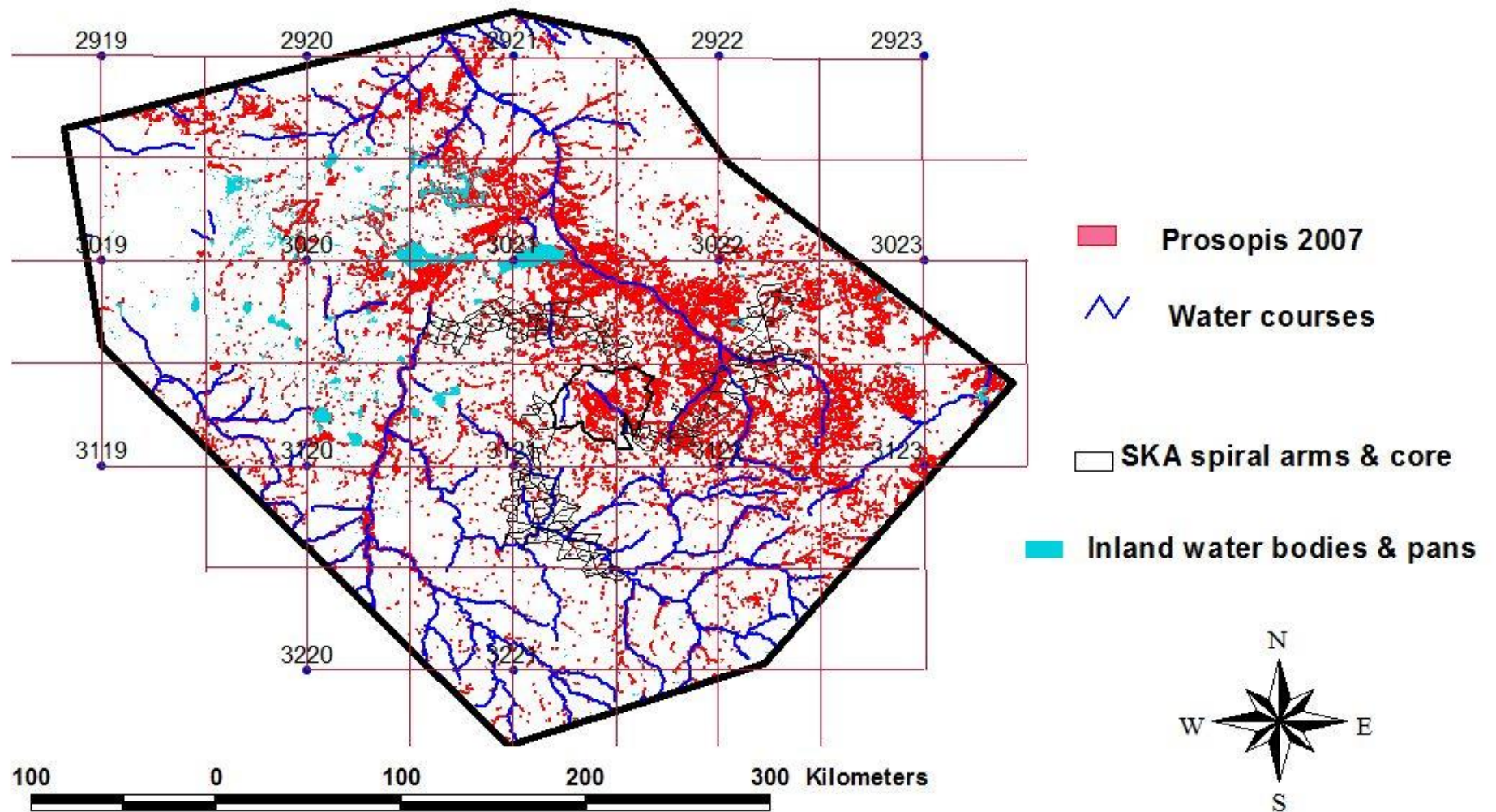


Figure 20: Distribution of invasive alien *Prosopis* sp. (red) in the KCAAA1 area. The spiral arms of SKA1_MID are indicated in black, and water bodies and rivers in blue. Coverage supplied by the CSIR.

8) Impacts related to people working in natural environment

During the construction phase of SKA1_MID, people will be working on sites in natural environment and might have negative impacts on biodiversity and the natural environment. Activities that require large teams of people in natural environment include road construction, infrastructure installation and clearing of invasive alien plant populations. The following types of negative impacts to habitats, flora and fauna can be caused by people working in natural environments:

- Organic waste pollution of water sources and river beds with organic waste. Work teams use river beds as toilets and rubbish dumps;
- Inorganic pollution of soil and groundwater with fuel, lubricant or poison spills. Work teams spill or discard fuel, lubricants or herbicides on site leading to long-term pollution of soil and water, and associated future risks for wildlife, livestock or people;
- Off-road driving causing damage to habitats, plants or animals. Work teams drive their vehicles off construction sites to hunt, collect wood, see the view from hill tops or take photographs. Off road driving may damage plants and animals and leave lasting scars in the veld that initiate soil erosion or change drainage patterns;
- Littering by abandonment or shallow burial of plastic, metal, glass, paper, clothing, batteries, machine parts, tyres, wire, cable offcuts and other objects in the natural environment. Work teams abandon or bury trash on site leaving a lasting legacy that is unsightly, and potentially dangerous to animals;
- Cutting of trees for fuel. Where work teams are, large trees or other woody plants are scarce, cutting of wood for fuel may have a long-lived impact on the density, height and population structure of woody plants and the fauna that depends on them for roosting, nesting or feeding;
- Collection of rare plants for own use or for sale to collectors. Listed plant species such as Boophone distichya, Aloe clorantha, Aloe dichotoma, and various Mesembryanthemaceae may be collected for own use or sale for their medicinal, rarity or ornamental values. In some cases, as observed on top of a dolerite hill in the SKA Core area, parts of rare plants (e.g. Aloe dichotoma) may be harvested for sale (Figure 21). These activities are not only illegal in terms of the biodiversity conservation legislation of the Eastern, Northern and Western Cape Provinces, but are also damaging to the reproductive output and persistence of rare and other listed species.
- Hunting of animals including hare, rabbit, porcupine, springbok, steenbok, aardvark and birds for food, and the wanton killing of snakes, lizards, scorpions, spiders and other animals. Time in the veld during construction work or the clearing of invasive alien vegetation provides work crews with opportunities to set traps and snares for bush meat. In cases of Listed animals species already threatened by habitat destruction (Riverine Rabbit) or collisions with vehicles and infrastructure (large birds), hunting can further endanger populations and species;
- Capture of live animals for own use or for sale to collectors. Snakes, tortoises, baboon spiders and trapdoor spiders, particular the rarer species, have a high monetary value among collectors both nationally and internationally. Other animals may have value in the traditional medicinal trade. Time in the veld during construction work or the clearing of invasive alien vegetation provides work crews with opportunities to set traps or hunt for animals for personal collections or sale.

In combination these negative impacts will be local (affecting plant and animal populations and water sources beyond the work site), long term in that they do not go away when the team leaves, have low to medium reversibility and are usually of medium intensity. It is highly probable that unsupervised work-teams will have these impacts. The significance on people on site is therefore medium without

mitigation. With mitigation including supervision by a well-trained environmental control officer, provision of toilets and appropriate waste disposal containers, the significance is low.

During the operation phase it is likely that smaller groups of people will be involved in infrastructure monitoring and maintenance, data collection and science tourism, but access to the site will be restricted and controlled therefore the main impact will occur during the construction phase. However, should people be working on sites in natural environment during the operation phase of SKA1_MID they could also have negative impacts on biodiversity and the natural environment and the above negative impacts to habitats, flora and fauna also applies. The unmitigated significance is high. Mitigation requires that field-based work teams must receive environmental briefing that includes rules relating to toilet use, disposal of solid and liquid wastes, limitations on driving off service roads, restrictions on removing plants, animals, wood, rocks or soil from the site, restrictions on firewood cutting, hunting and plant collecting. With mitigation including supervision by a well-trained ECO, provision of toilets and appropriate waste disposal containers, and fuel spill kits, the significance should be low.



Figure 21: Circles indicate stumps of *Aloe dichotoma* braches, probably cut for sale to nurseries some years ago (photo Lydia Cape)

V. Mitigation Measures and Environmental Management Actions

The overall environmental management goal for the development of the SKA1_MID is to construct and operate the project in a manner that:

- Minimises the ecological footprint of the project on the local environment;
- Minimises impacts on fauna, flora and freshwater ecosystems;
- Facilitates harmonious co-existence between the project and other land uses in the area; and
- Contributes to the environmental baseline and understanding of environmental impacts of SKA in a South African context.

This section provides an overview of the mitigation measures and management actions identified during the ecology and biodiversity assessment and describe in more details in Part 3 of this IEMP report. In addition to these ecology and biodiversity mitigation measures and management actions, a plant rescue and protection plan and a re-vegetation and habitat restoration plan are included in Part 3 of this IEMP report. An overview of these plans is provided below.

The alien invasive plant species control and management plan is discussed in Part 4 with recommendation on further research and monitoring activities to be undertaken on the SKA1_MID SEA study area.

1) Plants rescue and translocation

Where protection cannot be achieved by avoidance, succulent and bulb plants should be salvaged and translocated to adjacent habitat. Herbaceous and woody plants cannot successfully be translocated and no attempt should be made to do so. Instead, protected herbaceous plant species should be re-established from seed during the after construction re-vegetation phase and woody species replaced by nursery-grown plants where care during establishment is feasible.

Plant translocation should ideally take place in late summer (February to April) in anticipation of rain. Translocation immediately after heavy rain when the soil has been wet to a depth of 20-30 cm works well because the plants are easier to dig out, and will require less water after planting.

Before removing the plant from the construction site, a suitable site for translocation should be identified. The translocation site should be in the same soil type and depth and outside of the demarcated construction area, i.e. if the plants were growing in hard stony soil, do not plant them in loose sand.

According to the Northern Cape Nature Conservation Act 9/2009 (Provincial Gazette 1566 dated 19 December 2011), Section 49, a permit from Department of Environment and Nature Conservation (DENC) is required to destroy, translocate, transport or cultivate 633 of the plant species in the KCAAA1 area.

2) Revegetation and Habitat Restoration

The revegetation and restoration of degraded areas in the construction camps, temporary access roads, trenches, telescope construction sites, borrow pits and alien vegetation clearing sites should be undertaken according to the mitigation measures and management actions included in Part 3 of this

IEMP report. The environmental control officer or manager responsible for the rehabilitation should record the position (GPS), methods used, reseeded plant species, and maintain a photographic record of the work to inform ongoing rehabilitation work in the SKA area. It is very valuable to know what approaches work and which do not work under the harsh conditions of the KCAAA1.

Prior to the construction phase, the bulb of protected plants and succulent species should be salvaged and translocated to adjacent areas of similar habitat.

For the revegetation and restoration of temporary construction camps and temporary access roads, as well as dish-antennas construction sites, after salvage, the remaining vegetation should be scraped into windrows or removed with the topsoil. The dead vegetation is valuable as a source of seeds, mulch and plant nutrient during rehabilitation. The topsoil contains the nutrients, seeds and soil organisms required for habitat restoration after closure of the camp or temporary road, it should therefore be removed and stored for the restoration of degraded areas. All concrete structures and waste materials, as well as any soil polluted with hydraulic fluids, lubricants or fuel should be removed from the site. Any *Prosopis species* (mesquite), cactus and other listed Invasive Alien plants should be cleared from the site. The revegetation of an area should be undertaken after the completion of drainage, infiltration, runoff control and top soiling, with seeds of plants that are common and indigenous in the local area (Figure 22). Table 2 below presents recommended seeds for the revegetation activities in the KCAAA1. Spread the topsoil over the site and cover it with the dead vegetation that was removed from the site. The final surface should be rough and chunky with scattered rocks if available because rough surfaces capture water, seed and nutrients improving plant growth. The risk of soil erosion increases with slope and risk is high for gradient steeper than 14% (1:7)⁵⁴. Erosion risks are also increased on fine-textured, deep soils where rapid runoff after rain will cause dongas if water is channeled onto bare ground. Rapid runoff will shift the topsoil off the site unless the surface is stabilised, infiltration facilitated and runoff rate managed appropriately. Where berms and drainage ditches are already in place on roads on slopes, these should be left in place to avoid build-up of water that could cause gully erosion⁵⁵. Check all drains from berms and address gully erosion problems in the water discharge area by packing rocks to disperse runoff water⁵⁶. On steep slopes, mini catchments should be dug to trap runoff water. These can be supplemented by brush packs or windrows packed at right angles to the slope and pegged to the ground with stout stakes. On gentle slopes, the ground along the contour should be ripped to improve infiltration and capture water and seed. Small succulent plants from the surrounding area can successfully be translocated from surrounding natural vegetation onto the rehabilitation site. Decommissioned roads can be closed with jagged stones and no entry signs posted on closed roads and rehabilitating construction camps.

Table 2: Seeds for revegetation of bare ground in the KCAAA1

Landscape position	Soil type	Grasses for seeding	Shrubs for seeding
Hillside dolerite	stony	Cenchrus ciliaris, Fingerhuthia africana, Heteropogon contortus	Rhigozum obovatum
Hillside mudstone	stony	Enneapogon spp, Fingerhuthia africana	Eriocephalis ericoides, Tripteris sinuata

⁵⁴ Excellence in Environmental stewardship 14.0 Reclamation and closure. Prospectors and Developers Association of Canada <http://www.pdac.ca/docs/default-source/e3-plus---toolkits---environmental-stewardship/reclamation-and-closure.pdf?sfvrsn=4>

⁵⁵ Keller, G. & Sherar J. 2003. Low-volume roads engineering Best Management Practices Field Guide by USDA Forest Service/USAID http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices/technical_information.html

⁵⁶ Coetzee, K. 2005. Caring for natural Rangelands. University of KwaZulu-Natal Press. (order from books@ukzn.ac.za)

Foot slope	silt	Stipagrostis obtusa, Fingerhuthia africana	
Plain	silt	Stipagrostis obtusa, Eragrostis obtusa	Salsola aphylla
Plain	Gravel & calcrete	Eragrostis lehmanniana, Stipagrostis obtusa	
Plain	sand	Schmidtia kalahariensis, Eragrostis lehmanniana, Stipagrostis ciliata, S. obtusa	
Drainage line	silt	Cenchrus ciliaris,	Salsola aphylla
Drainage line	sand	Stipagrostis ciliata	



Figure 22: Approaches to improving infiltration and retaining seeds, water and nutrients in rehabilitations sites. UPPER: mini catchments and ripping, LOWER LEFT brush fencing combined with mini-catchments, LOWER RIGHT: bulb regenerating from spread topsoil on a construction site (note rough soil surface that maximises water infiltration), and translocation of succulent plants.

For the revegetation and restoration of trenches, after salvaging protected plants, the topsoil and surface rocks from the 3m wide trench to the depth of 100 mm should be removed using a mechanical digger. These should be placed this along the trench rout in a continuous series of heaps, as far from the trench as the digger can reach. The subsoil subsequently excavated by the trencher should be placed nearer the trench. After cable laying has been completed replace first the subsoil and then cover the subsoil with topsoil and rocks. If the trench runs up a steep hillside (1:7 or steeper), then place low berms across the trench at 10 m to 20 m intervals to divert water from the unstable soil of the trench.

For the revegetation and restoration of borrow pit, prior to the closure of the borrow pit, any soil contaminated by fuel or oil spills; all plastic bottles and other litter should be removed. The borrow pit walls should be shaped at a shallow enough angle (not steeper than 1:3) to hold soil and plants. Build a berm (approximately 30cm in height) along the entire upslope edge of the borrow pit to divert water away from the borrow pit. This will prevent rill erosion cutting back upslope into rangeland and will

facilitate establishment of Karoo vegetation by preventing inundation of the borrow pit depression. As far as practicably possible, ensure that the borrow pit is free draining towards natural drainage lines. Spread any unusable material stockpile over the mined out pit. Rip any remaining hardened or scalped surfaces to facilitate water infiltration and seedling establishment. Spread the topsoil stockpile throughout the reshaped borrow pit so that all subsoil is covered by topsoil throughout the borrow pit to facilitate colonization by plant species with soil-stored seeds. Spread large chunks of hard-rock debris (if available) over the floor of the closed borrow pit to provide shelter to establishing indigenous plants. Rough surfaces capture water, seed and nutrients improving plant growth. Once drainage, infiltration, runoff control and top soiling have been completed, sow the whole area with seeds of plants that are common and indigenous in the local area.

For the revegetation and restoration of alien vegetation clearing sites, according to the Working for Water Operational Standards: methods for manual clearing (February 2015), felled material and other dead material must be removed from all water courses, either 30m away from the river or out of the flood line itself. Branches with pods should be removed from the site to a licensed waste disposal facility or burned. Brushwood can be used in various ways as part of a post-clearing erosion control and rehabilitation programme, e.g. stacked along contours to reduce runoff and to control alien invasive plants species regrowth by shading or chipped and spread as a mulch (it is important that mulches used for restoration must not contain seeds of alien invasive plants species).

VI. Summary impact tables

1) Construction phase

Impact description	Mitigation	Confidence level	Significance (with mitigation)	Probability	Potential Intensity	Reversibility	Duration	Extent	Status
Road-construction activities, (clearing, filling, compacting, spills, topsoil loss), damage indigenous vegetation and soil fauna, and disperse seeds of invasive alien plants	Plan roads to avoid most sensitive locations where possible. An environmental control officer should monitor road construction activities monthly and report on non-compliance incidents; Road construction and road width should be minimised; Service roads should be kept to a minimum; Road camps and laydown areas must not be in sensitive sites; Topsoil should be saved in berms parallel to the road, topsoil berms must not be covered with subsoil, topsoil must be re-spread on roadsides on completion of construction, Multiple culverts should be built through raised roads to avoid damming and concentration of water; Spills of lubricants and fuel must be cleaned up immediately and disposed of appropriately, Compacted areas caused by construction camps and laydown areas should be ripped and rehabilitated as road sections are completed, Invasive alien plants should be monitored and removed within a	Medium	Medium	Probable (0.5)	High (8)	Low reversibility	Long Term (4)	Local (2)	Negative
			High	Definite (1)				Site specific (1)	

Confidence level	Significance (with mitigation)	Probability	Potential Intensity	Reversibility	Duration	Extent	Mitigation	Significance (without mitigation)	Potential Intensity	Reversibility	Duration	Extent	Impact description
							year of road construction						
		Probable (0.5)	Medium (4)	Low reversibility	Long Term (4)	Site specific (1)	Mitigation includes inspection of selected and alternative quarry or borrow pit sites by a qualified ecologists, avoidance of sensitive habitats and listed species, minimisation of damage, and post damage rehabilitation	High	High (8)	Low reversibility ²	Permanent (5)	Local (2)	Construction of roads and pedestals for the receptor dishes requires construction materials including crushed rock, gravel and sand. Rock suitable for construction of hard surfaces and concrete is usually quarried from exposed bedrock, often dolerite. Gravel is usually excavated from so-called "borrow-pits" in soft rock (typically mudstone or calcrete). Sand suitable for concrete making is usually mined from Aeolian sand deposits or from river beds
	Low	Low Probability (0.25)	Medium (4)	Low reversibility	Long Term (4)	Site specific (1)	Avoid building roads up hills where other routes are available. Use paths rather than vehicle roads for installation and maintenance of light-weight equipment; Engineer roads to minimise soil erosion. Avoid or translocate listed plant species such as Aloe dichotoma from the route for the road	High	High (8)	Irreversible	Permanent (5)	National (4)	Roads built up hills for the installation of web cameras, satellite dishes, or electrical infrastructure, are indelible. They cannot be rehabilitated so that the road scar disappears. Roads up hills accelerate water runoff and initiate soil erosion.

Confidence level	High
Significance (with mitigation)	Low
Probability	Low Probability (0.25)
Potential Intensity	Medium-Low (2)
Reversibility	Moderate reversibility
Duration	Long Term (4)
Extent	Site specific (1)
Mitigation	1. Ensure that installation is not on a sensitive habitat or in an area with populations of listed plant or animal species. 2. Take steps to prevent or clean up spills of diesel and lubricants in the natural environment; 3. Rehabilitate any damaged areas around the telescope area that are not required for future telescope access
Significance (without mitigation)	High
Probability	Definite (1)
Potential Intensity	High (8)
Reversibility	Low reversibility
Duration	Long Term (4)
Extent	Local (2)
Status	Negative
Radio-telescope (receptor) installation removal of vegetation, compaction of soil, elevation of ground using stone chips, installation of concrete pedestal to hold telescope dish	
Electricity / optic cable infrastructure installation - Trenching within a 2 km radius of the receptors has potential to damage vegetation, alter drainage patterns, leave enduring scars on the landscape & kill listed or protected plants or animals	
Confidence level	High
Significance (with mitigation)	Medium
Probability	Probable (0.5)
Potential Intensity	Medium (4)
Reversibility	Low reversibility
Duration	Long Term (4)
Extent	Local (2)
Mitigation	1. Biodiversity specialist to walk along trench routes and mark sensitive habitats and plant species that could be translocated prior to driving on or trenching the cable route; 2. Material excavated from the cable trenches must be separated into topsoil (upper 100 mm containing seeds, geophytes and other biological material, and subsoil (broken rock) containing little biological material. When trenches are back-filled the subsoil must be backfilled first, then covered with the topsoil; 3. The materials used for back-filling may contain seeds of invasive alien plants. The routes should therefore be monitored annually for the first five years and invasive alien plants removed as indicated in the Invasive Alien Vegetation Management Plan.
Significance (without mitigation)	High
Probability	Highly probable (0.75)
Potential Intensity	High (8)
Reversibility	Low reversibility
Duration	Long Term (4)
Extent	Regional (3)
Status	Negative

Confidence level	Medium	High
Significance (with mitigation)	Low	Low
Probability	Probable (0.5)	Low Probability (0.25)
Potential Intensity	Medium-Low (2)	Medium-Low (2)
Reversibility	Moderate reversibility	Low reversibility
Duration	Medium Term (3)	Medium Term (3)
Extent	Local (2)	Local (2)
Mitigation	1. Biodiversity specialist to walk along trench routes and mark sensitive habitats and plant species that could be translocated prior to driving on or trenching the cable route; 2. Clean up spills; 3. Rehabilitate laydown areas; 4. Monitor routes annually for the first five years and remove invasive alien plants as indicated in the Invasive Alien Vegetation Management Plan	Follow the recommendations in the Invasive Alien Vegetation management plan appended to this report
	Significance (without mitigation) High	Medium
	Probability Highly probable (0.75)	Highly probable (0.75)
	Potential Intensity High (8)	Medium (4)
	Reversibility Moderate reversibility	Moderate reversibility
Duration Long Term (4)	Long Term (4)	
Extent Regional (3)	Local (2)	
Status Negative	Negative	
Impact description	Electricity / optic cable infrastructure - installation of overhead powerlines over a minimum distance of 392 km of overhead cables carrying optic fibre and electricity from the SKA core area edge to all 21 SKA receptors in the three spiral arms. Installation will require roads for heavy machinery	Construction disturbance and imported materials result in weed invasions

Confidence level	Medium
Significance (with mitigation)	Low
Probability	Improbable (0.1)
Potential Intensity	Medium-Low (2)
Reversibility	Low reversibility
Duration	Long Term (4)
Extent	Site specific (1)
Mitigation	1 Field-based work teams must receive environmental briefing that includes rules relating to toilet use, disposal of solid and liquid wastes, limitations on driving off service roads, restrictions on removing plants, animals, wood, rocks or soil from the site, restrictions on firewood cutting, hunting and plant collecting. 2 An environmental Control Officer should inspect work teams and recently vacated work sites at 4 to 6 weekly intervals in addition to carrying out spot checks
Significance (without mitigation)	Medium
Probability	Highly probable (0.75)
Potential Intensity	Medium (4)
Reversibility	Low reversibility
Duration	Long Term (4)
Extent	Local (2)
Status	Negative
Impact description	People on site during construction - off-road driving
Confidence level	Medium
Significance (with mitigation)	Low
Probability	Improbable (0.1)
Potential Intensity	Low (1)
Reversibility	Low reversibility
Duration	Long Term (4)
Extent	Regional (3)
Mitigation	1. Field-based work teams must receive environmental briefing that includes rules relating to toilet use, disposal of solid and liquid wastes, limitations on driving off service roads, restrictions on removing plants, animals, wood, rocks or soil from the site, restrictions on firewood cutting, hunting and plant collecting. 2. An environmental Control Officer should visit work teams and recently vacated work sites at 4 to 6 weekly
Significance (without mitigation)	Medium
Probability	Probable (0.5)
Potential Intensity	High (8)
Reversibility	Low reversibility
Duration	Long Term (4)
Extent	Regional (3)
Status	Negative
Impact description	People on site during construction - hunting and collecting

Confidence level	Medium
Significance (with mitigation)	Low
Probability	Improbable (0.1)
Potential Intensity	Low (1)
Reversibility	Moderate reversibility
Duration	Medium Term (3)
Extent	Site specific (1)
Mitigation	1 Field-based work teams must receive environmental briefing that includes rules relating to toilet use, disposal of solid and liquid wastes, limitations on driving off service roads, restrictions on removing plants, animals, wood, rocks or soil from the site, restrictions on firewood cutting, hunting and plant collecting. 2 An environmental Control Officer should visit work teams and recently vacated work sites at 4 to 6 weekly
Significance (without mitigation)	Medium
Probability	Highly probable (0.75)
Potential Intensity	Medium (4)
Reversibility	Moderate reversibility
Duration	Long Term (4)
Extent	Site specific (1)
Status	Negative
Impact description	People on site during construction, operation and decommissioning phases - pollution & littering

2) Operation phase

Confidence level	
Significance (with mitigation)	
Probability	
Potential Intensity	
Reversibility	
Duration	
Extent	
Mitigation	
Significance (without mitigation)	
Probability	
Potential Intensity	
Reversibility	
Duration	
Extent	
Status	
Impact description	

Confidence level	High	Medium
Significance (with mitigation)	Medium	Medium
Probability	Highly probable (0.75)	Probable (0.5)
Potential Intensity	Medium (4)	Medium (4)
Reversibility	Highly reversible	Highly reversible
Duration	Long Term (4)	Medium Term (3)
Extent	Local (2)	Local (2)
Mitigation	none required, monitor vegetation	monitoring inside and outside SKA management areas
Significance (without mitigation)	Medium	Medium
Probability	Highly probable (0.75)	Probable (0.5)
Potential Intensity	Medium (4)	Medium (4)
Reversibility	Highly reversible	Highly reversible
Duration	Long Term (4)	Long Term (4)
Extent	Local (2)	Regional (3)
Status	Positive	Positive
Impact description	<p>Removal of livestock from the SKA core area is likely to have positive effect on flora and fauna of this area, in that populations of palatable plants are likely to increase, grass cover important for some endemic bird species is likely to increase</p>	<p>Cessation of predator control by gin trapping, hunting and poisoning is likely to lead to a change in the age structure and a stabilization of the jackal and Lynx populations in the area. By-catch of Bat-eared Foxes, Cape Foxes, Aardwolf, Aardvark, Porcupine and raptors is likely to be reduced so that their populations may increase, stabilise or change in age structure</p>

Impact description	Confidence level	
	Medium	High
Termination of ground water supply to livestock drinking facilities within SKA area should limit increases in any surface water-dependent wildlife present in the area. This will keep wildlife populations at densities that are sustainable and do not require culling or any other type of management. In terms of conservation of the original flora and fauna of the area this impact can be seen as neutral to positive.	Low	High
	Probable (0.5)	Highly probable (0.75)
Reinforcement of boundary fencing around the SKA using mesh or electric fencing	Low (1)	High (8)
	Medium (4)	Highly probable (0.75)
Exclusion of parts of the Astronomical Advantage Area from mining would thus protect fauna, flora and habitats from these negative impacts of mining	Highly reversible	Highly reversible
	Reversible	Highly reversible
None required	Long Term (4)	Long Term (4)
	Local (2)	Regional (3)
Do not use electric fencing. If used, the lowest strand must be a minimum of 200 mm above ground level. Monitor fence mortality and animal populations in Core	Local (2)	Regional (3)
	Medium term (4)	Long Term (4)
Significance (with mitigation)	Medium	High
	Medium	High
Significance (without mitigation)	Medium	High
	Highly probable (0.75)	Highly probable (0.75)
Probability	Highly probable (0.75)	Highly probable (0.75)
Potential Intensity	Medium (4)	High (8)
Reversibility	Highly reversible	Highly reversible
Duration	Long Term (4)	Long Term (4)
Extent	Regional (2)	Regional (3)
Status	Positive	Positive
	Negative	Positive

Impact description		Confidence level	Significance (with mitigation)
Road operation - Water flow disruption by built up roads		Medium	Low
Road operation - Runoff results in establishment of weedy species adjacent to roads		High	Low
Mitigation			
Significance (without mitigation)		Medium	Medium
Probability	Probable (0.5)		Highly probable (0.75)
Potential Intensity	Medium (4)		Medium (4)
Reversibility	Moderate reversibility		Low reversibility
Duration	Long Term (4)		Long Term (4)
Extent	Local (2)		Regional (3)
Status		Negative	Negative

Culverts must be kept open; Woody and perennial invasive alien plant species must be monitored and controlled along road side annually

Runoff areas adjacent to roads should be sown with indigenous grass species. Woody and perennial invasive alien plant species (e.g. Prosopis spp., Cactaceae, Pennisetum setaceum) must be monitored and controlled along road side annually

Confidence level	Medium
Significance (with mitigation)	Low
Probability	Probable (0.5)
Potential Intensity	Low (1)
Reversibility	Moderate reversibility
Duration	Long Term (4)
Extent	Regional (3)
Mitigation	Use underpasses in combination with fencing on built-up roads. The most effective mitigation would be the imposition of a 60 km/hr speed limit on those roads likely to be driven daily by SKA personnel. Monitor roadkill and erect signs at sites with higher collision probabilities
Significance (without mitigation)	Medium
Probability	Highly probable (0.75)
Potential Intensity	Medium (4)
Reversibility	Moderate reversibility
Duration	Long Term (4)
Extent	Regional (3)
Status	Negative
Impact description	Road operation - Roadkill of slow-moving, basking, scavenging and nocturnal animals

Confidence level	Medium
Significance (with mitigation)	Low
Probability	Probable (0.5)
Potential Intensity	Medium-Low (2)
Reversibility	Moderate reversibility
Duration	Long Term (4)
Extent	Local (2)
Mitigation	Careful management of soil erosion structures (berms, ditches) to shed and spread water will reduce soil erosion impacts to medium low. Strict supervision of visitors and work teams will reduce access to rare listed plants and animals during the operational phase. Hill roads no longer required for infrastructure must be closed and rehabilitated.
Significance (without mitigation)	Medium
Probability	Highly probable (0.75)
Potential Intensity	Medium (4)
Reversibility	Low reversibility
Duration	Permanent (5)
Extent	Local (2)
Status	Negative
Impact description	Road operation - Roads up hills accelerate water runoff and initiate soil erosion. Road up hills also provide vehicle access to listed plants and animals

Impact description	Confidence level		
	Medium	High	
Radio telescope (receptor) operation - water shedding & soil erosion	Low		
	Significance (with mitigation)	Low	
	Probability	Low Probability (0.25)	
	Potential Intensity	Low (1)	
	Reversibility	Moderate reversibility	
	Duration	Long Term (4)	
	Extent	Local (2)	
	Radio telescope (receptor) operation - use by nesting birds	Low	
		Significance (with mitigation)	Low
		Probability	Low Probability (0.25)
Potential Intensity		Low (1)	
Reversibility		Highly reversible	
Duration		Temporary (1)	
Extent		Site specific (1)	
Radio telescope (receptor) operation - water shedding & soil erosion		Medium	
		Significance (without mitigation)	Medium
		Probability	Highly probable (0.75)
	Potential Intensity	Medium (4)	
	Reversibility	Moderate reversibility	
	Duration	Long Term (4)	
	Extent	Local (2)	
	Radio telescope (receptor) operation - use by nesting birds	Medium	
		Significance (without mitigation)	Medium
		Probability	Highly probable (0.75)
Potential Intensity		Low (1)	
Reversibility		Highly reversible	
Duration		Long Term (4)	
Extent		Site specific (1)	
Radio telescope (receptor) operation - water shedding & soil erosion		Negative	
		Status	Negative
		Radio telescope (receptor) operation - use by nesting birds	Negative
	Status		Negative

Confidence level	High
Significance (with mitigation)	Low
Probability	Low Probability (0.25)
Potential Intensity	Medium-Low (2)
Reversibility	Highly reversible
Duration	Short Term (2)
Extent	Site specific (1)
Mitigation	<p>1. On plains dominated by Prosopis or Rhigozum trichotomum, total clearing of woody vegetation would be acceptable provided that the cleared area is sown with seed of locally indigenous grass species. 2 Where the servitude crosses rocky ground with diverse vegetation and a higher probability of affecting listed plant species, little or no clearing permitted. 3 Aloe dichotoma and other special plants within the servitude should be translocated</p>
Significance (without mitigation)	Medium
Probability	Probable (0.5)
Potential Intensity	Medium (4)
Reversibility	Moderate reversibility
Duration	Long Term (4)
Extent	Regional (3)
Status	Negative
Impact description	<p>Servitude for overhead infrastructure. There will be 9 m wide servitude under powerlines and maintenance may involve vegetation clearing or reduction of the heights of plants under the cables. In some cases the impacts of this maintenance activity may be positive (invasive alien vegetation control) and in other negative (damage or removal of listed plant species).</p>

Confidence level	Medium
Significance (with mitigation)	Low
Probability	Low Probability (0.25)
Potential Intensity	Low (1)
Reversibility	Moderate reversibility
Duration	Medium Term (3)
Extent	National (4)
Mitigation	On wood pole section of line ensure that it is not be possible for birds with wingspans >2.0 m (vultures, martial eagles) to breach the gap between 2 live conductors or between live and earth phases
Significance (without mitigation)	Fatally Flawed
Probability	Highly probable (0.75)
Potential Intensity	Very High/Fatal Flaw (16)
Reversibility	Low reversibility
Duration	Long Term (4)
Extent	National (4)
Status	Negative
Impact description	Overhead electricity infrastructure operation - bird kill through electrification

Confidence level	High	High
Significance (with mitigation)	Medium	Low
Probability	Probable (0.5)	Improbable (0.1)
Potential Intensity	Medium (4)	Low (1)
Reversibility	Moderate reversibility	Highly reversible
Duration	Long Term (4)	Temporary (1)
Extent	National (4)	Site specific (1)
Mitigation	<p>1) Have no above-ground overhead cables (i.e. bury all cables). This would eliminate mortality risk to the large bustards and cranes. (2) All overhead cables must carry markers, including LED illuminated markers, particularly on those power lines adjacent to seasonally flooded areas (pans) since several "water birds" travel at night. (3) Keep records of mortalities.</p> <p>Remove nests of Sociable Weavers and Crows from poles</p>	
Significance (without mitigation)	Fatally flawed	Medium
Probability	Highly probable (0.75)	Highly probable (0.75)
Potential Intensity	Very High/Fatal Flaw (16)	Medium (4)
Reversibility	Low reversibility	Highly reversible
Duration	Long Term (4)	Temporary (1)
Extent	National (4)	Local (2)
Status	Negative	Negative
Impact description	Electricity / optic cable infrastructure operation - Bird kill through collision with cables	Electricity / optic cable infrastructure operation - bird nests on support poles

Impact description	Confidence level	
	Low	High
Electricity / optic cable infrastructure operation - birds perching and causing "streamer faults"	Significance (with mitigation)	
	Low	Low
	Probability	Low Probability (0.25) Improbable (0.1)
	Potential Intensity	Medium-Low (2) Low (1)
	Reversibility	Highly reversible Highly reversible
	Duration	Temporary (1) Temporary (1)
	Extent	Site specific (1) Site specific (1)
	Mitigation	
	Fit spikes or bird discouragers on vulnerable poles in wetland areas where large waterbirds are present at times	Regular patrols of powerline infrastructure and removal of invasive alien plants
	Significance (without mitigation)	Medium Medium
Probability	Probable (0.5) Probable (0.5)	
Potential Intensity	High (8) High (8)	
Reversibility	Highly reversible Moderate reversibility	
Duration	Short Term (2) Long Term (3)	
Extent	Regional (3) Local (2)	
Status	Negative Negative	
Electricity / optic cable infrastructure operation - Powerline pole perches and spread of Cactus		

Confidence level	Low
Significance (with mitigation)	1.25
Probability	Low Probability (0.25) Medium-Low (2)
Potential Intensity	Moderate reversibility
Reversibility	Short Term (2) Site specific (1)
Duration	
Extent	
Mitigation	1. Field-based work teams must receive environmental briefing that includes rules relating to toilet use, disposal of solid and liquid wastes, limitations on driving off service roads, restrictions on removing plants, animals, wood, rocks or soil from the site, restrictions on firewood cutting, hunting and plant collecting. 2 An environmental control officer should visit work teams and recently vacated work sites at 4 to 6 weekly
Significance (without mitigation)	High
Probability	Highly probable (0.75)
Potential Intensity	High (8)
Reversibility	Low reversibility
Duration	Long Term (4)
Extent	Local (2) Negative
Status	
Impact description	People on site during operational phase - Combined effects

VII. Conclusions and Recommendations

The vegetation, flora and smaller fauna of the project area are poorly documented. This biodiversity and ecology specialist report is largely based on desktop studies, previous field research conducted within the KCAAA1 area, supplemented by a short data collection visit to the SKA core area and sites of eight proposed radio telescope receivers to verify desktop assessments. On the basis of the available information the major negative impacts that the SKA1_MID development is likely to have on the vegetation, flora and fauna are development of roads, trenches, construction camps, borrow pits, telescope installations and overhead cables that will remove vegetation, displace fauna, reduce habitat, increase the risk of soil erosion and of invasions by alien plant species, or increase the mortality of large birds. These negative effects can be partially mitigated by minimisation, management, plant protection and translocation, control of invasive alien plants, and revegetation and habitat restoration. The major positive effects that the SKA development could have on the natural environment are the release of the SKA core area from its current grazing regimes (livestock ranching), the reduction of the potential threat of future mining on biodiversity, and the initiation of control programmes for invasive alien plant species, particularly *Prosopis* that has invaded drainage lines, pans posing a threat to water resources and biodiversity. Due to the uncertainty around the distribution of species of conservation concern and the coarse nature of the sensitivity mapping, the final selection of sites for telescopes, cable trenching and roads should be ground-truthed by a field ecologist before construction, and where found to impact sensitive habitats, an acceptable alternative should be approved. An environmental officer should be appointed by the SKA to monitor impacts, and mitigation management activities, report on non-compliance to relevant contractors, and to oversee implementation of recommended actions.

The installation and operation of roads, webcams, radio-telescope dishes, electrical and optical fibre below and above-ground infrastructure is likely to have negative impacts including increased soil erosion, disruption of endorheic drainage features, increases in density and distribution of invasive alien plants, increases in roadkill of mammals, reptiles and birds, and increase access to Red Listed plants by people. The soil erosion, water flow disruption, and alien plant invasion problems are likely to persist beyond the decommissioning phase unless adequately managed. The electrical infrastructure to be constructed in the three spiral arms poses a major threat to large birds, particularly Ludwig's Bustard, Kori Bustard and Karoo Korhaan, but also Raptors, Flamingos and other large waterbirds that use pans, because the infrastructure is to be established in an area with very little existing electrical infrastructure and will cross waterbodies.

The SKA core area comprises Bushmanland Basin Shrubland (68%), Upper Karoo Hardeveld (22%), Western Upper Karoo (5%) and Bushmanland Vloere (5%)⁵⁷. There are no protected areas within or in close proximity to the SKA core area and all the vegetation types represented in the SKA core area are unprotected or poorly protected. Protected area status for the SKA core area would contribute significantly to the conservation targets for all these vegetation types. Geological, hydrological and biotic features characteristic of the Central Karoo, including dolerite hills, ephemeral pans and rivers, healthy populations of *Aloe dichotoma* typify the landscape of the SKA core area. Endangered species such as the Vulnerable Karoo Padloper Tortoise and the endemic Sclater's Lark may occur in the SKA core area. The SKA Core area would be a valuable conservation and research asset assuming that *Prosopis* sp. Populations are controlled, domestic livestock removed, pesticide-based locust control operations excluded, and ecological damage caused by roads, construction and overhead infrastructure are mitigated and restored well enough to maintain ecosystem functions and viable populations of the species of conservation concern. The southern and western parts of KCAAA1 are of

⁵⁷ Todd, S. & Henschel, J. 2016. Environmental Baseline Study for the SKA Core Area: Biodiversity Analysis for Potential Protected Areas Expansion. Draft document produced by SAEON Arid Lands Node for SKA & DEA (April 2016)

highest conservation concern and contain the greatest number of plant, invertebrate, reptile and mammal species of conservation concern. The northern part of the KCAAA1 area⁵⁸ is important for conservation of bird species endemic to the Nama Karoo such as Sclaters Lark and Red Lark which occur within the SKA1_MID spiral arms. These species are threatened by renewable energy, petroleum, and mining developments, and therefore would benefit from reduced human activity provided that SKA1_MID land management did not promote soil erosion or invasion by alien plant species.

VIII. Appendices

See attached excel sheets

⁵⁸ .Astronomy Geographic Advantage Act (21/2007); Notice of intention to make regulations on the protection of the Karoo Central Astronomy Advantage Areas in terms of the Act. Government Gazette 39442 (23 November 2015)