# CHAPTER 6: RESEARCH AND MONITORING PROGRAMMES

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I. Specialists inputs

This chapter of the Integrated Environmental Management Plan (IEMP) includes:

- guidelines for the protection and rescue of plants and habitat rehabilitation for the areas disturbed and degraded during the SKA construction activities;
- guidelines for the clearing and control of alien invasive plants species; and
- proposed long term research and monitoring programmes to be implemented and monitored during the construction and operation phases of the SKA mid-frequency dish array (SKA1_MID).

Table 1 below lists the authors and peer-reviewers of the guidelines and long-term research and monitoring programmes included in this chapter.

Table 1: Authors and peer-reviewers

<table>
<thead>
<tr>
<th>Author</th>
<th>Peer-reviewer</th>
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</thead>
<tbody>
<tr>
<td>Alien invasive plants control and management guidelines</td>
<td></td>
</tr>
<tr>
<td>Sue Milton (Dr)</td>
<td>Director at RENU-KAROO Veld Restoration cc.</td>
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<tr>
<td></td>
<td>South African Council for Natural Scientific Professions (SACNASP)</td>
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<tr>
<td></td>
<td>Professional Natural Scientist (Reg. No. 400047/08).</td>
</tr>
<tr>
<td></td>
<td>Graham Harding (Dr)</td>
</tr>
<tr>
<td></td>
<td>Director at Invader Plant Specialists (Pty) Ltd</td>
</tr>
<tr>
<td></td>
<td>SACNASP Professional Natural Scientist, Pest control operator Registration No 2012/036721/07.</td>
</tr>
</tbody>
</table>

| Protection, rescue and translocation programme |                                                                 |
| Sue Milton (Dr)                                 | Director at RENU-KAROO Veld Restoration cc.                    |
|                                             | SACNASP Professional Natural Scientist (Reg. No. 400047/08).    |
|                                             | Joh Henschel (Dr)                                             |
|                                             | Manager at South African Environmental Observation Network (SAEON) Arid Lands Node. |

| Re-vegetation and habitat restoration programme |                                                                 |
| Sue Milton (Dr)                                 | Director at RENU-KAROO Veld Restoration cc.                    |
|                                             | SACNASP Professional Natural Scientist (Reg. No. 400047/08).    |
|                                             | Joh Henschel (Dr)                                             |
|                                             | Manager at SAEON Arid Lands Node.                             |

| Global change monitoring and land-use change research and monitoring programmes |                                                                 |
| Simon Todd                           | Ecologist at SAEON Arid Lands Node. SACNASP Professional Natural Scientist (Reg. No. 400425/11). |
|                                     | Joh Henschel (Dr)                                           |
|                                     | Manager at SAEON Arid Lands Node.                            |
|                                     | Emma Archer (Dr)                                            |
|                                     | Chief Researcher in Sustainable agriculture, managed ecosystems, Climate Studies, Modelling and Environmental Health at the Council for Scientific and Industrial Research. |

| Predator species long term research and monitoring programme |                                                                 |
| Gabriella Duncan                        | Intern at the South African office of SKA. SKA South Africa Young Professionals Programme |
| Justin O'Riain (Prof)                   | Professor at the Department of Biological Sciences of the University of Cape Town. Director at the Institute for Communities and Wildlife in Africa. |
| Lydia Cape                              | Environmental Scientist at the CSIR SACNASP Professional Natural Scientist (Reg. No. 400359/13) |
II. Implementation of the research and monitoring programmes

The South African Environmental Observation Network (SAEON) and the National Research Foundation (NRF) have signed an Integrated Memorandum of Understanding for the establishment of a SKAEON committee. This Integrated Memorandum of Understanding defines the governance structure and objectives of SKAEON and has been developed based on the mutual benefit provided by the presence of SAEON at the SKA site. It is the intention to declare the SKA land core area as a National Park under the management of a Land Management Authority with special restrictions/limitations in compliance with the requirements for protection of the SKA activities. The NRF is in the process of appointing SANParks as the Land Management Authority that will be responsible for the development and implementation of a Land Management Plan (further called a Park Management Plan) for the protected area. The NRF in conjunction with its appointed Land Management Authority, SANParks will manage mutual responsibilities and opportunities within the SKA land core area in line with the Park Management Plan.

All environmental research and monitoring programmes implemented within the SKA land core area (including endangered species monitoring and predator species monitoring, heritage and ecological fieldwork, etc.) will be coordinated and approved by the appointed Land Management Authority (SANParks) in conjunction with SARAO which is in accordance with the SANParks Standard Operating Procedures for the registration of research in SANParks.

A three year contractual agreement has been established between the SAEON and the NRF to conduct fieldwork, collect data, provide baseline and manage ongoing environmental monitoring within the SKA land core area. SAEON will collaborate with the Land Management Authority (SANParks) to coordinate the activities proposed by SKAEON as part of their environmental research and monitoring programmes which is in accordance with the SANParks Standard Operating Procedures for the registration of research in SANParks.

The main goal of the SKAEON committee is to address the information gaps required to manage the land, to the advantage of South Africa, while at the same time furthering the goals of SAEON with respect to Global Change Research. A research and training platform will be established by SKAEON with the following outcomes and activities:

- Provide baseline and ongoing environmental monitoring at the SKA site to inform the SKA1_MID EMPr included in the IEMP.
- Coordinate environmental research at the SKA site: this will ensure that current and emerging issues can be addressed to inform the IEMP, as well as ensure that research at the site takes place in a coordinated manner to maximise science impact and output.
- Coordinate long term biodiversity assessment to monitor the presence and relative abundance of predators and their natural prey within the SKA land core area.
- SAEON Arid Lands Node will develop a sentinel research and training platform at the SKA site, which will focus on land-use impacts, climate change impacts and adaptation.

The knowledge of farmers and their mentorship role in the study area is recognised as a pillar to the Karoo region and it is strongly recommended that the knowledge of the farmers about the land and the area (i.e. knowledge of factors - impacting ecosystems, construction activities, stormwater control, erosion management, maintenance of ground water, pollution of natural resources, etc) is shared with the appointed Land Management Authority and SAEON prior to their departure of the land within the SKA land core area.
The use of existing artificial water points in the SKA land core area will be monitored by the appointed Land Management Authority, SAION experts and other researchers involved in the long-term research and monitoring programmes (e.g. EWT and Human-Wildlife Research Institute). A comparative study of animals using water supplies on the farms neighbouring the SKA land core area and within the core area will be conducted during the long-term research and monitoring programmes and the results of this study will be included in the review of the IEMP.

III. Plant Rescue and Protection

The objective of this Plant Rescue and Protection programme is to mitigate the risks associated with the permanent removal or damage of plant species of conservation concern (species listed as threatened, vulnerable or endangered in the Red Data List\(^1\) or protected by national/Provincial legislation) during SKA construction activities, as well as prevent the further reduction of the abundance of these species.

The National Environmental Management Biodiversity Act (Act no 10 of 2004) must be complied with when conducting any activity related to the permanent removal or damage of plant species of conservation concern. The implementation of this Plant Rescue and Protection programme must be conducted by a suitably qualified and experienced plant ecologist. The findings and recommendations resulting from the implementation of this Plant Rescue and Protection programme must be made available to the public in a transparent manner.

The Northern Cape Nature Conservation Act\(^2\) makes provision for restricting activities concerning “Specially Protected and Protected species” of fauna and flora. 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” (Section 50 of the Act). There are 44 plant species classified as “Specially Protected” and 589 plant species classified as “Protected” within the Karoo Central Astronomy Advantage Area\(^3\). Most of the specially protected and protected species within the Karoo Central Astronomy Advantage Area are trees, bulbs, succulents and herbaceous medicinal plants from the Fabaceae and Aneuraceae families. A permit\(^4\) is required to destroy, translocate, transport or cultivate any of these plants.

The plant families with the most species of conservation concern are Mesembryanthemaceae (18), Iridaceae (13), Amaryllidaceae (9) and Asphodelaceae (8). Three plant species of conservation concern occur within the SKA core area, namely Acacia erioloba (declining\(^5\)), Aloe dichotoma (listed as vulnerable in the Red Data List) and Hoodia gordonii (Data deficient, declining).

This section provides guidelines and minimum requirements to be included in the Plant Rescue and Protection Plan to be compiled by SKA.

General principles for the protection, rescue and translocation of plant species:

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\(^1\) See IUCN Red List Categories and Criteria: http://www.iucnredlist.org/


\(^3\) Government Notice 141 dated 28 February 2014 (Government Gazette 37397)

\(^4\) dencpermits@ncpg.gov.za Department of Environment and Nature Conservation (D.E.N.C.), Private Bag X6120, Kimberly, 8301 Tel: +27 (0)53 807-7416/7300

\(^5\) Victor and Keith (2004) developed additional categories (Critically Rare, Rare and Declining) to flag taxa of conservation concern that would be classified as Least Concern (LC) according to the IUCN system (J.E. Victor, M. Keith, The Orange List: a safety net for biodiversity in South Africa, South African Journal of Science, 100 (2004), pp. 139–141).
The protection of plants within construction areas requires mapping of plant populations using a Global Positioning System (GPS) to record co-ordinates, and temporary demarcation of protected plant populations usually by means of hazard tape, undertaken by a suitably qualified field ecologist.

Areas with substantial populations of plants with high conservation significance or protected plants by national or provincial regulations should be avoided. 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.

The translocation should occur immediately after heavy rain when the soil has been wet to a depth of 20-30 centimetres (cm) 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.

A permit should be issued by the Northern Cape Department of Environment and Nature Conservation for the removal and translocation of these plants of interest.

The following equipment will be required for the plant rescue and translocation activities:

- **Tools:** spades, hand trowels, “koevoets” (i.e. heavy sharpened iron bars for digging in hard rocky ground), large screw drivers (for excavating small bulbs); sacks and canvas for carrying plants;
- **Irrigation equipment:** 1000 litres water tank, watering cans,
- **Recording equipment:** camera, GPS for recording the locality of the translocation site (for later monitoring and quality control), notebook or data sheet for recording the numbers of each plant species (or growth form) translocated,
- **Safety equipment:** leather gloves for handling spiny plants and plants containing poisonous sap or latex; first aid officer, first aid box.

The following guidelines should be followed in order to improve transplanting success:

- **Training:** The manager of the translocation work should be familiar with the types of plants that can be translocated, and these guidelines. The procedure should be demonstrated to the work team before the translocation work starts;
- **Before digging out plants** count how many are growing in the open and how many near bushes. Dig the appropriate number of holes in the translocation sites (a) near bushes, (b) away from bushes;
- **Leaf and stem succulents** should be dug out saving as much of the roots as possible. Remember that the roots are the most important part of the plant for survival in an arid system;
- **Bulbs and corms** must be dug out complete with their roots. If the base of the bulb breaks off the plant will not survive;
- **Do not shake soil off the roots** – keep as much soil on the roots as possible to protect fine roots;
• Avoiding damage to the stems and leaves of succulents;
• Do not leave the salvaged plants lying in the sun;
• Do not immerse salvaged plants in buckets of water;
• Plants that grow in the shade of rocks or other “nurse” plants should be planted in a similar relative position, i.e. if the target plant was growing on the south side of a Lycium bush in the construction side it should be planted on the south side of a tall shrub in the translocation site;
• Do not bend or wind up the roots when planting, rather enlarge the planting hole so that roots can be spread out;
• Make sure the plant is the right way up and at the correct depth – i.e. the roots, but not the leaves, must be covered with soil;
• Bulbs and corms that were deeply buried must be deeply planted, i.e. only the green part of the leaves must show above ground;
• Press the soil down around the plant to stabilise it in the soil and if rocks are available pack these around the base of the plant to prevent it blowing or washing away;
• Water the plants well after transplanting, preferably with fresh water (i.e. with a low mineral content), to settle the soil and encourage root growth; and
• Storage of excavated plants: If there is a rush to remove plants from a site before construction, excavated succulents and bulbs can be stored in cool dry conditions for up to two weeks (e.g. in a shed or under a tree).

IV. Habitat Rehabilitation

1. General guidelines

This section provides revegetation and habitat rehabilitation guidelines for disturbed areas including construction camps, temporary access roads, trenches, dish-antennas and tower construction sites; borrow pits, old plowed farm fields and alien vegetation clearing sites. These are general guidelines that may need to be adapted according to soil type and slope.

The National Environmental Management Biodiversity Act (Act no 10 of 2004) must be complied with when conducting any activity related to revegetation and habitat rehabilitation. The implementation of this revegetation and habitat rehabilitation programme must be conducted by a suitably qualified and experienced plant ecologist. The findings and recommendations resulting from the implementation of this revegetation and habitat rehabilitation programme must be made available to the public in a transparent manner.

The principles governing the design and implementation of a rehabilitation programme are as follows:

- Rehabilitation is the reinstatement or improvement in the effectiveness of the driving forces that created and continue to shape and sustain the ecosystem;
- The goal of rehabilitation should not be to return an ecosystem to and maintain it in a static state at some time in the past, but rather to aim to achieve a dynamic and resilient system that can respond to change and that is largely self-maintaining, requiring little human intervention over time;
- Rehabilitation should be integrated with the surrounding landscape in order to address the upstream and downstream causes of degradation;

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The rehabilitation programme will be implemented on the long term by the NRF and the appointed Land Manager with a commitment to sustaining the integrity of the system;

Rehabilitation should be well-planned with clearly stated and measurable objectives, effectively implemented, and must be continually monitored and evaluated. Rehabilitation of disturbed areas must be undertaken as soon as possible after construction.

As such, records of all areas where construction will mechanically disturb the soil below surface in any way (GPS coordinates of each area) including date and depth of topsoil stripping, and date and depth of topsoil re-spreading/rehabilitation for each of these areas must be kept. Areas should be photographed thereafter on an annual basis to record vegetation re-establishment.

The following applies to all disturbed areas requiring rehabilitation:

- All disturbed areas must be mulched to encourage vegetation re-growth. Mulch used must be free from exotic plant seed and the subsoil must be used for shaping during the reinstatement phase prior to placing the topsoil on top;
- Weeds are to be removed, if any, prior to rehabilitation, compacted areas/subsoil must be ripped (i.e. either manual or machine driven ripping) and the topsoil layers reinstated (containing seed and vegetative material) as soon as construction is complete to allow the plants to rapidly re-colonise the bare soil areas. It is important to use locally-sourced seed of indigenous grass species that were recorded on site during the pre-construction phase for the re-seeding, supplemented with translocation of succulents and bulbs from adjacent areas where possible;
- Nursery-grown Acacia erioloba must be used to replace felled specimens where maintenance of the trees is feasible;
- Ripping must be done to a depth of 250 millimetres (mm) in two directions at right angles. Topsoil must be placed in the same soil zone from which it has been stripped and must be evenly spread over the entire disturbed surface so as to facilitate seeding and minimise loss of soil due to erosion; and
- Use hand-dug micro-catchments, mulch and brush packing to retain water to improve infiltration (compacted soils delay recovery).

2. Rehabilitation of construction camps sites and temporary access roads

While access roads to antennas and to some tower sites shall be maintained, there are situations where road closures will be required. These locations are usually in environmentally sensitive sites and were identified in Chapter 2 of this IEMP. Furthermore, the closure of a road may also be specifically requested by a landowner within the proposed development area.

The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of the construction camps and temporary access roads within the proposed development area:

- **Vegetation clearing.** After salvage scrape remaining vegetation into windrows or remove it with the topsoil. The dead vegetation is valuable as a source of seeds, mulch and plant nutrient during rehabilitation.
- **Topsoil management:** remove 100 millimetres of the surface soil and store it in low berms (less than 2 metre (m) high) adjacent to the construction area and upslope, in a position where it will not be driven on, washed away by flooding or polluted by fuel spills or building materials. Do not place any construction materials or subsoil on the topsoil storage heaps. Topsoil
contains the nutrients, seeds and soil organisms required for habitat restoration after closure of the camp or temporary road.

- **Preparation for re-vegetation:** Remove all concrete structures and waste materials from the site and remove any soil polluted with hydraulic fluids, lubricants or fuel. Fell and poison any *Prosopis* (mesquite) on or adjacent to the site and remove any cactus and other listed Invasive Alien plants from the site. Use only herbicides registered for treatment of the target species. Spread and level any heaps of building materials (sand, crushed rock) that remain on site. Build berms to close disused roads – i.e. low humps (0.2-0.3 m) at right angles to the slope (i.e. along contours). In areas of 30 % slope and less, the fill of the road should be placed back into the roadway to restore the natural ground slope (Figure 1). Here it is important to use equipment that does not work outside of the road it is closing. (For example, a Tractor Loader Back-hoe may be used and should operate from the cut portion of the road, working backwards and closing the road as it retreats). On steeper slopes (greater than 30 % slope), the equipment should break the road shoulder down, so that the slope nearly approximates to the original slope of the ground (Figure 1). The cut banks should be pushed down into the road, and a terraced side slope should be re-established with an erosion control system and re-vegetated. Rocky hills (koppies) with little soil may be steeper in places and there is no soil to replace. However, soil should not be taken from another place and added to rock outcrops. Replacement of earth should be at a slope less than the normal angle of repose (the natural angle of soil spill) for the soil type involved.

![A: Side slope 30% or less](image1)

![B: Side slope more than 30%](image2)

**Figure 1: Road Closure in steep terrain**

- **Top soiling.** Where topsoil has been saved as recommended, spread this over the site and top it with a mulch of the dead vegetation that was removed from the site. The final surface should be rough and chunky with scattered rocks if available. Rough surfaces capture water, seed and nutrients improving plant growth. Where access roads have crossed cultivated farmlands, the lands should be rehabilitated by ripping to a minimum depth of 600 mm. Rehabilitation can also be done by using Geo grids (Geotex) or Geo cells (Hyson or Multi cells) with topsoil and re-seeding, in particular under windy conditions where soil is dry and loose. Note that Hyson cells and similar grids merely contain topsoil on a temporary basis to allow the re-growth of natural vegetation and are not suitable for carrying traffic or for use in the presence of large amounts of flowing water.
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- **Erosion control and infiltration.** The risk of soil erosion increases with slope and risk is high for gradient steeper than 14 % (1:7). Erosion risks are also increased on fine-textured, deep soils where rapid runoff after rain will cause dongas if water is channelled 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 erosion. Check all drains from berms and address gully erosion problems in the water discharge area by packing rocks to disperse runoff water. On steep slopes hand dig mini catchments 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 rip the ground along the contour to improve infiltration and capture water and seed. Figure 2 shows some methods to improving infiltration and retaining seeds, water and nutrients in rehabilitations sites: A) mini catchments and ripping. B) brush fencing combined with mini-catchments. C) bulb regenerating from spread topsoil on a construction site (note rough soil surface that maximises water infiltration), and translocation of succulent plants.

- **Seeding.** Once drainage, infiltration, runoff control and topsoiling have been completed, sow the whole area with seeds of plants that are common and indigenous in the local area (Table 2). These can be harvested locally or bought from specialised suppliers of Karoo seed. Where required, re-vegetation can be enhanced using a vegetation seed, provided it is carefully selected to ensure the following:
  a) Annual and perennial plants are chosen;
  b) Pioneer species are included;
  c) Species chosen must grow in the area without any problems;
  d) Root systems must have a binding effect on the soil;
  e) The final product should not cause an ecological imbalance in the area.

- **Translocation.** Small succulent plants from the surrounding area can successfully be translocated from surrounding natural vegetation onto the rehabilitation site. Do not attempt to move non-succulent shrubs or grasses as they are unlikely to survive. Nursery-grown *Acacia erioloba* must be used to replace felled specimens were maintenance of the trees is feasible.

- **Site protection.** Ensure that decommissioned roads and construction sites are inaccessible for vehicles. Roads can be closed with jagged stones and no entry signs posted on closed roads and rehabilitating construction camps;

- **Record keeping.** The Environmental 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 construction footprint area. It is very valuable to know what approaches work and which do not work under the harsh conditions of this area.

<table>
<thead>
<tr>
<th>Landscape position</th>
<th>Soil type</th>
<th>Grasses for seeding</th>
<th>Shrubs for seeding</th>
</tr>
</thead>
</table>

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9 Coetzee, K. 2005. Caring for natural Rangelands. University of KwaZulu-Natal Press. (order from books@ukzn.ac.za)
<table>
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<tr>
<th>Topography</th>
<th>Soil Type</th>
<th>Dominant Species</th>
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<td>Hillside dolerite</td>
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<tr>
<td>Hillside mudstone</td>
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<td>Enneapogon species, Fingerhuthia africana</td>
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<tr>
<td>Foot slope</td>
<td>silt</td>
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</tr>
<tr>
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<td>Stipagrostis obtusa, Eragrostis obtusa</td>
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<td>Gravel and calcrete</td>
<td>Eragrostis lehmanniana, Stipagrostis obtusa</td>
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<tr>
<td>Drainage line</td>
<td>sand</td>
<td>Stipagrostis ciliata</td>
</tr>
</tbody>
</table>
3. Rehabilitation of trenched areas

The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of the trenched areas within the proposed development area:

- **Topsoil and subsoil replacement.** After cable lying has been completed replace first the subsoil and then cover the subsoil with topsoil and rocks.
- **Erosion control.** If the trench runs up a steep hillside (1:7 or steeper), then place low berms across the trench at 10 to 20 metre intervals to divert water from the unstable soil of the trench.
- **Reseeding:** as per Table 2. Where required, re-vegetation can be enhanced using a vegetation seed, provided it is carefully selected to ensure the following:
  a) Annual and perennial plants are chosen;
  b) Pioneer species are included;
  c) Species chosen must grow in the area without any problems;
  d) Root systems must have a binding effect on the soil; and
  e) The final product should not cause an ecological imbalance in the area.

4. Rehabilitation of dish-antenna sites

The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of dish-antenna construction sites within the proposed development area:

- **Drainage and erosion control.** The dish-antenna footprint area is raised above the surrounding landscape, gravelled and surrounded by a compacted road to give access to service vehicles. These semi-permanent structures result in some accelerated runoff of rainwater into the surrounding vegetation. To avoid gully formation on deep soils the runoff channels should be stabilized with stones and sown with grass seed.
- **Soil preparation and topsoiling of damaged areas around telescope (excluding access road):** Where the construction footprint for the telescope exceeded the area of the telescope infrastructure and access road, rip any compacted ground and re-spread the topsoil salvaged from the telescope site. Mulch with dead plants salvaged from the construction site.
- **Seeding:** Should not be required unless the bare ground area exceeds one hectare. If required, seed with grasses or shrubs appropriate for the soil type.

5. Rehabilitation of power infrastructure sites
Under normal circumstances, most of power infrastructure tower sites, being located on relatively even terrain, will not require extensive rehabilitation or mitigatory measures. If the top-soil is replaced in the final layer of backfill, natural ground cover vegetation will usually grow back in spite of extensive removal of surface vegetation during construction. The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of dish-antenna construction sites within the proposed development area:

- **Drainage and erosion control.** Any soil removed by erosion, must be back-filled evenly and, graded to conform to the surrounding terrain. All slope areas at tower sites should be stabilized. Where towers are placed on steep slopes resulting in disturbed surfaces, or lose ground, the slopes should be rehabilitated or refurbished by one of the following methods:
  
a. Steep slopes: use retaining systems such as Gabion basket systems, retaining blocks or stone masonry.
  
b. Moderate slopes: use Geo grids (Geotex) or Geo cells (Hyson or Multi cells) with topsoil and re-seeding. Note that these may be difficult to install on rocky ground with little soil. The broken rock should be packed along contours to trap soil, organic matter and seed over the years.

- **Soil preparation and top soiling of damaged areas around tower:** Following foundation excavation, care must be taken to replace top-soil on the final uppermost layer of foundation backfill. Rip any compacted ground and re-spread the topsoil salvaged from the tower site. Mulch with dead plants salvaged from the construction site. Failure to replace topsoil in the final layer will leave infertile subsoil on the surface, thus impeding re-growth.

- **Seeding:** Should not be required unless the bare ground area exceeds one hectare. If required, seed with grasses or shrubs appropriate for the vegetation and soil type. Note that vegetation emerging from soil-stored seed is generally dominated by annual plants and grasses and it may take many years for perennial plants with animal or wind-dispersed seed to return to the site. As such seeding may therefore be best.

6. **Rehabilitation of borrow pits**

In addition to the requirements of the Department of Mineral Resources’ mining permit rehabilitation, the following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of borrow pits sites within the proposed development area:

- **Pre-closure clean up.** Remove any soil contaminated by fuel or oil spills; remove all plastic bottles and other litter.

- **Shaping.** Shape the walls of the borrow pit at a shallow enough angle (not steeper than 1:3) to hold soil and plants. Surface topography should emulate the surrounding areas and be aligned to the general landscape character.

- **Erosion control.** Build a berm (approximately 30 cm 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.

- **Drainage.** As far as practicably possible, ensure that the borrow pit is free draining towards natural drainage lines.

- **Preparation for re-vegetation.** 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 (Figure 2).

- **Seeding.** Once drainage, infiltration, runoff control and topsoiling have been completed, sow the whole area with seeds of plants that are common and indigenous in the local area. These can be harvested locally or bought from specialised suppliers of Karoo seed. Where required, re-vegetation can be enhanced using a vegetation seed, provided it is carefully selected to ensure the following:

  a) Annual and perennial plants are chosen;
  b) Pioneer species are included;
  c) Species chosen must grow in the area without any problems;
  d) Root systems must have a binding effect on the soil;
  e) The final product should not cause an ecological imbalance in the area.

- **Translocation.** Small succulent plants from the surrounding area can successfully be translocated from surrounding natural vegetation onto the rehabilitation site. Do not attempt to move non-succulent shrubs or grasses as they are unlikely to survive. Nursery-grown *Acacia erioloba* must be used to replace felled specimens were maintenance of the trees is feasible;

- **Record keeping.** The Environmental 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 construction footprint area. It is very valuable to know what approaches work and which do not work under the harsh conditions of the site.

7. Rehabilitation of alien vegetation clearing sites

In addition to the Working for Water Guidelines for indigenous vegetation restoration following invasion by alien plants (2000), the following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of alien vegetation clearing sites within the proposed development area:

- **Management of brushwood.** According to the Working for Water Operational Standards: methods for manual clearing (February 2015), “felled material and other dead material (brush and logs) shall not be allowed to block or impede water courses and must be removed from all water courses, either 30 m away from the river or out of the flood line itself”. Branches with pods should be removed from the site to a licenced waste disposal facility or burned. Felled material (thicker than 70 mm) shall be de-branched and cross cut in manageable logs that can be harvested for firewood.

- **Erosion control.** Brushwood can be used in various ways as part of a post-clearing erosion control and rehabilitation programme. Brushwood can be stacked along contours to reduce runoff and to control Alien Invasive Plant Species regrowth by shading. Rows should be at least 3 meter apart, no more than 3 metre wide, and no longer than 15 metre long with a two meter gaps between the ends of adjacent rows to allow for teams conducting follow-up clearing to move through the cleared site. Alternatively, brushwood can be used in

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combination with geo-textile material\textsuperscript{12} to make “sausage” fences pegged to the ground for erosion control and resource (seed, water, nutrient) trapping (Figure 3). Brushwood can also be chipped and spread as a mulch in hand dug mini-catchments (Figure 3). Ensure that mulches used for restoration must not contain seeds of Alien Invasive Plant Species.

- **Reseeding.** Sowing seeds of indigenous plants on the bare areas where *Prosopis* was cleared speeds up recovery of natural vegetation and slows down *Prosopis* regeneration from the seed bank. Seeding should take place between February and April. Sow the whole area with seeds of plants that are common and indigenous in the local area (Table 2). These can be harvested locally or bought from specialised suppliers of Karoo seed.

- **Record keeping.** The Working for Water contractor must complete the latest version of the Department of Environmental Affairs “Site inspection report”. The Environmental Manager in charge of revegetation in the SKA construction footprint area 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 construction footprint area. It is very valuable to know what approaches work and which do not work under the harsh conditions of the site.

8. **Rehabilitation of river crossings**

Most of the rehabilitation of aquatic features revolves around the re-shaping and stabilisation of the bed and banks of watercourses and wetlands, to ensure that surface hydrology returns to pre-construction patterns and flow levels. The following programme should be followed for the re-

\textsuperscript{12} Milton SJ 2010. Feasibility and benefits of veld rehabilitation following control of invasive Prosopis in the Calvinia area. Working for Water: Namaqua District Municipality. 2010.01.10
vegetation and habitat restoration (rehabilitation) of river crossings within the proposed development area:

- **Re-shaping of river banks:** The ideal longitudinal slope to prevent erosion in a river channel is 1:7, while re-shaped bank slopes should, in general, not be steeper than 1:3. It is recommended that the shape of the rehabilitated river or wetland bank be heterogeneous – with steeper sections and gentler sections, in order to mimic the natural shape of a river bank. Work in watercourses and wetlands shall be undertaken in such a manner to minimise the extent of impacts caused by such activities. Surface flow should be diverted while work is underway, in such a way that does not cause erosion of the surrounding landscape, and to avoid mobilisation of sediments downstream. All river diversion materials must be completely removed from the river after completion of the rehabilitation works.

- **Stabilisation of banks:** It is important to consider using various stabilisation measures after the banks have been shaped, to prevent erosion. Stabilisation materials include: Ecologs, particularly effective in areas of low gradient, such as over much of the SKA construction footprint area (see Figure 4-A), biodegradable netting/matting, MacMat (see Figure 4-B) and mulch stabilisation.

![Figure 4: Stabilisation of banks](image)

**V. Alien invasive plants monitoring**

The various SKA construction activities resulting in the reduction of vegetation cover, hydrology changes, and seeds introduction, create opportunities for invasion by alien plant species. The efficient and effective control and management of listed alien invasive plants species within the SKA construction footprint area will require a combination of invasion risk reduction on construction sites,

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14 Dry woody material or sand contained in a hessian and chicken wire roll.

15 Made by Maccaferri – a non-woven geotextile matting of thick filaments designed to be secured over a vulnerable slope to prevent surface erosion.
and proactive containment of existing invasions by means of mapping, prioritization, biocontrol\textsuperscript{16}, systematic clearing, monitoring and follow up treatments on clearing projects\textsuperscript{17}. Information on methods and chemicals to be used for the control of alien invasive plant species is provided as guidelines only.

Preliminary control methods, impact management actions and impact management outcomes compiled by Dr Sue Milton and Dr Harding for this study have been included in the SKA1 \_ MID EMPr (Chapter 5 of this IEMP). Further research and monitoring activities are required to understand the densities and distributions of the different alien invasive plant species and to include detailed control and management options in the detailed Alien Invasive Plant Species Management Plan. Additional information species-specific herbicide application rates should be obtained from labels of registered herbicides.

The control and monitoring of alien invasive plants species must comply with applicable legislation in South Africa including:

- Conservation of Agricultural Resources Act [Act 43 of 1983];
- National Environmental Management Biodiversity Act [Act 10 of 2004];
- National Environmental Management Biodiversity Act (NEMBA): Invasive Alien Species List was published in the Government Gazette on 12 February, 2014 (an updated set of Invasive Species Lists (as per the NEMBA Regulations) were published on 29 July 2016);
- National Veld and Forest Fires Act [Act 101 of 1998];
- National Water Act [Act 36 of 1998];
- National Environment Management Act [Act 104 of 1998];
- National Heritage Resources Act [Act 25 of 1999];
- Fertilizer, Farm Feeds Agricultural and Stock Remedies Act [Act 36 of 1947]; and

During the Strategic Environmental Assessment process, the South African Office of the SKA initiated a discussion with the Natural Resource Management Programme of the Department of Environmental Affairs (DEA) (contact person: Michael Braack, Deputy Director at the directorate: Operational Support and Planning) on a collaboration between the NRF and the Working for Water programme\textsuperscript{18} for alien invasive plants clearing and control activities within the SKA core area. The Department of Environmental Affairs Natural Resource Management Programmes operational Support and Planning unit is currently working on a Management Unit Control Planning (MUCP) tool which aims to quantify the extent of the alien plants invasion problem, prioritise most important areas for clearing and calculate required investment for the implementation of the alien invasive clearing and control programme, depending on the timeframe and availability of funds. Department of Environmental Affairs Natural Resource Management Programmes indicated that the MUCP tool could be used for the SKA core area once invasions maps with info on species and densities, landscape management units, and a detailed history of clearing efforts in the area are available. Further research and monitoring activities are required in order to understand the densities and distributions of the different alien invasive plant species and to include detailed control and management options in the detailed alien invasive plant species Management Plan.

1. General Guidelines

\textsuperscript{16} https://www.environment.gov.za/projectsprogrammes/wfw/biocontrol
\textsuperscript{17} Department of Environmental Affairs 2014. A National Strategy for dealing with biological invasions in South Africa https://sites.google.com/site/wfwplanning/strategy
\textsuperscript{18} https://www.environment.gov.za/projectsprogrammes/wfw
The key objectives of this Alien invasive plants monitoring programme are:

- Maintain an updated map of alien invasive plants extent and density within the SKA construction footprint area and report on evolution of distribution of alien invasive plants to the Department of Environmental Affairs (at least annually);
- Maintain a track-record of successful clearing and control activities (e.g. percentage of new alien invasive plants-free site) with detailed information on the season during which the control measures was implemented as well as the herbicide used and the successful application method and report on successful activities to the Department of Environmental Affairs (at least annually);
- Collaborate with the Department of Environmental Affairs Natural Resource Management Programmes (NRMP) and other conservation/academic institutes to promote surveys of alien invasive plants within the entire Karoo Central Astronomy Advantage Area (photograph, identify and record locations); and
- Collaboration with the Expanded Public Works Programme (EPWP)\(^\text{19}\) and Working for Water programme for monitoring of the activities and successful eradication of alien plants within the SKA construction footprint area.

The following guidelines apply to all alien invasive plant species identified within the SKA1_MID development footprint and must be implemented during all phases of development:

1) Undertake monthly walk-through of the SKA1_MID construction areas to quantify the extent of the alien plants invasion problem and prioritise most important areas for clearing activities.

2) Collect information on the densities and distributions of the different alien invasive plant species during monthly walk-through of the SKA1_MID construction areas, using a grid-approach over the study area with each grid cell numbered for tracking and mapping of progress, methods, dates and follow-up work (capture information in a management unit table - see Table 6-3 for template).

3) Compile and update invasions maps with info on species and densities and landscape management units based on observations made during monthly walk-through of the SKA1_MID construction areas.

4) Conduct systematic clearing programme prioritizing the lower-density edges of the invasion based on available alien plants population density map, very small areas of high density invasion (<1 hectare), and areas subject to high levels of SKA-related activity for clearing must be implemented.

5) Keep track-record of a detailed history of clearing efforts in the area to feed into the monitoring tools for control sites. The monitoring checklist should include, at a minimum, information on the initial survey date, the density on site during the initial survey, the control methods implemented on site, the audit date, the density on site after the implementation of control methods, and any follow-up treatment method.

6) Ensure that materials extracted from borrow pits, quarries and sand mines, for construction activities and rehabilitation, originate from alien invasive plants-free sites.

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\(^{19}\) The EPWP projects are funded by the Department of Environmental Affairs Natural Resource Management and Social Responsibility Programmes. The main focus of the EPWP is to provide income relief through temporary work for the unemployed to carry out socially useful activities.
7) All construction machinery and plant equipment delivered to site for use during the construction phase must be cleaned in order to limit the introduction of Alien Invasive Plant Species.

8) Contractors working within the SKA1_MID development footprint must comply with all operation standards as per Working for Water Project Operating Standards\(^{20}\), including disposal of seed bearing Alien Invasive Plant Species material. Environmental Officer and appointed Land Management Authority to inspect work areas and construction sites and complete audit sheets and collect photographic evidence.

9) Topsoil removed for construction activities on SKA1_MID construction areas is salvaged and correctly stored for post construction rehabilitation. Construction sites are restored by topsoil replacement, scarification and reseeding with appropriate local seed. Environmental Officer and appointed Land Management Authority to inspect sites before signing off the work.

10) Inspect all receptor dish sites and access routes, roads, optic fibre trenches, on completion of construction activities and update the alien invasive plant species database, report on the success of areas where control measures were implemented (% kill), specifying season, herbicide and application method. Environmental Officer and appointed Land Management Authority to inspect sites and complete alien invasive plant species clearing audit.

11) All clearing and control activities must be conducted in compliance with the Alien and Invasive Species Regulations under the National Environmental Management Biodiversity Act [Act 10 of 2004].

12) All herbicide treatments must be conducted in compliance with the Fertilizer, Farm Feeds Agricultural and Stock Remedies Act [Act 36 of 1947] and the Department of Environmental Affairs' revised and updated policy on the use of herbicides and mycoherbicides for the control of alien vegetation (2012).

13) All herbicide treatments applied to alien Invasive plants must comply with the South African National Standards for handling, storage and disposal of Pesticides (SANS 10206:2010, Edition 2.2). Only herbicide registered for a particular plant species are to be used. Where no herbicide has been registered, use the least hazardous herbicide registered\(^{21}\) for a similar plant species (i.e. another species of tree or shrub).

14) No herbicides may be applied within heritage sites of Grade 1, 2 or 3a status, burial grounds and rock art as the herbicides may contaminate the soil of the heritage sites and data potential from these sites, and may cause damage to rock art.

15) Removal of Alien invasive plant species located within heritage sites must be subject to a permit application process in terms of section 27, 34, 35 or 36 of the National Heritage Resources Act [Act 25 of 1999].

16) Removal and eradication of alien vegetation in watercourses and riparian areas must be undertaken with extreme care to limit the risk of pollution and should be conducted by people trained in herbicide application.

Invasive alien perennials (*Prosopis glandulosa*, *Prosopis velutina* or hybrids that prefers to grow where there is moisture, and so tends to invade riparian areas, river channels, floodplains, and wetlands).

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\(^{20}\) [https://sites.google.com/site/wfwplanning/implementation](https://sites.google.com/site/wfwplanning/implementation)

\(^{21}\) See Hazard ratings for common commercial herbicides in Chapter 5 of the IEMP.
According to existing models for the prioritization of alien invasive plants control operations by Working for Water in South Africa (Van Wilgen et al. 2012)\(^{22}\), areas where alien invasive plants can be a threat to surface water (particularly water resources stressed by human demand), soil stability, and regional poverty levels; as well as areas with existing high levels of alien invasive plants invasion (especially where the invader is *Prosopis* species) should be targeted for priority control activities.

The Karoo Central Astronomy Advantage Area includes stressed surface water resources, priority wetland for conservation, erodible soils and a high river length ratio as well as high level of poverty especially in small rural towns. Within the Karoo Central Astronomy Advantage Area, the “Carnarvonleegte” drainage line between Kenhardt, Van Wyksvlei and Carnarvon is an obvious focus for biocontrol and clearing because it is heavily invaded by *Prosopis* and lies between under-resourced towns. This area should be targeted for biocontrol (seed-feeding beetle) release - ensure compliance with the Working for Water Biocontrol guidelines (2007); and the guidelines of Agricultural Research Council on the biocontrol agents established in South Africa\(^{23}\).

Within the Strategic Environmental Assessment study area, the *Prosopis* invasion is most concentrated within the SKA core characterised by lowland area receiving drainage from the mountains to the South. The degree of soil and vegetation and hydrological disturbance will also be greatest within the SKA core area. The major steps in achieving effective control of *Prosopis* (and other alien invasive plant species) in the SKA land core area would be financial and project planning, mapping, prioritization, appointment of contractors, clearing and rehabilitation, monitoring and follow-up control. A systematic clearing programme which aims to prioritize the lower-density edges of the invasion, very small areas of high density invasion (less than 1 hectare), and areas subject to high levels of SKA-related activity for clearing should be developed and implemented within SKA land core area with appropriate monitoring tools for control sites.

The monitoring and control of Alien Invasive Plant Species must be conducted in collaboration with the Working for Water Programme of the Department of Environmental Affairs (Natural Resources Management Programmes) and must follow their recommendations for initial population reduction, follow-up control and long-term maintenance at all SKA sites, roads and servitudes. Existing Working for Water programmes are located outside the boundaries of the Karoo Central Astronomy Advantage Area, the nearest being at Beaufort West to the South and in Calvinia to the West. The involvement of the Working for Water operations contractors in the alien invasive clearing and control activities on the SKA core site requires that a proposal including the detailed alien invasive management plan informed by the Management Unit Control Planning (MUCP) information is submitted to Department of Environmental Affairs Natural Resource Management Programmes (NRMP) for consideration. The proposal including the detailed alien invasive management plan should be prepared by the NRF during the final design phase once a final detailed design for SKA1_MID is available. The proposal must make use of the NRMP Management Unit Control Planning (MUCP) tool to develop the biocontrol plan, a clearing plan, as well as required budgets for contractors, tools, herbicides, training, safety equipment and transport, monitoring, administration and management.

2. Monitoring and control of woody plants

   a. Cut stump

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Fell trees according to label instructions using a suitable tool (lopper, hand saw or chain saw). Label recommendations suggest that trees should be felled between 10-20 cm above the ground. Field conditions may dictate that trees are felled outside these parameters, but this should be the exception and not the norm. A suitable and registered herbicide should then be applied as per label recommendations. When treating the cut stump of a felled tree all cut branches and stems must be treated.

b. Foliar applications

Foliar applications are not recommended for the SKA core area (since development areas must be cleared for construction activities; and it is not applicable for the climate and growth characteristics of the trees in the SKA core area) but can be used for follow-up operations, treatments of suckers and any seedlings that cannot be hand pulled.

c. Mechanical Control

Mechanical Control is also not recommended for the SKA core area as it is not suitable for the alien plant species present within this area.

d. Biological control

The only tree with biological control available is *Prosopis*. The beetle is wide spread and well established already so no further action is required.

e. Handling of trash

Trash from felled trees should be stacked in a suitable area (to be included in the detailed Invasive Alien Species Management plan for the SKA construction footprint area). Stacking will depend on the desired and recommended actions but there is no need to remove off site.

3. Monitoring and control of *Prosopis* species

This group of plants is renowned to be hard to kill. Young trees (2 m tall) of all species can be foliar sprayed but this is difficult and has limited success due to the tree and climate. Research has shown that the window for spraying is limited both daily and yearly. Trees cannot be sprayed during the heat of the day and should only be treated late summer to autumn. The best method to manage *Prosopis* trees is to use cut stump operations. Numerous herbicides are registered but experience has shown that not all are equally effective. Herbicides that may be used include:

- Triclopyr 480g EC with diesel;
- Triclopyr/clorpyralid (270/90) in water;
- Picloram/Triclopyr 50 50 Gel; and
- Triclopyr 360 SL in water.

Triclopyr 480 EC is not a widely used option due to the cost of the diesel, but it is widely accepted as the product that is the most reliable. Follow-up treatments of felled trees will need to continue for at least 24 months. Coppice growth can be treated with one of the registered herbicides but Triclopyr/clorpyralid (270/90) is possibly the best. Use the herbicide according to the label and ensure thorough wetting of all leaves.

4. Monitoring and control of Poplar species
Poplar is easy to kill but difficult to manage due to the fact that it produces root suckers. Any treatment programme must treat the parent plant and all juveniles in the area. This may involve a cut stump and foliar methods included at the same time.

a. **Cut stump**

Apply the herbicide of choice to the stems felled as discussed above. Herbicides registered for this tree include:

- Imazapyr 100;
- Picloram 240;
- Picloram/Triclopyr gel; and
- Triclopyr 360 SL.

Refer to Tables 5-3 and 5-4 below. Due to the ability of “Imazapyr 100” to translocate readily through the plant, this would be the herbicide of choice. Treatment for poplar is best conducted in late summer just before the onset of leaf fall.

b. **Foliar treatments of suckers and seedlings**

The only herbicide registered for this end use is metsulfurom-methyl (600 grams per kilogram).

5. **Monitoring and control of Tamarisk species**

This is a problem species to manage as there are no registered herbicides currently available in South Africa. The only method of managing tamarisk legally is to use mechanical control. This however will require felling followed either by digging it out or by stump grinding.

6. **Monitoring and control of Sisal species**

These plants are too large to remove manually. Both Sisal species can be controlled by the injection of 2 mm neat MSMA into pre-made holes in the stem. It may be necessary to remove some leaves to allow access to the bole to make the holes. These plants do not re-sprout once removed and cannot regenerate from the leaves. Leaves are useful mulch if chopped and spread on site to reduce soil erosion and provide a seed bed and protection for regenerating indigenous plants. Figure 5 shows the leaves of cleared agave spread over bare ground to facilitate regeneration of indigenous plant species after reseeding (Photo credits: Wilderness Foundation).
7. Monitoring and control of Cactus species

a. Manual control

Manual control should be confined to single plants or very small groups of plants because felling large plants, digging out the roots and collecting up all the fruits and “cladodes” (pieces of stem) that break off while moving the cactus not only creates disturbance but increases risk of further invasions. Pieces of stem that are left on the soil surface will take root and lead to re-invasion of the site. Moreover, Cactus spines are barbed and painful to remove, and the smaller hair-like spines (glochids) on the nodes of cactus pads spines can cause long-lasting skin irritation and eye damage. Glochids blow in the wind and embed themselves in skin and clothing when a cactus plant is cut or moved. When removing Cactus, workers need additional safety equipment including goggles, masks, boots and thick overalls.

b. Chemical control

Inject MSMA 720 grammes per litre into pre-made holes in the stems of the cactus. This herbicide is yellow-labeled (Table 3 and Table 4). Not all cactus plants have a stem injection registration, and a few have a foliar spray registration. As indicated above, further research and monitoring activities are required in order to understand the densities and distributions of the different cactus species and to include detailed management options in the detailed Alien Invasive Plant Species Management Plan.
Table 3: Hazard ratings for commonly used herbicides available in South Africa24

<table>
<thead>
<tr>
<th>South African hazard classification for herbicides</th>
<th>Hazard statement</th>
<th>Colour band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Ia – Extremely hazardous</td>
<td>Very toxic</td>
<td>Red</td>
</tr>
<tr>
<td>Class Ib- highly hazardous</td>
<td>Toxic</td>
<td>Red</td>
</tr>
<tr>
<td>Class II - moderately hazardous</td>
<td>Harmful</td>
<td>Yellow</td>
</tr>
<tr>
<td>Class III - slightly hazardous</td>
<td>Caution</td>
<td>Blue</td>
</tr>
<tr>
<td>Class IV - Acute hazard unlikely in normal use</td>
<td>-</td>
<td>Green</td>
</tr>
</tbody>
</table>

Table 4: Example of chemical control (herbicides) products and associated hazard ratings

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Active ingredient</th>
<th>Concentration</th>
<th>Hazard class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dow Agroscience SA (Pty) Ltd</td>
<td>c1opyralid/triclopyr (triethylamine salts)</td>
<td>90/270 g/l</td>
<td>Class II</td>
</tr>
<tr>
<td>Monsanto SA (Pty) Ltd</td>
<td>glyphosate</td>
<td>360 g/l</td>
<td>Class III</td>
</tr>
<tr>
<td>Monsanto SA (Pty) Ltd</td>
<td>glyphosate</td>
<td>540 g/l</td>
<td>Class III</td>
</tr>
<tr>
<td>Monsanto SA (Pty) Ltd</td>
<td>glyphosate</td>
<td>450 g/l</td>
<td>Class III</td>
</tr>
<tr>
<td>Arysta Life Science Pty Ltd</td>
<td>imazapyr</td>
<td>100 g/l</td>
<td>Class III</td>
</tr>
<tr>
<td>Arysta Life Science Pty Ltd</td>
<td>MSMA</td>
<td>720 g/l</td>
<td>Class II</td>
</tr>
<tr>
<td>Dow Agroscience SA (Pty) Ltd</td>
<td>triclopyr (butoxy ethyl ester)</td>
<td>480 g/l</td>
<td>Class II</td>
</tr>
<tr>
<td>Dow Agroscience SA (Pty) Ltd</td>
<td>triclopyr (Pyridyloxy Compound)</td>
<td>360 g/l</td>
<td>Class II</td>
</tr>
</tbody>
</table>

**c. Biocontrol**

Biocontrol organisms are available for long-term control of some Cactus species (Figure 6). However, the biological control agents appropriate for the particular cactus species must be used25. Cactus species for which biocontrol is currently available are Boxing Glove and Imbricate Cactus (*Dactylopius tomentosus*, imbricata biotype, a cochineal insect), and Prickly Pear (*Cactoblastis cactorum* a stem boring caterpillar, and *Dactylopius opuntiae*, a sap sucker). Information on obtaining biocontrol agents can be obtained from the Agricultural Research Council26.

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26 Agricultural Research Council information on Biocontrol Agents Tel: +27 (0)12 427 9700, Email: enquiry@arc.agric.za and see website [http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/BrochuresFact-sheets-on-weed-biocontrol-agents-and-their-target-weeds--.aspx](http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/BrochuresFact-sheets-on-weed-biocontrol-agents-and-their-target-weeds--.aspx)
8. Monitoring and control of herbaceous plants

   d. **Solanum elaeagnifolium (Satan Weed)**

   This herbaceous, perennial plant has a deep root system that re-sprouts after above-ground parts of the plant have been cleared. For this reason, it should be controlled by foliar spraying with systemic
herbicides (fluroxypyr). For chemical control to be effective the herbicide must be applied with a wetter to aid penetration and sticking on the hairy leaves. Ensure that all plants are treated and that regular follow-up treatments are made to kill any plants that were missed. Biocontrol is not a suitable method of management in construction areas but will have a role to play in large or widespread population of the plant. The leaf-feeding biocontrol Chrysomelid beetles *Leptinotarsa defecta* and *Leptinotarsa texana* are effective and can be obtained from the Agricultural Research Council (ARC). Sites cleared of this species must be monitored and receive follow-up treatment until it is obvious that the plant has been killed.

9. Monitoring and control of herbaceous weeds

Broadleaved herbaceous weeds such as Mexican Poppy, Blasiebrak and Tumbleweed, and the shrub Wild Tobacco (*Nicotiana glauca*) can all be controlled in the same way. The only exception is *Solanum elaeagnifolium* (see above section) which is a re-sprouter.

a. Broad-leaved herbaceous weeds

When broadleaved herbaceous weeds are immature (have not yet made seed), the most effective means of control is by manual removal using a hoe or spade. Immature plants without seed can be left on site. However, if the weeds have seed heads they must be gathered up, put in garbage bags or waste drums, transported and disposed of at a licensed waste disposal facility. Alternatively, broadleaved weeds that are green and actively growing can be killed by foliar spraying with herbicides such as those used to maintain road verges. Re-invasion of broadleaved weeds after cessation of construction activities is best prevented by re-seeding the area with indigenous grasses and shrubs. Indigenous plants that can colonise bare soil and are suitable for the Central Karoo include the grasses *Fingerhutia africana*, *Cenchrus ciliaris* and *Stipagrostis* species, and the shrubs *Pentzia incana* and *Eriocephalus* species. However, the appropriate species for re-seeding will vary with soil type, altitude and drainage.

b. *Pennisetum setaceum* (Fountain Grass)

There are no registered herbicides for the control of fountain grass. However, it grows as a roadside weed so a suitable grass herbicide applied as a post-emergent herbicide will control the plants. Figure 7 shows the control methods of Fountain Grass on roadsides which consists of cutting the grasses, allow to re-sprout and then spray with a herbicide containing a marker dye. Further research and monitoring activities are required to provide details on *Pennisetum setaceum* and other herbaceous plant control and to include detailed management options in the detailed Alien Invasive Plant Species Management Plan. As is the case of other invaders of disturbed sites, re-invasion by Fountain Grass after construction site closure is best prevented by re-seeding the area with appropriate indigenous grasses and shrubs. Monitor construction sites from which Fountain Grass was removed after 12 months, and hand pull or spot spray any Fountain Grass seedlings that have established.

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27 Biocontrol agents available from the Agricultural Research Council Tel: +27 (0)12 427 9700, Email: enquiry@arc.agric.za and see website [http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/BrochuresFact-sheets-on-weed-biocontrol-agents-and-their-target-weeds--.aspx](http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/BrochuresFact-sheets-on-weed-biocontrol-agents-and-their-target-weeds--.aspx)
10. Monitoring and control of *Arundo donax* (Spanish reed)

Spanish reed is difficult to control because of its extensive underground rhizomes. Options are to completely excavate the rhizomes (roots and underground stems) using a mechanical shovel. Alternatively cut or burn and after 6-8 weeks spray the 1 metre regrowth with a systemic herbicide (glyphosate, Table 6-6), or spray standing (uncut) reeds in late summer, after flowering, but before the leaves turn brown in autumn\(^2\). Dead stems should not be left standing in rivers that are subject to flash flooding because they can block waterways and bridges. The dead reeds can be used as mulch on surrounding bare soil. Reed regrowth should be monitored within six months after clearing, and follow-up treatment applied as required.

11. Species-specific management plans

In addition to conducting the general guidelines for the clearing and monitoring of Alien Invasive Plant species on the SKA1_MID footprint area throughout all development phases, it is recommended that specific alien invasive plants species management plans are developed during the final design phase of SKA1_MID. These species- specific management plans should be developed for the various sections of the SKA construction footprint area with the services of an invader plant specialist and should include (at least) category 1 and 3 invasive species as listed in the NEMBA: Alien and Invasive Species

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List within the proposed SKA_MID development areas, and *Prosopis glandulosa*\(^9\), *Prosopis velutina*\(^4\) or hybrids within the SKA core area.

The Working for Water invasive alien plant control management plan\(^{31}\) should be taken into consideration when preparing the specific alien invasive plants species management plans. These plans must be informed by the general guidelines included in the previous section, the existing Prosopis and SKA1_MID infrastructure maps, and should include refined mapping for other alien invasive plants species of interest for the study area. These maps should be created using a grid of the management area and each grid cell numbered and prioritised for tracking and mapping of progress, methods, dates and follow-up work.

Once compiled, the specific alien invasive plants species management plans should be added to the IEMP and specific management actions and outcomes included in the SKA1_MID EMPr (Chapter 5 of the IEMP). This must be done prior to the construction phase of SKA1_MID, to ensure that the required control methods, impact management actions and impact management outcomes are implemented, monitored and reported on at regular interval of time during the lifecycle of SKA. The Environmental Officer and appointed Land Management Authority are responsible to oversee the preparation of these specific alien invasive plants species plans and inclusion into the IEMP.

The implementation of these species-specific management plans will provide opportunities for capacity building, particularly in the fields of species identification, biocontrol, environmental management, data and human resource management, communication and law enforcement. It is recommended that interns from the Department of Environmental Affairs internship programme\(^{32}\) provide support to the Environmental Officer and Environmental Control Officer responsible for administration and monitoring of the alien invasive plants species clearing and biocontrol programmes. Long-term research and monitoring programmes including systematic clearing and follow-up observations should be based in Van Wyksvlei and Carnarvon and should focus on low density invasions at the edges of the main invasions that appear to follow the major drainage systems.

### VI. SAEON Global Change Research Programme

The primary goals of SAEON as part of their Global Change Research (0 to 5 year) include:

- Fully establish the ecological monitoring programme at the SKA site;
- Complete installation of monitoring equipment at the SKA site;
- Establish a data management system specifically related to data generated at the SKA site;
- Establish collaborative projects with other organizations wanting to work at the SKA site;
- Maintain a steady stream of students working at the SKA site, with associated theses and publications; and
- A number of papers published in peer reviewed journals and a steady flow of papers being generated from research conducted at the SKA site.

A summary of the activities and associated outcomes of the SAEON research platform over the coming five years is outlined in Table 5.

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30 Listed invasive species classified as Category 1b in Western Cape and Category 3 in Northern Cape: according to NEMA it is prohibited to allow the spread of any specimen of a category 1 or 3 invasive species.

31 https://www.environment.gov.za/projectsprogrammes/wfw/alienplantcontrol_managementplan

### Table 5: SAEON 5-year research programme

<table>
<thead>
<tr>
<th>Year</th>
<th>Activities</th>
<th>Outcomes and Outputs</th>
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<tbody>
<tr>
<td>Year 1</td>
<td>Staff Recruitment – appoint Senior Scientist, Junior Scientist and Admin Assistant. Recruit 1xMsc and 1xPhD for global change research at the SKA site. Conduct gap analysis to identify gaps and priorities at the SKA site and in the Upper Karoo. Initiate Baseline Social and Environmental studies at the SKA site. Establish long-term monitoring sites within the SKA site as well as on adjacent farmland. Establish SAEON-SKA Research Platform in collaboration with other partners. Set up and test electronic soil-water-climate monitoring equipment at the SKA site and other selected sites.</td>
<td>Publication on the baseline conditions and conditions at the SKA site in regional context. Initiation and establishment of SKAEON research and training platform. Development of a long-term global change monitoring strategy for the SKA site.</td>
</tr>
<tr>
<td>Year 2</td>
<td>Recruit 1xMSc student for global change research at the SKA site. Expand SAEON SKA Research Platform through collaboration with other project partners and institutions. Evaluate soil-water-climate monitoring equipment and supplement or adapt as required for global change research. Collect baseline information and develop comprehensive inventories on key biogeophysical parameters at long-term monitoring sites.</td>
<td>First MSc completed based on research at the SKA site. Development of soil-water-climate-vegetation monitoring systems at the SKA site which will contribute significantly to global change research at national and international levels. Establishment of the SAEON SKA Research Platform as a key driver of research and student development in the Karoo region.</td>
</tr>
<tr>
<td>Year 3</td>
<td>On-going monitoring and evaluation of biogeophysical monitoring with first publications being developed. Increased student participation and training at the SKA site. Host a special session on Global Change in the Upper Karoo based on the work at the SKA site, at the Arid Zone Ecology Forum or other similar conference. Mid-term evaluation of SAEON Research Platform to identify gaps and implementation priorities before the operational phase of SKA commences.</td>
<td>Second MSc completed based on research at the SKA site. Increased exposure and traction of SAEON-SKA Research Platform within the country, which should enable it to start leveraging additional funding or collaboration opportunities. Increasing amounts of bio-geophysical data accumulated for the area, which will facilitate increased opportunities for students and publications.</td>
</tr>
<tr>
<td>Year 4</td>
<td>Recruit second PhD student and another MSc student for global change research at the SKA site. Maintain bio-geophysical monitoring equipment and continue with data collection. Identify priority studies for research and student projects.</td>
<td>First PhD student working within the project graduates. Second PhD student comes on board. A variety of collaborations with different institutions has been established and increasing numbers of students are being trained at the SKA site.</td>
</tr>
</tbody>
</table>
Register the SKA site as an official International Long Term Ecological Research Network (ILTER) site with the international ILTER network. SAEON-SKA Research and Training Platform can contribute significantly to global change research in South Africa.

Year 5: Five-year review of SAEON activities and outcomes at the SKA site. Identification of major outcomes and contributions over the period and mapping the way forward. Maintain bio-geophysical monitoring equipment and continue with data collection. Prepare publications based on work at the SKA on global change, with reference to climate change impacts as well as land use effects.

Third MSc completed based on research at the SKA site. First synthesis publications from the site, based on analysis of all the research that has taken place to date. SAEON SKA Research and Training Platform is fully established and can maintain a steady output of students and publications. SAEON SKA Research and Training Platform is a significant contributor to long-term capacity development and training in the Northern Cape and South Africa.

The SAEON Arid Lands Node Science Plan forms the frame for projects undertaken by the Arid Lands Node, which all have the long-term goal of contributing to the NRF Strategy 2020 strategic outcome of establishing “Leading edge research and infrastructure platforms” as well as contributing significantly towards the other four strategic outcomes through activities such as postgraduate support and research collaborations, and the development of new topical Global Change Research fields such as the nexus between water, climate, CO$_2$, biodiversity, energy and economics.

The Arid Lands Node has responsibility for meeting SAEON’s environmental monitoring and research mandate across the hyper-arid to semi-arid western half of South Africa, which has an area of approximately 555 000 km$^2$ or approximately 43% of the country. This area includes 5 different biomes: Desert, Succulent Karoo, Nama Karoo, Arid Savanna, and Grassland Biomes, as well as the Azonal vegetation types associated with the major drainage systems of the region. Since establishment, the Arid Lands Node has developed a significant and growing presence in the Arid Zone and manages several key long-term monitoring sites across the region.

Themes of the SAEON Arid Lands Node science plan are:

- Biome and land cover shifts due to global change
- Broad-scale infrastructural developments related to energy development
- Large infrequent events of economic and ecological significance
- Arid hydrological systems
- Degradation and ecosystem integrity in relation to land use practices

The value of the opportunities presented by the long-term research and monitoring programme within the SKA land core area (land owned by the NRF) and terrestrial environmental research in the arid zone are summarised below:

- The opportunity of studying a change in land use across an extensive area is unique, especially from farmland to conservation-orientated land use;
- The SKA site is representative of a large proportion of the Upper Karoo and has a wide variety of representative landforms and vegetation types present, which adds to the ecological value of the SKA site as well as the validity and broad applicability of science carried out at the SKA site;
The land use at the SKA site for the foreseeable future will be stable, which makes it highly suitable for long-term environmental science, especially as a reference site in the light of Shale Gas, Uranium mining and other developments that are happening in the rest of the Karoo;

- The SKA site is located within an area that is predicted to undergo a high degree of climate change and represents an ideal site for investigating biome shifts and related climate-change induced impacts;
- There is very little existing data for the SKA site or broader area, with the result that all information collected will be novel and contribute significantly to baseline knowledge in the area;
- The SKA site has high potential as a student training platform supported by both SAEON and SKA and a large student throughput is anticipated; and
- The SKA site will complement and enhance the Arid Lands Node’s existing network of study sites, which lacks a core site at the centre of the Karoo.

A summary of the main topics identified as research and monitoring priorities for the research and monitoring programme within the SKA land core area are listed below. SAEON Arid Lands Node will collaborate with other institutions and facilitate access to the site and baseline information as it emerges, to enhance the value of the site as a science and training platform.

- **Eco hydrological and Biogeochemical Cycling in relation to Vegetation Dynamics under Climate Change**

  The interaction between climate change and vegetation can be observed through changes in the fluxes and availability of carbon and water in the environment at the earth-atmosphere interface. The impacts of these changes on vegetation and land cover are best understood through the examination and monitoring of ecosystem-level indicators, particularly vegetation dynamics, shifts in plant functional types, growth-form composition, productivity and diversity.

- **Ecosystem monitoring for change detection**

  SAEON will establish an array of Square Kilometre Environmental Observatories to monitor changes in diversity and distribution of species in response to changes in climate across habitats. This will be allied with detailed soil water and climate monitoring as detailed above.

- **Ecosystem-Level Dynamics**

  The dynamics of Nama-Karoo vegetation particularly shifts in the abundance of major functional groups such as grasses vs. shrubs is not well understood but is required to predict the impacts climate change and land use.

- **Vegetation Recovery Rates and Dynamics**

  Natural recovery rates of vegetation will be recorded in areas that are currently degraded and dominated by indigenous indicators of degradation, such as Rhigozum, or with alien species, such as Prosopis.

- **Faunal Population Dynamics**

  Changes in forage availability, predation, persecution and water distribution is likely to cause changes in faunal populations, such as springbok, hyrax, jackal, caracal, locusts and some birds. In addition, long-term changes in faunal community structure or abundance may be indicative
VII. Endangered species monitoring

The Drylands Conservation Programme’s experts of the Endangered Wildlife Trust (EWT) conducted a survey on the presence of Riverine Rabbit within the SKA land core area (land owned by the NRF). No Riverine Rabbit were identified during the survey. The EWT can conclude with a fair degree of certainty that the Riverine Rabbit does not occur in the core area even though there are areas of near suitable habitat in the area. The possibility that these riparian areas could have been historically inhabited by the Riverine Rabbit cannot be excluded. EWT indicated that more research will be undertaken to determine the northern most extent of Riverine Rabbit distribution in the Northern Cape.

Depending on access to funding, EWT would like to be involved in the long-term research and monitoring programmes within the SKA land core area. The EWT proposed the following monitoring activities for baseline- and during- and post-construction monitoring in any areas should Riverine Rabbits be discovered in the future:

- Pre-, during- and post-construction monitoring of numbers, behaviour and movements of established Riverine Rabbit populations in close proximity to developments, through the use of camera trap grid arrays;
- Pre-construction dispersal patterns of established Riverine Rabbit populations near developments;
- Monitor all pre-, during- and post-construction traffic volumes and roadkill numbers of all faunal species on existing roads and implement as new roads are constructed. Standardised protocols for monitoring road-kill and measures to reduce road-kill have been developed by the EWT Wildlife and Roads Project;
- The construction phase of the SKA structures would be of high risk for the Rabbit, in terms of noise, disturbance and the presence of construction crews which could also lead to poaching incidents. The EWT would recommend that Construction Crew Biodiversity Training is implemented, including rabbit identification, regulations required for minimizing disturbance impacts, speed control measures and poaching restrictions;
- Pre- and post-construction soil stability and erosion rates;
- We would recommend the publication and dissemination of the monitoring results in the broader scientific community, not just in required reports;
- The EWT would recommend the development of a comprehensive rehabilitation plan, as erosion processes happening on higher ground will impact the rivers downstream, particularly in the sensitive arid environment of the Nama-Karoo, with repercussions for rabbit habitat; and
- Monitoring of riparian vegetation over time pre-and post- withdrawal of livestock. This could make for an interesting case study.

Furthermore, the EWT proposes the use of the SKA land core area, once declared as a Protected Area, as a case study for the development of a model / approach that could be applied for the relocation or reintroduction of the species to new sites in the SKA project area that may be suitable. While this does not imply that the SKA site will be a suitable site for reintroduction, the knowledge gained would greatly inform future conservation action for the species across their current and potential range.

The NRF intends to retain strategic artificial water points operational in the SKA land core area during the construction and operation phase for this study. Sufficient and scientifically sound baseline data
must be gathered prior to any intervention so that the impact of the intervention can adequately be measured. Where the analysis confirms that certain boreholes can be decommissioned, a phased approach to the closing of artificial water points should be implemented so that the local wildlife can adapt to changes in water availability. A comparative study of animals using water supplies on the farms neighbouring the SKA land core area and within the core area will be conducted during the long-term research and monitoring programmes. The use of these water points will be monitored by the appointed Land Management Authority, SAEON experts and other researchers involved in the long-term research and monitoring programmes. If, for example, it is seen that the fauna does rely on these water sources, adaptive management actions will be taken. The appointed Land Management Authority and SAEON experts must determine the condition and timeframe of the phased approach to the closing of artificial water points if implemented onsite. Rapid decommissioning will exacerbate possible movement of wildlife and predators to neighbouring farms.

**VIII. Predator species monitoring**

1. **Introduction**

The most noticeable human-wildlife conflict impeding livestock management in South Africa is that of the predator-farmer conflict\(^3\) where carnivores prey on livestock or valued wildlife resulting in financial losses and farmers respond by killing carnivores for both preventative and retaliatory reasons.\(^2\)

The issue of predator control on the land acquired by the NRF was raised by several land owners and local stakeholders during the stakeholder engagement process as part of the Strategic Environmental Assessment (SEA) of the SKA Phase 1 in South Africa. Land owners conducting farming activities in the area have stated that predators (in particular black-backed jackal and caracal) attack the livestock for feeding purpose and that collectively these losses can have adverse economic impacts on their livelihoods and the sustainability of small livestock farming in the Karoo. Due to the lifetime of SKA\(_{\text{MID}}\) (at least 50 years) it is important for SKA to take into consideration the needs and issues of the surrounding community and local stakeholders when developing the project.

The NRF is currently in consultation with wildlife experts and the local farming community to develop strategies for long-term wildlife management in and around the project area, as well as to foster partnerships, trust and cooperation with local stakeholders. The primary potential benefit of the establishment of a consensual predator management strategy is to prevent or minimise any potential impact resulting from the SKA activities onto surrounding properties. This engagement will also enable the development of an integrated strategy between all local stakeholders where set objectives can be established for wildlife management in the Karoo region. The NRF intends to promote the use of alternative and sustainable predator management practices.

In a recent study, Drouilly et al. (2017)\(^3\) concluded that farmers must protect their livestock from predators, even when wild prey are abundant because black-backed jackals prefer sheep and goats over similar sized wild mammals. It was further concluded that it is still likely that protected areas provide sources of dispersing predators to recolonize territories rendered vacant on farmland by culling efforts.

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\(^3\) Nattrass, N., Conradie, B. and Conradie, I., 2014: *The Koup fencing project: Community-led job creation in the Karoo*, Centre for Social Science Research.

The NRF is collaborating with research and conservation institutes to develop long term monitoring programmes for the management of wildlife (including preys and predators) on the NRF owned-land and neighbouring properties. The development of a long term efficient and effective strategy to manage predator population on NRF owned land must take into consideration:

- wildlife land management activities required on the land;
- SKA RFI policy (limited electric equipment may be employed e.g. no electric fencing, limited monitoring cameras and minimal human presence on site);
- best practices in terms of public acceptance and ethical issues; and
- long-term collaboration with neighbouring land owners.

Data on current populations of wildlife present on the NRF owned-land and neighbouring properties is necessary to inform the efficient long-term management of the land.

Endangered Wildlife Trust Carnivore Conservation Programme Manager Kelly Marnewick has indicated that more research is required to confirm the correlation between the removal of sheep and other agricultural activities from an area and the increase in predator distribution and abundance and livestock losses adjacent to this area. A baseline must be established to confirm the presence and relative abundance of predators, especially in relation to any past and present lethal activities for mesopredator species management in the area.

The long-term monitoring programmes will further investigate the potential impacts of the removal of abundant prey resource such as sheep and artificial watering points from the the NRF owned-land on the wildlife distribution and behavior, especially in terms of potential migration to neighbouring properties.

2. Predator species

Both the fragmentation and transformation of natural land has impacted adversely on most large carnivore species which are currently experiencing global declines. Large carnivores have disappeared from areas of high human density, and the species most exposed to conflicts with people are those most prone to extinction. Africa’s large carnivores have declined over the last 30 years, with several species threatened according to the International Union for Conservation of Nature and Natural Resources (IUCN) red list of threatened species, including: the endangered African wild dog (Lycaon pictus), the vulnerable African lion (Panthera leo), the vulnerable cheetah (Acinonyx jubatus) and the near threatened brown hyaena (Parahyaena brunnea).

According to Nattrass and Conradie predators in South Africa have historically been shown to have evolved alongside indigenous pastoralists, adapting to include domestic livestock in their prey base. Black-backed jackals (Canis mesomelas) and caracals (Caracal caracal), are considered two of the major contributors to livestock losses in South Africa. These mesopredators have been subject to

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38 Nattrass, N. and Conradie, B.I., 2013. *Jackal narratives and predator control in the Karoo, South Africa*. Centre for Social Science Research.
persecution for centuries but unlike many larger, specialist apex predators; they are far more resilient to persecution and continue to proliferate in farming communities\textsuperscript{40,41}.

Black-backed jackals (Figure 8) are opportunistic, omnivorous, generalist predators, which according to Mckenzie (1993)\textsuperscript{42} are traits that enable them to adapt to a wide range of food types and diverse habitats including those derived from human modified areas. It is generally found that jackals have a feeding preference for mammals (especially rodents and small ungulates) but they readily include reptiles, birds, human refuse, carrion, beached marine mammals, seals, fish, fruit (particularly berries) and insects in their diet\textsuperscript{43}. The black-backed jackals, being opportunistic feeders, feed on wild prey in the area but are also widely recognised for preying on farmers livestock particularly lambs and sheep\textsuperscript{38}. Black-backed jackal diet also changes with seasonal changes in prey abundance and with the presence of apex predators\textsuperscript{39}.

Black-backed jackals are seasonal changes in habitat use, with use of closed habitat increasing through winter as prey in open areas becomes scarcer\textsuperscript{42}. Black-backed jackals are most active in the evening and early morning, however, activity patterns are markedly affected by persecution: in conservation areas there is a considerable amount of activity during daylight, while this becomes almost non-existent under persecution. In a stable social structure, black-backed jackals are strictly monogamous, and each Jackal pair forms a life-long bond. Jackals become sexually mature at around 11 months of age and will typically leave their natal range in search of a mate and territory at around 1 year of age. Those jackals that do not disperse from their natal range remain and assist their parents with raising the next litter\textsuperscript{44}. Generally, one-third of sexually mature Jackals will remain as helpers. The black-backed jackal mating season occurs during June and July and young are born between August and November after a two-month gestation period\textsuperscript{44,42}.

Jackals are territorial animals and jackal pairs will generally defend mutually exclusive territories. Generally, jackal territorial ranges adjust depending on resource availability (Ferguson et al., 1983). According to Bothma (2012) jackals will hunt and scavenge alone or in pairs for food but occasionally form packs to hunt larger antelopes that are old, weak, sick or injured. Within an adult pair’s home range there is a core area which is intensively used. Only a small part of the total home range is used when prey is abundant, with wider-ranging movements occurring when prey is scarce. Jackal home ranges tend to overlap particularly with immature or subordinate jackals on the fringes of a dominant pairs territory, as such the home ranges cannot be equated with true territories\textsuperscript{44}.

Once persecuted, the jackal social structure is altered. Black-backed jackals, like coyotes, are highly adaptable animals and can show signs of compensator reproduction when the population is under stress. Minnie et al. (2015) compared life-history responses of black-backed jackals on farms and conservation areas to identify the impact predator control on farms have on jackal populations within the Western and Eastern Cape of South Africa. Results from the study showed that Jackals on farms compensate for increased mortality by increasing the pregnancy rate of young individuals and increasing the litter size at younger ages, thereby increasing reproductive output.

The Caracal (Figure 9) is a medium-sized member of the Felidae family standing 400-450 mm at the shoulder – although this varies greatly for different regions with males generally heavier than females from the same region\textsuperscript{13}. Caracal colouring also varies regionally but in general is uniformly reddish tending to be paler in arid regions. Caracals have a wide habitat tolerance ranging throughout Africa except in closed forested regions and central Sahara. Outside of Africa they range across northern India, the Arabian Peninsula, Israel, Syria, Iraq, Iran and Turkestan occupying a wide variety of habitats\textsuperscript{46}.

The caracal is ecologically similar to species of the Lynx genus and is characteristically agile and slender and capable of jumping more than 2m into the air\textsuperscript{45, 46}. Caracals are generalist feeders feeding on a wide range of prey. An adult caracal requires around 1 kilogram of food per day. Generally, their diet comprises of rodents, hyraxes, hares, vervet monkeys, dassies, birds, reptiles and small antelope \textsuperscript{56}. Caracals weigh between 8–20 kilograms, but regularly kill prey more than twice their own mass\textsuperscript{46}. Caracals are solitary hunters, feeding mainly on fresh prey although they have been found to store fresh food in trees or under grass to return to later.

Similarly, to black-backed jackal, caracal can act as both hunters and scavengers depending on the presence of apex predators\textsuperscript{46}. The home range of an adult Caracal varies depending on habitat quality and the density of prey species\textsuperscript{45} and a male home range may include the home range of several adult females. According to Bothma (2012)\textsuperscript{56} the range of an adult male Caracal in the semi-arid Karoo can be 440 km\textsuperscript{2} or more. Caracals are mainly solitary, except when mating, although a female and her kittens will move around together\textsuperscript{46}.

Caracals reproduce throughout the year from an age of 12 to 15 months in a male and 14 to 16 months in a female. However, caracal births tend to peak between October and February in South Africa and litters of up to six kittens are born\textsuperscript{46}. Young caracals disperse after around 9 months of age and dispersal can take place over 65 kilometres (km) or more from the natal site\textsuperscript{46}. Similar to black-backed jackal and other mesopredators caracals display compensatory mechanisms when under persecution\textsuperscript{49}.

There is clearly a lack of scientific information on the ecology and management consequences for damage causing mesopredators in South Africa (black-backed jackal and caracal). Du Plessis et al. (2013\(^{47}\), 2015\(^{48}\)) assessed the quantity and extent of research conducted on black-backed jackal and caracal throughout Southern Africa finding that a total of 77 studies have been conducted on these predators – 50 black-back jackal studies and 22 caracal studies. The majority of these studies were fairly old, with a median publication age of 16 years and 25 years for black-backed jackal and caracal studies respectively. More than half of the publications for both species occurred prior to 2000.

3. Lethal vs non-lethal predator control techniques

   a. Ethics and impacts of lethal versus non-lethal control methods

According to Bailey and Conradie\(^{49}\), predator management is one of the most significant threats to the economic viability of the sheep industry. Predator control techniques require large investment from farmers, for installation and maintenance of predator-proof fencing, predators hunters, animal husbandry practices and animal care and disease prevention (particularly for sheep kept in enclosures or during shed lambing)\(^{50}\).

Due to the current lack of regulated practices for predator management in South Africa, predator control issue is a sensitive topic amongst farming communities and wildlife conservation agencies. Conradie and Piesse (2014)\(^ {51}\) demonstrated that culling of leopard (*Panthera pardus*) and caracal (*Caracal caracal*) on farms was associated with increased stock losses the following year by 27.2% and 5.7% for leopard and caracal respectively. Similarly results from a study by Bailey and Conradie (2013)\(^ {49}\) revealed that caracal (Caracal caracal) culling increased subsequent livestock losses when compared to farms where fewer caracals were culled, increasing the likelihood of livestock losses in the following year by 17.5%. Farm owners and managers surrounding the Alkantpan military test


range site also indicated that the predator control measures currently in use (call-and-shoot hunting, denning, contract hunting and helicopter hunting on occasion) have not resulted in the reduction of predators in the area.

Ecological concerns of predator control appeared in the early 1980’s in South Africa, bringing about more environmental awareness within farming communities and cutting down on the unregulated blanket killing of predators. The shift in thinking was brought about by data showing that blanket culling may not be having the desired effect of reducing population numbers as previously thought as well as the ethical considerations surrounding mass killing of species through inhumane practices of lethal control. Small-to medium-sized predators are far more resilient to persecution and have persisted (or even flourished) despite heavy hunting pressures. Ecological studies have found that culling may cause an increase in the densities of the targeted species.

Furthermore, ethical considerations about the unregulated nature of predator killing are based on the right to life of species and the ethical concerns of systematic persecution and eradication of a species. In nature mesopredators form an intrinsic and important part of the ecosystem and are essential for the functioning of the natural system and the maintenance of a balanced ecosystem structure, much like any other species in the ecosystem (e.g. Black-backed jackals are important in controlling rodent populations and caracals are important in controlling Hyrax numbers on farms).

Over the last fifty years the international debate on optimal predator management has also shifted from government supported eradication to a non-lethal control position. This has largely been driven by the acknowledgement that predators fulfil an important ecological role within rangelands in conjunction with the public perception that lethal management is unethical and causes serious welfare concerns to both target and non-target species. Consequently, there has been a shift in policy, abolishing hunting clubs, gin traps and poison collars and ensuring permits are required for the removal of damage-causing species.

b. Lethal predator control techniques

Lethal predator control techniques, used for the protection of livestock or the enhancement of game populations, can be separated into non-selective and selective approaches:

- Non-selective techniques (e.g. foothold traps devices, snares, poisoning) are indiscriminate to the animals captured or killed and as such are ethically questionable; and
- Selective techniques include livestock protection collars, call-and-shoot operations, denning and other hunting operations (on foot, in vehicles and via helicopter).

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Poison collar is a form of lethal selective predator control technique, placed around the neck of livestock. Poison collars contain a toxicant stored in a pouch which is released into the predator’s mouth when punctured by a predator bite. There are legal implications associated with the use of poison collars as it may result in environmental contamination and health issues to humans therefore specific training and licensing is required to deploy these collars.

Gin trap (foothold traps device) falls under the non-selective predator control technique as it can impact on any wildlife species present on the targeted land. Foothold trap systems induce the death of the animal by painful injuries, starvation or dehydration. The use of this technique is restricted in terms of the National Biodiversity Act (Act 10 of 2004) due to the potential impacts on endangered or threatened species population.

Certain foothold trap devices are designed to cause less tissue damage when closed around the animals’ limb and can be set for animals of a specific weight however if not regularly inspected and serviced, even soft hold traps can result in significant damages to both target and non-target wildlife and domestic species.

c. Non-lethal predator control techniques

The NRF intends to promote the use of ethical and sustainable wildlife management activities in and around the SKA project area. Non-lethal predator control techniques focus on protecting and isolating livestock from predators and include sheep guarding practices, fencing and shed lambing as well as behavioural modifications and animal sterilization. The NRF will further participate educating local communities and farm owners/managers on alternative methods to lethal controlin collaboration with local conservation agencies and NGOs.

The Shepherding Back Biodiversity project owned by the Landmark Foundation Trust and located in Beaufort West (Western Cape) is a great success story of the implementation of non-lethal predator control techniques over a large livestock area. The project aims to reverse current unsustainable agricultural farming practices (poor land use management and lethal predator controls) which have resulted in land degradation and biodiversity loss of both plants and wildlife in productive agricultural areas. The Shepherding Back Biodiversity project supports the uptake of shepherding and conservation-friendly land use with the implementation of various non-lethal controls on 22 000 hectares of land hosting 800 sheep and about 250 antelope. The Shepherding Back Biodiversity project has illustrated that it is possible to successfully manage predation through nonlethal controls. These include placing collars on the sheep, as Black-backed jackals only go for the neck of an animal when attacking. There is also a mechanical “shepherd” that emits sounds (such as dogs barking and alarms) and smells at random intervals. The shepherds’ presence and grouping the animals together act as further deterrents. The project established a shepherding academy to train shepherds and develop shepherding co-operatives; and developed an ethical brand trademark for game meat, the Fair GameTM brand, in partnership with Woolworths. This project is a good example of how traditional skills and knowledge can be applied to commercial agriculture, while minimising environmental impacts.

Non-lethal alternative to poison collars are “King Collar” which is a type of ‘animal armor’ developed in South Africa to prevent canids from being able to grasp and kill sheep with a neck bite. Further non-

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lethal predator control techniques used for the protection of livestock are being researched and monitored such as sterilization of predators, behavioural modification, shed lambing and the use of guard dogs, herders and shepherds or other guarding wild animals such as llamas and donkeys. Few cases where poorly trained or unsupervised guard dogs have killed sheep and lambs, harassed or killed wild animals, and threatened people working with the livestock have been reported however these cases remain limited. The training and close supervision of the guard dogs is critical for the success of this method. According to Hulet et al. (1987)\(^{62}\) guard llamas provide some advantages over guard dogs, including 1) greater longevity, 2) fewer training requirements, 3) faster acquisition of guardian status, and 4) fewer special management considerations involving food and maintenance, and 5) compatibility with other depredation control techniques. Llamas exhibit behaviours similar to their wild predecessor, the guanaco (\textit{Lama guanicoe}), and have been found to defend territories and family groups\(^{63}\). Llamas have an inherent dislike for canines and when pastured away from other llamas, readily bond with sheep. The Endangered Wildlife Trust (EWT) is investigating the possibility of using Anatolian shepherd dogs on farmland to prevent lethal control on African wild dogs. If such an initiative proves to be successful it can be used as a case study on the land acquired by the NRF.

d. **Predator-proof fencing**

The NRF intends to install perimeter predator-proof fencing around the boundaries of the protected area to mitigate the impact of wildlife (especially black-backed jackals and caracals) on surrounding livestock farmers.

The Predator Management Forum (PMF), represented by its chairman Guillau du Toit, recommends the following specifications for predator-proof fencing:

- Corner and end poles should be at least 65mm in diameter
- Iron poles must be 1.85m
- Droppers must be 1.4m
- Bottom steel wire of fence must be 2.2mm
- Remaining steel wires must be 2mm
- Netting must be 1.2m (height) with 75mm gap openings and 1.8mm wire thickness.
- Fence must be protected by both inner and outer anti crawlers
- Crawlers must be packed with stones
- All gates to the premises must have cement anti crawlers underneath gate
- Total height of fence must be 1.4m
- Overhang of 500mm must be constructed on top of fence

Once erected, the predator-proof fences must be maintained throughout the year with regular inspections for damages caused by natural elements (rain, wind and snow). In February and March, it is recommended to conduct inspections 3 times per week due to the dispersion of the black backed jackal juveniles. Furthermore, daily inspections are encouraged during the natural lambing season of small game and neighbouring livestock.

The management of the predator-proof fencing will be included in the Park Management Plan for the protected area, developed in compliance with the requirements of the National Environmental Management: Protected Areas Act (NEMPAA) [Act No. 57 of 2003] as well as other relevant legislation. The required management actions for the construction, maintenance and monitoring of the predator-proof fencing will be included in the Park Management Plan.

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The PMF recommends the review of the predator-proof fencing management actions three years after the installation of predator-proof fences based on the state of the fences, distribution of wildlife (including game and predators), predators hunting behavior and input from neighboring livestock farmers.

4. Research and monitoring programmes

Given the current knowledge gaps on the biology and ecology of predators in the area, further targeted research will be critical to the success of the long-term research and monitoring program. The following knowledge gaps have been identified (further gaps will be identified through the collaboration with local experts, academics and research institutions):

- the relative abundance of mesopredators (e.g. black-backed jackal, caracal, cape fox) and their natural prey within the region and across different land uses or landscape units;
- an estimation of the impact of each predator on livestock losses within the region;
- the factors that people perceive as threats to their current livelihoods in the region identified through community engagement;
- the relative effectiveness and cost-efficiency of different predator management techniques within the study area; and
- details on farming practices within the area to determine alternate reasons for livestock mortality e.g. starvation or multiple births.

It is important to ensure the independence of research on potentially sensitive issues such as livestock losses and the use of predator lethal management techniques. Furthermore, it is essential to ensure that research is multi-disciplinary focusing on both the people and the wildlife within the context of the unique South African history and current socio-political standing.

Long term research and monitoring programmes on NRF owned land require the establishment of appropriate research objectives, funding and supervision in collaboration with knowledgeable institutions. SKAEON will coordinate the research and monitoring partners’ programmes in collaboration with the appointed Land management Authority within the SKA land core area during all phases of development. SKAEON is currently working with the Institute for Communities and Wildlife in Africa (iCWild) within the Department of Biological Sciences of the University of Cape Town, represented by Professor Justin O’Riain (director of the iCWild) for the development of a research and monitoring programme of predator species at the SKA site.

The institute proposes to conduct observations in the field using camera traps and scat sampling in the SKA core and surrounding farms to develop a baseline study which will inform long term research and monitoring programme for the effective and efficient management of predators in the area.

In order to establish a long term efficient and effective strategy to manage predator population, the principles of adaptive management, based on long term evaluation and monitoring, must be implemented. Adaptive management consists of altering management activities during the process of implementation based on the result of monitoring to alleviate, minimise or alter any undesirable impacts, results or consequences that may arise during the management process. Adaptive management is a dynamic process working on a trial and error approach. The adaptive management process may involve the management of other species or resources within the area that are having an impact on predator populations (e.g. rodent populations or water supply). Throughout the implementation of the predator management strategy regular, consistent and targeted monitoring (both performance and operational management) must be implemented including compliance with the management objectives through daily operation of the implemented program.
Operational monitoring estimates the proportional change in the management species population as a result of the implemented management activities. Performance monitoring assesses whether the objectives of the program have been achieved as a result of management activities implemented\(^{64}\). Populations may fluctuate due to external forcing which have not been considered or planned for in the research programme requiring revision of the research objectives and observation parameters. In addition to this, changes in predator behaviour within the area may take time, making time a crucial aspect of adaptive management\(^{65}\).

A baseline data on site predator population, vegetation cover and other species presence must be established prior to the implementation of predator control activities on the acquired land, in support of the development of a long term efficient and effective strategy to manage predator population and livestock losses in the study area. Data on the presence and relative abundance of flora and fauna within the SKA core area as well as on neighbouring farmland is necessary to provide a robust baseline data set which can be used to 1) make informed decisions on whether to initiate management and 2) to assess the impact of SKA and neighbouring farms’ land management activities on both the target and non-target species and the ecosystem more broadly.

Ideally the baseline data should be collected prior to the removal of the sheep on the land to be able to compare the presence and relative abundance of flora and fauna within the SKA core area before and after the removal of the sheep. Baseline data should include:

- what predator management took place on the SKA land prior to the acquisition of the land;
- the current management practices on neighbouring farms;
- the current livestock losses neighbouring farmers are experiencing;
- the survival rates of livestock throughout the lifecycle of sheep (including conception, lambing, weaning, birthing etc); and
- the identification of predator dens on the SKA acquisition site.

The declaration of the SKA land core area as a Protected Area, on completion of the construction phase, will offer a unique opportunity to investigate how wildlife responds to a landscape level change in land use from small livestock farming to a nature reserve. Provided sampling commences in 2017 there is an opportunity to use a statistically powerful “Before, after and Control sites” design to monitor changes associated with the change in land use. This research will fall under the coordination of SAEON who will also provide data on important predictor variables such as changes in plant productivity and ground cover, rainfall and temperature, all of which are predicted to have an additional effect on mammal diversity and abundance in both the short and long-term.

The ICWild proposes to record how livestock losses to wildlife vary in response to the intervention. The comparison will be between farms that border the SKA site and control farms that are further away. Farmers predict that livestock losses will increase on the periphery of the protected area (edge effect) because there will be both less drinking water (artificial water points will be closed in a phased approach so that the local wildlife can adapt to changes in water availability) and a reduced prey biomass (livestock are removed) on land converted in the SKA land core area. Together these changes are expected to lure wildlife that are water dependent, in particular predators, onto neighbouring farms that continue to stock the land with domestic prey species that are both catchable and palatable.


\(^{65}\) Luton, R., 2012: Understanding participation and integration as interlinked phenomena for Integrated Water Resources Management (IWRM) in complex systems, PhD research proposal, University of Witwatersrand, Johannesburg, South Africa.
(i.e. sheep and goats) and provide abundant water points. The assumed net movement of predators away from the SKA land core area and onto neighbouring farms is predicted to result in higher livestock losses and further threaten this already marginal agricultural sector.

The Institute for Communities and Wildlife in Africa’s goals include the annual monitoring of mammal species richness and relative abundance, predator diet and livestock losses. These variables will be recorded on:

- **Treatment farms**: five small livestock farms before and after removal of livestock and cessation of farming practices,
- **Edge effect farms**: five small livestock farms neighbouring the SKA land core area, before and after removal of livestock and cessation of farming practices,
- **Control farms**: five small livestock farms that do not neighbour the SKA land core area but are in the same district and hence experience similar climatic, social and economic impacts but are not predicted to be overly impacted by SKA1_MID.

Together these data will be used to support or refute the short-term predictions that on treatment farms there will be:

- a reduction in the relative abundance and species richness of medium and large mammals including obligate drinking species (e.g. baboons) and predators as a result of the closure of artificial water points and the removal of catchable and palatable livestock,
- an increase in the relative abundance and species richness of small mammal species as they will be subject to less grazing competition, disturbance by trampling and reduced predator presence and human disturbance.

While on edge effect farms there will be:

- an increase in the relative abundance and species richness of medium and large mammal species as they move away from the special reserve and towards farms that have abundant water points and a higher biomass of palatable and catchable prey,
- a decrease in the relative abundance and species richness of small mammal species that are subject to the normal disturbance associated with livestock and farming, but which may also experience higher numbers of wildlife grazers and predators as they move away from the SKA land core area.

Changes on control farms will reflect variation in climatic factors (e.g. rainfall) at a regional level and management factors at the level of each farm (e.g. a block hunt) with only minimal impact predicted to result from the change in land use associated with SKA1_MID.

Long-term predictions on treatment farms include:

- an increase in the species richness and relative abundance of medium and large mammals on treatment farms resulting from the recovery of the natural vegetation reduced grazing competition with livestock and an increase in micromammals that are preferred prey for most mesopredators.
- a stabilisation of small mammal abundance with annual fluctuations in relative abundance associated with regional climatic variables. The possible increase in species richness associated with a recovery of the natural vegetation.
**Edge effect** farms are predicted to experience a gradual increase in small, medium and large mammal species as they disperse out of the land acquired by the NRF and into surrounding farmlands. The construction of a fence between treatment and edge effect farms remains a critical yet undefined variable in the predictions for mammal populations on neighbouring farms. The higher the specifications and maintenance of the final fence the less dispersal there will be from the SKA land core area onto neighbouring farms. Control farm predictions are as for short term predictions.

Species richness and relative abundance of small, medium and large mammals on different farms (intervention, edge effect and control) will be measured using both Sherman traps (small mammals) and camera traps (medium and large mammals). Motion-sensing cameras are an effective and efficient technique for assessing changes in both predator and prey population. Sample sites within each of the farm types will be stratified (according to major habitat types: plain, riverbed and hill/mountain) and then assigned randomly with a minimum of 25 camera traps/habitat arranged in clusters of five cameras. This will result in a maximum of 75 camera trap stations per farm which with three replicates of each farm type results in a total of 675 camera stations. This will require rolling camera traps over throughout the year across different sites and hence it will not be able to control for season, but the extremes of summer and winter will be avoided. Prior to the use of any such monitoring equipment the NRF will require appropriate RFI tests.

Track or foot-print detection can also be used to indicate the presence of an animal in a particular area or can be used to provide an index of abundance, based on the number of tracks counted per unit distance. One of the main constraints of this technique is that it is most likely to monitor predator activity, which may vary seasonally, and may not be related to abundance. It is also time-consuming and labour intensive, affected by weather, and requires a high level of skill. Also, to identify any change in activity will require a high investment in the number of plots assessed.

Sherman traps will be used to sample the relative abundance and species richness of micro-mammals in each habitat type following a similar approach of stratified random sampling used for camera trapping. Each habitat type will be sampled using 240 traps in each of 5 replicates for a total of 1200 trap sites/habitat per farm type. Across all farm types (treatment, edge and control) this will amount to a maximum of 32000 trap sites.

Scats of both jackal and caracal will be collected opportunistically when sampling for small, medium and large mammals using the methods detailed above. Scat analysis can give insight into feeding preferences on predators however it will not identify if the predator is just moving through the SKA site or resides on the property. This approach ensures a random search in each habitat type on each farm and has proven useful in identifying both the rate of occurrence of different prey (including livestock) in the diet of predators in addition to biomass estimates that are predictably biased towards small mammals. It will not be possible to use GPS clusters given the limitations on the use of radio technology in the SKA land core area. A comprehensive hair library developed between Rhodes University and the University of Cape Town will be used to identify prey remains with other hard tissues (e.g. hooves, horns and bones) being used to assist in species identification.

The ICWild will deploy camera traps along fence lines between the SKA and edge farms and on control farms. Cameras will also be placed at holes in fences and the rate and direction of movement of wildlife will be recorded. The goal of this approach will be to test the popularly held perception that wildlife and in particular predators will den in the SKA land core area but will move across the fences at night time to feed on sheep in neighbouring farms.

Michelle Blanckenberg, under the supervision of Professor Justin O’Riain, is investigating the effects of landscape level changes in land use on mammal communities and mesopredator conflict in the SKA region as part of her PhD research. The study aims to investigate how landscape scale land use change
can influence vegetation recovery and mammal population abundance and occurrence using a Before-After-Control-Intervention (BACI) design. Furthermore, the study aims to investigate the impact of livestock removal on the behaviour and diet of mesopredators and how this will influence farmer-predator conflict within the Karoo. This study will address three major questions:

1. How does the mammal community respond to land use change?
   a. Is there a correlation between vegetation cover and small mammal abundance?
2. How do predator (Black-backed Jackal and Caracal) populations respond to land use change in different treatment areas (i.e. intervention vs. edge farms), with regards to:
   a. mesopredator activity patterns?
   b. mesopredator diet?
3. How does the potential change in predator populations influence predator-farmer conflict?
4. How does the improvement of predator proof fences impact the movement of predators between core and edge farms?

The project will take four years to complete and will focus on the same nine farms for data collection surveys. There are two main phases of the project, a before survey which was carried out at the end of 2017 and an after survey which will be completed in 2019, approximately a year after sheep are removed from the SKA land core area. These two data points will provide a comparison to accurately show the potential impact of the SKA on mammals in the area and inform management decisions.

5. Predation Management Information

The below information on predation management in relation to livestock farms was provided by the African Large Predator Research Unit (ALPRU) and the Predation Management Information Centre (PMiC) at the University of the Free State; represented by Professor H.O. de Waal.

Prof. H.O. de Waal from the University of the Free State stated that predation losses on livestock farms and wildlife ranches are poorly quantified. Recently annual predation losses on sheep and goats in five provinces were estimated to be more than ZAR 1.39 thousand million (Van Niekerk, 201066). Another study (Badenhorst, 201467) estimated annual predation losses for beef cattle in seven provinces at more than ZAR 383 million. A third study (Schepers, 201668) quantified the negative impact of predation on wildlife ranches in South Africa, which is comparable to those for livestock. Generally, the predation losses are ascribed mostly to black-backed jackal Canis mesomelas, caracal Caracal caracal, leopard Panthera pardus, brown hyaena Hyaena brunnea, cheetah Acinonyx jubatus and vagrant dogs Canis familiaris. A few other wildlife species are also causing damage but at a lesser scale and more localised. In many parts of South Africa traditional livestock farming, but also other agricultural activities have been replace by wildlife ranching. As these activities rely on the same natural resource base, changing from domesticated ruminant livestock to ruminant antelopes provides no escape from the negative impact of carnivorous predators. Hence, losses due to predation impact negatively on both the livestock and wildlife ranching industries. Large tracks of South African landscape are devoted to national parks (SANParks) and provincial nature reserves; bordering on livestock farms and wildlife ranches. Similarly, public land (devoted to military activities, municipal commonages, etc.) is also bordering agricultural farmland. These borders are sources of continuous human-wildlife conflict, specifically predation and must be managed.

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It was further recommended that relevant information regarding predation and predation management methods must be collated and analysed continuously and made available in a management information system to guide the specialists in predation management more effectively.

The African Large Predator Research Unit (ALPRU) suggests a system of coordinated predation management that would involve the farmers and the government as equal partners each with specific responsibilities. The government would be responsible for policy, coordination, extension, training, research, monitoring and effective communication, while the livestock farmers and wildlife ranchers would be responsible to protect their animals and control predators. An important element of the system of coordinated predation management is an institutional memory or management information system; it is the pivot for common information, planning, leadership and guidance for predation management and to prevent fragmented and uncoordinated actions.

The ALPRU at the University of the Free State and specifically its Canis-Caracal Programme (CCP) has established a Predation Management Information Centre (PMiC) in support of a system of coordinated predation management in South Africa.

The management information system is a national asset and the information must be readily available for all users. Good information regarding predation and different control methods are important components of a system of coordinated predation management. The institutional memory serves as central information source and should quickly provide practical answers on the following type of questions:

- Which areas are reporting predation losses (species involved)?
- Is there a relation between reported cases of predation and the predation management?
- Is there a decline in reported cases of predation following predation management?
- What are the results achieved with different predation management methods?
- Which relevant questions must be resolved through directed scientific research?
- Who are the recognised and proven role players (e.g. specialists in managing predators)?

The management information system must maintain (in real time) a range of information sets (electronic/hard copy) and integrate it in an orderly system of coordinated predation management, for example:

- Reported cases of predation (type of animal, where, etc.).
- Reported cases of predation control (method used, species, sex, date, time, etc.).
- Contacts of government departments and functional offices/staff who are involved with the initiative.
- Contacts of the Predation Management Forum’s and the livestock and wildlife producers’ organisation’s functional offices/staff who are involved with the initiative.
- Contacts of other role players (universities and scientific research institutions) regarding offices/specialised staff who are involved with the initiative.
- Contacts and relevant information regarding the fields of expertise of the specialist predator hunters.
- Detail regarding relevant acts, regulations and policies applicable to different aspects of the initiative.
- Contacts of the relevant departmental offices/staff responsible for enforcement of regulations and issuing of permits.
- Collection of publications (hard copy and/or electronic) on predators, predation and relevant associated topics.
• Collection of available management methods (non-lethal and lethal) devices or equipment (foot-hold traps, cage traps, collars, bells, getters, etc.) as well as the appropriate specifications and correct way to obtain, safeguard, store and handle the device or equipment.

The management information system must be kept updated by the coordinated predation management; it is meant to lay the information basis for a continuous assessment of biological, physical, economic and social factors to make meaningful adjustments of the different elements of coordinated predation management.

The Predation Management Forum recommends the construction of jackal-proof fences to isolate the land acquired by the NRF (land currently not occupied by farmers and thus not under predator control programme) from neighbouring farms with livestock. The following specifications were suggested for the construction of jackal proof fences:

- Corner and end poles should be at least 65mm in diameter
- Iron poles must be 1.85m
- Droppers must be 1.4m
- Bottom steel wire of fence must be 2.2mm
- Remaining steel wires must be 2mm
- Netting must be 1.2m (height) with 75mm gap openings and 1.8mm wire thickness.
- Fence must be protected by both inner and outer anti crawlers
- Crawlers must be packed with stones
- All gates to the premises must have cement anti crawlers underneath gate
- Total height of fence must be 1.4m
- Overhang of 500mm must be constructed on top of fence

The specifications of the fences, construction and maintenance of the fences will be discussed within the SKAEON committee in collaboration with the appointed Land Management Authority.

Prof. H.O. de Waal states that the potential human-wildlife conflict must be pre-empted and managed. The black-backed jackal and caracal are the predominant medium-sized predator species in the area. The first line of defence for livestock farmers to mitigate the impact of predation is a good perimeter fence. Therefore, ensuring that appropriate fences are erected and maintained on the perimeter of the SKA and adjacent farmland is a high priority. The Predation Management Forum further recommends the construction of access roads next to the jackal proof fences is recommended to enable a more efficient and regular management.

The ICWild at the University of Cape Town recommends that camera traps are installed on the fences around the boundary of the SKA land core area to monitor the movement of predator through the fences and confirm the required specifications for the jackal proof fences. Such survey with camera traps will also demonstrate what is happening at the boundaries of the land owned by the NRF land and what is required in terms of predator control techniques.

South Africa indicated that collaboration with the farm owners neighbouring the land owned by the NRF would be initiated or the construction and maintenance of the fences around the boundary of the SKA land core area. Direct engagement will be initiated between South Africa and the neighbouring farm owners to discuss the terms of this collaboration. SAEOAN and the ICWild at the University of Cape Town should be part of the discussions with respect to the construction and maintenance of the fences around the boundary of the SKA land core area in terms of their involvement in the research and monitoring programmes for predator species and other mammal species within the SKA land core area and surrounding farms.
With respect to the implementation of lethal predator control techniques as recommended by the Predation Management Forum, given the current knowledge gaps on the biology and ecology of predators in the area as well as the lack of consensus on the merits and efficiency of lethal predator control techniques, the current approach proposed by the IEMP is to establish baseline data on site predator population, vegetation cover and other species presence prior to the implementation of any predator control activities on the acquired land, in support of the development of a long term efficient and effective strategy to manage predator population and livestock losses in the study area.

Prof. H.O. de Waal and the Predation Management Forum stress the need for regular removal of unwanted predators by specialist predator hunters, call-and-shoot, foothold traps and cage traps as well as the use of an accredited damage causing animals (DCA) hunter. The strategy to control predators by means of a good method of isolation (Jackal proof fence) is supported as described in the above sections. The proposed lethal control techniques are however not recommended as the efficacy of lethal management of predators at the landscape level for the specific purposes of reducing stock losses remains equivocal and hence it cannot be assumed at this stage that lethal control of predators on the SKA land core area will provide a solution to livestock losses on neighbouring farms.

A working group will be established by SKAEON as part of the environmental research and monitoring agreements, including the NRF (South Africa), SAEON, the ICWild at the University of Cape Town, the Predation Management Forum and the ALPRU as well as other experts (e.g. Professor Graham Kerley from the Nelson Mandela Metropolitan University, Niel Viljoen and Magdel Boshoff from the Department of Environmental Affairs).

The working group will evaluate the results of the research and data collection undertaken within the SKA land core area and surrounding farms as part of the research and monitoring programmes for predator species and discuss which predator control techniques should be implemented on the site based on scientific data and observations in the field. Any lethal predator control activities must be approved, and permits must be issued by the provincial and national authorities responsible for the management of damage causing animals. All personal and staff participating in this type of activities must be properly trained and qualified.

The data and information collected on the SKA site should be integrated into the Predation Management Information Centre (PMiC) to inform the development of coordinated predation management in South Africa.