Biotope assessment for Areva Resources Namibia's Trekkopje Mine in the central Namib Desert

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Summary

As a first step towards a biodiversity strategy, Areva Resources Namibia commissioned a biotope assessment at the end of the rainy season in 2009 (April/May). A biotope assessment is based on ecologically rated mapping units and provides a means of (1) guiding environmental impact management by identifying areas that require special attention, if these are impacted by the mine's activities and (2) measuring and reporting on biodiversity impacts.

Landforms and dominant plants were used as the key features for outlining biotopes. Eleven biotopes were mapped in the Trekkopje licence area. Based on plant endemism as the key indicator for rating biotopes in three categories (general, rare and critical), four biotopes received the highest biodiversity rating ("critical"), covering nearly 40 % of the licence area. This is largely a reflection of the central Namib's importance for plant endemism.

To date 4.5 % of the licence area has been disturbed by mining and exploration activities and associated infrastructure, nearly equally affecting "critical" and "rare" biotopes.

This biotope assessment should be used to:

- manage impacts on biodiversity
- report on progress
- evaluate impacts in a constantly changing (mining and natural) environment and
- improve biodiversity data collection in a systematic manner.

Some recommendations to achieve this:

- Distribution of easy-readable information on critical biotopes and selected plant species to all staff on the mine will help to raise awareness amongst mine staff and may generate information to improve the biotope assessment.
- Integration of regular biotope assessments in an environmental monitoring programme will take care of changing mining and environmental conditions and can in the longer-term incorporate information on rehabilitated and recovering areas. This will provide the mine with a transparent process to indicate its impacts on biodiversity and its progress in managing these impacts, thus averting claims of greater damage than can be attributed to the mine's activities, e.g. induced by climate change.
- More specific recommendations are detailed in the report.

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Background

Biodiversity strategy and action plans are today a requirement for most companies operating globally. In order to monitor and report performance related to managing the impacts on biodiversity, meaningful and transparent measures are needed. The "biotope" method – originally developed for a Swedish power generation company – has been adapted and tested successfully in the central Namib. In simple terms, this method is a GIS-based tool which maps homogenous ecological units ("biotopes") and classifies these using the conservation status of plants in each biotope as the key indicator. It then compares the biodiversity importance of each biotope (critical > rare > general) between the natural situation before the mining commenced (before) and the situation after the mine has been established (after) (Burke et al. 2008). This gives an indication of the scale of impact on biodiversity important biotopes in the mines' impact area, backed by a fully transparent process of the assessment.

EnviroScience was tasked to undertake a biotope assessment as a first step towards the development of a biodiversity strategy for the mine. This document reports on the field- and analytical biotope assessment

Field survey

The field survey took place during the period 22-29 April 2009, following an exceptionally good rainy season in the central Namib. Well over 100 mm of rain were measured during the period of November 2008 to March 2009. However, the season was early and extended periods of hot easterly "bergwinds" had dried up most of the short-lived plants such as annual herbs at the time of the survey. Many could nevertheless still be identified. Lilies had come up very early and only few remains of these were visible. Areva environmental staff had however, collected lilies and photographed many of the early vegetation. These records were incorporated where they could be matched with localities. The mapping boundary was Areva's extended mining and exploration licence area.

Data collection in the field focussed on the main landforms: plains, drainage lines and hills, as well as varied, underlying rock types. Data collection consisted of recording locality, landform, overall vegetation cover and height and compiling a plant species list at each sampling point. A total of 58 sampling points was established in the study area (Figure 1). Most plant identifications were done directly in the field, but collections of doubtful plants were made and lodged at the National Botanical Research Institute in Windhoek. The plant species list included in the flora specialist study for the initial Environmental Assessment was used to cross-check species identifications (Mannheimer 2006).

The Biotope Method

The main purpose of the Biotope Method is to quantify biotope or habitat changes that take place when land is put to a new use. This method consists of a number of steps. (1) System boundaries are defined and then subdivided into discrete biotopes (or habitats) of site-specific ecological characteristics. (2) Biodiversity indicators suitable in the local context are selected to assign the relative importance of the biotopes. (3) Biotopes are then grouped into four standard categories, (a) critical, (b) rare, (c) general biotopes, and (d) areas which no longer support biodiversity, termed technotopes (Kyläkorpi et al. 2005). (4) Once exploration and/or mining activities commence, comparing the assigned biotope categories "before" and "after" the impact (in hectares or as a percentage) provides a measure of the impact on the ecological mapping units which are rated according to biodiversity importance.

System boundaries and biotope mapping

This report covers the biotope baseline ("before" the impact) and the assessment of impacts at the time of the present survey. The impact areas were defined as direct impacts (habitat conversion) based on the outlines of exploration and mined areas and already established infrastructure (such as offices, workshops, roads, pipelines and power line) at the time of the survey. The impact area of linear infrastructure was defined as a 20 m wide corridor. The assessment area only covered the licence area. Impact areas along the pipelines beyond the boundary of the licence area were thus not included. Secondary impacts on habitats such as dust and potential other emissions, or impacts related to water abstraction were not included in the assessment, as these require longer-term monitoring and could not be predicted at the time of the assessment. LANDSAT TM 2000 satellite imagery at 15 m pixel resolution, draped over a 2004 SRTM (Namibian Shuttle Radar Topography Mission digital elevation model) at altitude intervals of 90 m of the study area served as a mapping backdrop. This was supplemented by print-outs of high resolution aerial photography provided by the mine. Most mapping took place at approximately 1: 10000. The mapping resulted in 11 biotopes in the study area (Figure 2).

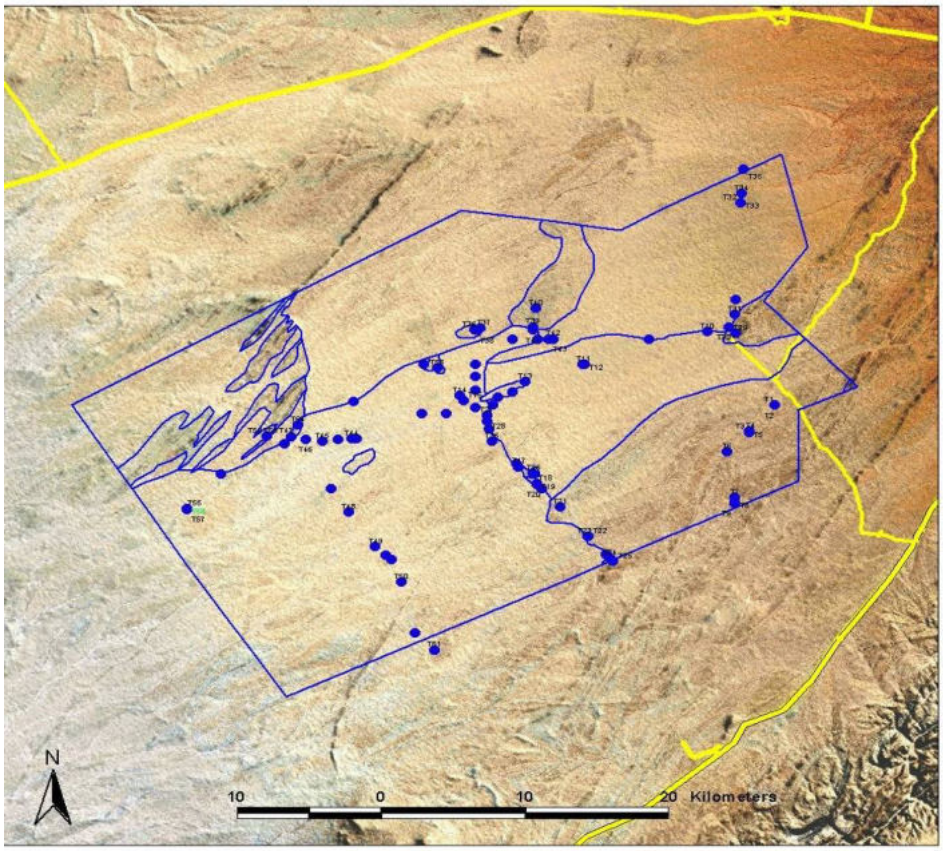

Figure 1. Sampling points (blue) in the Areva mining and exploration licence area, outline of biotopes (blue) and major roads (yellow).

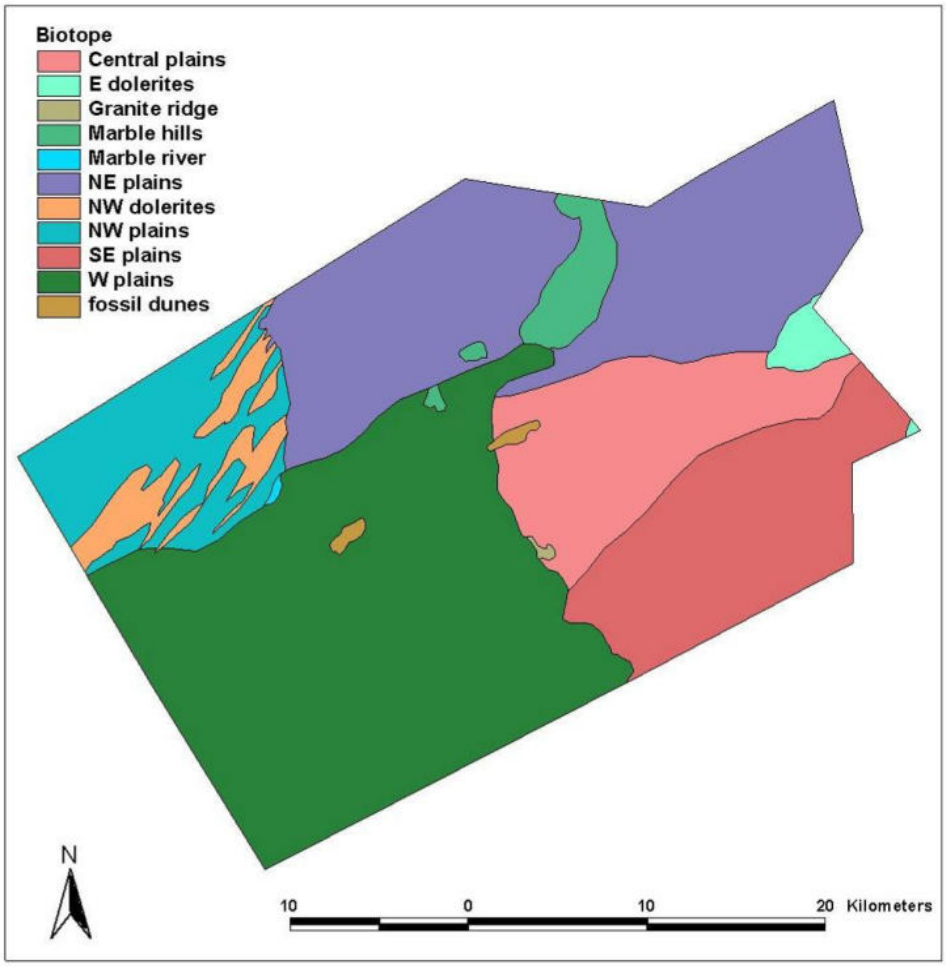

Figure 2. Biotopes in the Areva mining and exploration licence area.

Biodiversity indicators

During previous assessments, plant endemism had been identified as an important feature in the study area (Burke 2007b). The presence of endemic, red-list and protected plants in a mapping unit was thus used as indicators for biodiversity value. Red list status referred to the IUCN threat status “vulnerable”, “near threatened” or “threatened with extinction”. A total of 162 plant species was recorded during the April 2009 survey (Appendix 1). Thirty-eight of these were indicator species of biodiversity importance, mainly based on their endemism status. All species assessed for red-listing were of “least concern” (Loots 2005) and thus not included as indicators. Not to inflate the numbers, scores for protected species were only added, if these were not already listed as endemics or red-list species.

Table 1. Rating of endemism (3 = highest, 1= lowest) and red-list status.

	Rating
Endemism range	
Central Namib	3
Central Namib and one more region	2
Central Namib and several other regions in Namibia	1
Red-list category	
Vulnerable	1
Near-threatened	2
Threatened with extinction	3
Protected	1

For consistency the same endemism rating as for previous biodiversity assessments in the central Namib was applied (Burke 2005, 2007) and endemics were classified according to range. Those with the most restricted range received the highest rating on a three-point scale (Table 1).

The ratings from the red-listing and endemism ranking were added up per species (Table 2). These 38 species were then used to rate the biotopes by recording their presence and adding up their scores per biotope. Species for which identifications were still outstanding could not be included.

Table 2. Rating of indicator plant species based on level of endemism and protection status recorded in the Trekkopje licence area. No species were listed in any threat category according to IUCN.

Plant species	**Endemism**	**Protected**
Aizoanthemum galenioides	3	
Cleome carnosa	3	
Petalidium lanatum	3	
Salsola cf. swakopmundii	3	
Aizoanthemum rehmannii	2	
Arthraerua leubniztiae	2	
Calostephane marlothiana	2	
Commiphora dinteri	2	
Euphorbia giessii	2	
Hermbstaedtia spathulifolia	2	
Jamesbrittenia barbata	2	
Ornithogalum rautanenii	2	
Stipagrostis namibensis	2	
Zygophyllum stapffii	2	
Acrotome fleckii	1	
Acacia erioloba		1
Aloe asperifolia	1	
Anacampseros albissima		1
Anticharis imbricata	1	
Blepharis gigantea	1	
Commiphora saxicola	1	
Commiphora virgata	1	
Crinum parvibulbosum	1	
Euclea pseudebenus		1
Euphorbia lignosa	1	
Geigeria rigida	1	

Hoodia sp.		1
Lavrania sp.		1
Monechma desertorum	1	
Ornithogalum stapffii	1	
Parkinsonia africana		1
Pelargonium otaviense	1	
Psilocaulon salicornioides	1	
Sesbania pachycarpa dinterana	1	
Stipagrostis damarensis	1	
Stipagrostis gonatostachys	1	
Stipagrostis hochstetteriana var. *hochstetteriana*	1	
Zygophyllum cylindrifolium	1	

Biotope assignation

Species lists were then compiled for the mapped biotopes in the Trekkopje mine area by summarising the detailed field data for each mapping unit. Well over 800 records were so generated and these were then cross-tabulated to present the occurrence of plants in different biotopes in the study area (Appendix 1).

The biotope scores ranged from 9 to 34. The scores were then divided into three classes of equal intervals of integer numbers (except for the "high" which included 7 instead of 8 values). These correspond with the biotope assignation in the following manner:

Table 3. Assignation of scores for biotopes in the Trekkopje mining area based on 31 indicator plant species.

Score	Biodiversity rating	Biotope assignation
0		technotope
9-17	fair	general
18-26	medium	rare
27-34	high	critical

In the Trekkopje area four biotopes were classified as "critical", and four as "rare" (Table 4). These cover the majority of the surface area (Figure 2).

Table 4. Biotope assignation in the Trekkopje mine area.

Biotope	Biotope assignation
Central plains	rare
E(astern) dolerites	rare
Fossil dunes	general
Granite ridge	general
Marble hills	critical
Marble river	general
NE (north-east) plains	critical
NW (north-west) dolerites	rare
NW (north-west) plains	critical
SE (south-east) plains	critical
W(estern) plains	rare

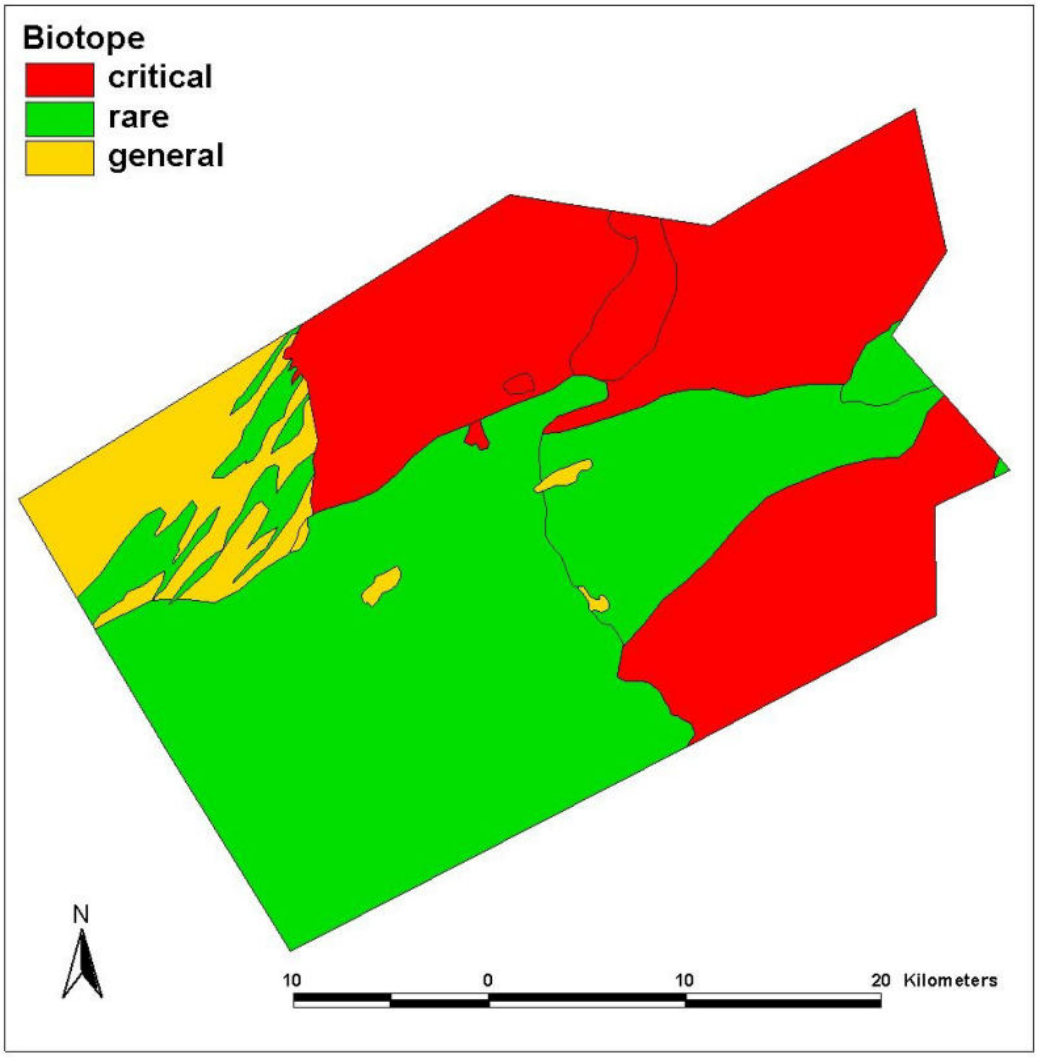

Figure 2. Biotope assignation in the Trekkopje licence area (brown and black outlines show the extent of disturbed areas as of May 2009).

The data quality of the assessment was rated “poor”, “medium” or “good” per biotope, taking into account (1) data coverage in relation to the size of the mapping unit and (2) likelihood of recording all plant species in this mapping unit. For example the western part of the study area received less rain, likely resulting in lack of species that only emerge after good rains.

Table 5. Data quality assessment per biotope.

Biotope	Data quality
Central plains	good
E(astern) dolerites	medium
Fossil dunes	medium
Granite ridge	poor
Marble hills	good
Marble river	poor
NE (north-east) plains	good
NW (north-west) dolerites	medium
NW (north-west) plains	poor
SE (south-east) plains	good
W(estern) plains	medium

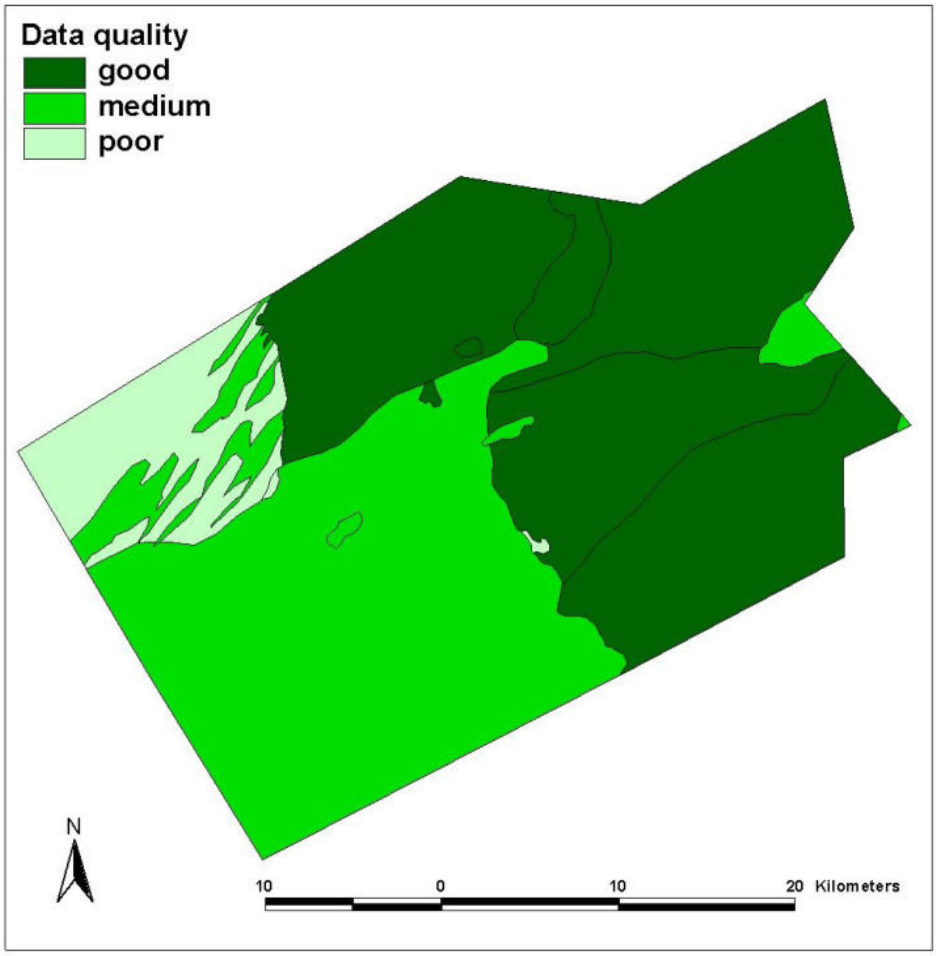

Figure 3. Data quality of biotope assessment in the Trekkopje licence area.

Biotope assessment

Surface areas of different classes of biotopes were then calculated and presented as a percentage of the total area to depict the “before” situation. All impact areas were then overlaid and classified as “technotopes” assuming that these have no biodiversity value. Percentages of the biotope classes were then calculated for the “after” situation.

Biotope mapping in the Trekkopje licence area

The biotope assessment of the "before" situation serves as a baseline of biotopes in the study area. Although undertaken after a good rainy season, some of the short-lived components of the vegetation were unfortunately missed, and not all mapping units were easily accessible. Further field work would likely add more records of plant species for individual biotopes. The survey gives nevertheless a very good assessment, but should not be considered as complete. Localised mapping units such as the granite ridge, marble river and fossil dunes were only delineated where these could be accessed along the survey routes. There are likely more of these localised biotopes which are not depicted on the map.

Biotopes that were rated of poor data quality are the north-west plains and the granite ridge. These should receive more attention during future field surveys.

Some species that were listed in the flora specialist study of the EIA (Mannheimer 2006) as occurring in the Trekkopje area were not found during the recent survey. This list was based on a brief field survey and records from the NBRI's specimens database, which records species per quarter degree square covering a much larger area. It is therefore possible that this list includes species that were observed during the recent survey only outside the mining licence area, such as *Adenia pechuelii, Aloe namibensis* and *Commiphora tenuipetiolota*. The current field survey missed most lilies, and taxonomic changes and some possible misidentifications would explain further discrepancies with the plant species list of 2006.

In the longer-term it would useful to include other biodiversity components such as invertebrates, birds and reptiles to make these assessments more comprehensive. Such surveys would, however, first have to identify ecologically sound and suitable, mappable indicators (e.g. presence/absence of highly seasonal and migratory species such as birds would not be useful). Second, ways to link these assessments to the derived biotopes will have to be developed.

Comments to the biotope assignation

Although the assignation of biotopes follows a transparent process based on simple mathematical principles (i.e. dividing the range of calculated values into three evenly spaced intervals), these assignations and associated class intervals may change as soon as new species of conservation importance are recorded in those biotopes that currently define the lowest and highest value (fossil dunes and south-east plains). There may also be a shift in assignation if new plant species of conservation importance are found in biotopes that are presently at a threshold between two classes. This is true, for example, for Central plains (value 24), where finding one more species of conservation value would move it from "rare" to "critical".

Presently the assignation of biotopes is only based on endemism, as no single plant of threatened red-list status was recorded. This is, however, a reflection of the way IUCN prescribes red-list assessments, whereby only a known decrease in a population will result in a listing in a threatened category. In Namibia, where scientist are only just establishing the ranges of plant species, information on changes of population sizes are simply not available and thus many species are listed as "data deficient" or "least concern".

Before/after biotope assessment

Despite the apparently homogenous landscape, the area is diverse in plant species and supports a high number of endemic species (19%). Nearly half of these show a restricted range (central Namib and maximum one more region in Namibia) which explains why at the

baseline situation (BEFORE), before any disturbance took place, 40 % of the surface area has been rated as a “critical” biotope, 52 % as “rare” (Figure 4).

Overall, during the establishment of the mine at the time of the survey (May 2009), 6.2% of the licence area has been disturbed by mining and exploration activities and its associated infrastructure. Most affected were “rare” biotopes showing a 5 % reduction.

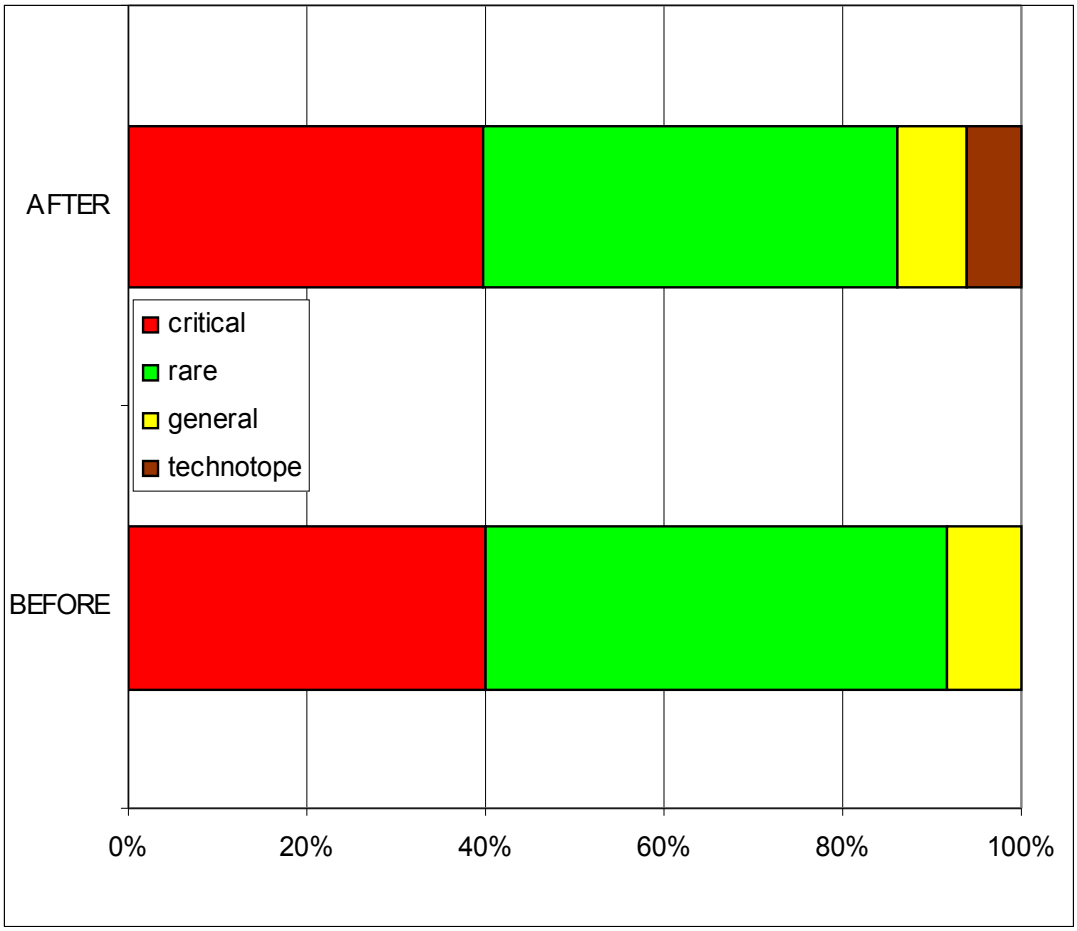

Figure 4. Biotope assessment at the baseline situation (BEFORE) and during the establishment (AFTER) of the Trekkopje Mine, status May 2009.

It has to be noted that the assessment assumes that disturbed areas are completely sterile and have no plant species or any other biodiversity left, which is obviously a simplification of the situation in nature. In the field “technotopes” are not necessarily devoid of any wild- or plant life, and also, over time, natural recovery takes place in some of these disturbed areas and plants and animals re-colonise those that are not too severely damaged (i.e. polluted or completely stripped of life-supporting substrate).

The assessment also only deals with direct impacts which are measurable as surface area. It does not take into account presently intangible, longer-term impacts related to pollution (e.g. radiation or dust) or abstraction of groundwater.

Restoration potential

Added to the biotope assessment is an expert assessment of restoration potential of the different biotopes. This was based on information on natural recovery in the southern Namib (Burke 2007b), a review of ecological restoration for the southern Namib (Burke2003) and many years of general ecological work in the central Namib.

The following assumptions were made:

- No toxic substances pollute water or soil.
- Pre-mining water flow is restored.
- Topsoil is available to undertake rehabilitation.
- Measures to restore plant cover are undertaken.
- Invasive alien plants are not encroaching.
- No livestock farming, wood collecting or any other human activities take place which disturb natural recovery.
- Restoration aims to achieve pre-mining conditions.

Restoration potential was rated on a three-point qualitative scale (fair, medium and poor) and took into account the difficulty of re-creating the original landform, substrate and plant diversity. Thus species-rich biotopes as well as biotopes that contain diverse topography, such as rocky outcrops and areas with many drainage lines were rated as of "poor" restoration potential.

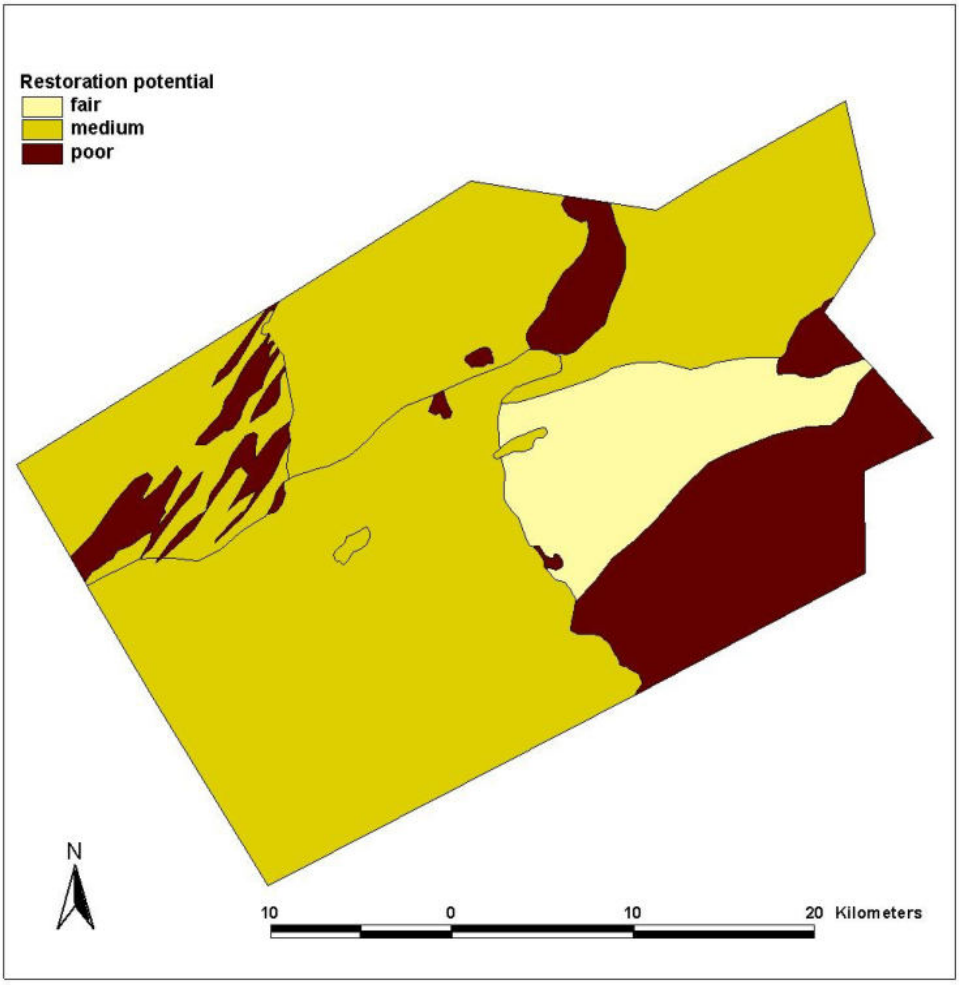

Figure 5. Restoration potential of biotopes in the Trekkopje study area.

Description of biotopes

This section describes the biotopes that were mapped in the Trekkopje mine area.

In a broader context the vegetation in the study area belongs to the central Namib (Giess 1971), gravel plains of the central Namib (Burke et al. 2002) and the Zygophyllum stapffii zone in the east and Arthraerua leubnitziae zone in the west of the study area (Hachfeld 1996).

The Trekkopje mine area is characterised by gravel plains intersected by a dense network of drainage lines running mostly in a west-south-westerly direction. Except for dolerite dykes in the very north-east and north-west of the study area, changes in landforms are thus rather subtle. Resulting boundaries in vegetation types, which were used as the basis for the biotope mapping, are thus also subtle and determined by broad biogeographic ranges of key species such as *Arthraerua leubnitziae* and *Zygophyllum stapffii*. As the licence area stretches from east to west over more than 50 km, climatic conditions clearly change over the licence area. Fog is much more regular in the west than in the eastern sections of the licence area, and rainfall increases towards the east (Hachfeld & Jürgens 2000). To some extent, underlying rock types such as marble and granite resulted in different and more diverse plant assemblages. However, as the entire licence area is largely dominated by plains and drainage lines, differences between some biotopes are subtle and based on an overall change in dominant plant species. Plant species richness clearly declines from east to west in the study area, following the gradient of decreasing rainfall towards the west.

Plant cover was relatively high during the survey, due to the good rainy season, and ranged from 1 % in the west to 30% in the east. Not only drainage lines, but also plains showed locally high plant cover which is unusual for a desert area.

For simplicity, simple descriptive terms were used to name the biotopes which were based on position in study area, characteristic landform and/or rock type if relevant.

Central plains.

The gravel plains in the central part of the study area are generally level and dissected by few wide, but shallow riverbeds running in a north-east to south-westerly direction. The plains gently slope towards the south-west. Coarse quartz and other gravels, mixed with patches of loamy sand are the dominant surface substrate.

Some 75 plant species were recorded in this mapping unit, which is 46 % of all species recorded in the licence area. *Stipagrostis obtusa* (small bushman-grass) is the dominant grass on these plains, accompanied by *Stipagrostis namibensis* (Namib bushman-grass) and carpets of the small herb *Monechma desertorum* (desert monechma).

Shallow drainage lines in this mapping unit are dominated by *Zygophyllum stapffii* (dollar bush) and the larger riverbeds support, amongst others, stands of *Euclea pseudebenus* (false ebony) and *Stipagrostis damarensis* (Damara bushman-grass). Occasional trees, such as *Acacia reficiens* (red thorn) and *Acacia erioloba* (camel thorn) grow in these riverbeds.

Species of conservation importance include, amongst others, *Aizoanthemum galenioides*, *Cleome carnosa* and *Petalidium lanatum*. Biodiversity value was rated medium, thus assigning this a rare biotope. Data quality was good.

Eastern dolerites

Dolerite ridges and outcrops in the eastern part of the study area are included in this mapping unit. However, only the higher and more extensive ridges have been mapped, as these harbour distinctly different vegetation than the surrounding. There are more ridges, particular in the south-east plains, which are similar, but because of local extent and similar species assemblages to the surrounding plains were not mapped individually.

Zygophyllum cylindrifolium (cylinder-leaf zygophyllum) is the characteristic dwarf shrub on these outcrops, but the grasses *Stipagrostis obtusa* (small bushman-grass) and *S. namibensis* (Namib bushman-grass) as well as the geophyte *Dipcadi glaucum* (wild onion) were dominant after this good rainy season. The stem-succulent *Commiphora dinteri* (Dinter's commiphora) and *Commiphora saxicola* (rock commiphora) occur. *Commiphora virgata* (twiggy commiphora) was only recorded on these outcrops during the recent survey. The eastern dolerites are of medium species richness. During the recent survey 40 species were recorded. This included species of conservation importance such as *Commiphora dinteri* and *Euphorbia giessii.* The biotope was assigned as "rare" and data quality of this mapping unit was medium.

Fossil dunes

Large hummocks up to 3m high, formed by *Salsola* cf. *swakopmundii*, occur in the central part of the mining area. These are likely positioned in a former riverbed which runs in a south-westerly direction through the licence area. A similar concentration of Salsola hummocks was observed in the western part of the study area. More of these are likely to occur in larger riverbeds which could not be accessed during the recent survey.

Only 18 species were recorded during the recent survey, and data quality was rated as medium. Although *S. swakopmundii* is a central Namib endemic and thus of conservation importance, only few other species of conservation importance were recorded (e.g. *Stipagrostis namibensis* and *Zygophyllum stapffii*) in this mapping unit and it was assigned a general biotope.

Granite ridge

Low granite ridges occur throughout the study area, particularly in the west – although only one of these could be accessed along the pipeline and mapped adequately. They generally do not rise more than 20 m above the surrounding, but they are noteworthy because they provide a different type of habitat and thus harbour some plant species that are rare in the study area.

The surveyed granite ridge was dominated by the dwarf shrubs *Galenia africana* (kraalbos) and *Zygophyllum cylindrifolium* (cylinder-leaf zygophyllum). Of interest, because rarely encountered elsewhere in the study area, are the dwarf succulent *Larryleachia* sp., *Gazania jurineifolia* (white gazania) and the low stem-succulent *Othonna lasiocarpa* (wool-fruit Othonna).

During this survey 27 species were recorded, including the endemic *Commiphora dinteri* and *Petalidium lanatum*. But the biotope was ranked as general. Since only one of these ridges was surveyed, data quality has been rated as poor, and more surveys of similar ridges are likely to increase species richness and possibly change the biotope assignation.

Marble hills

Undulating hills, largely composed of marble, occur in the north-eastern part of the study area. These are likely the rocky/gravelly outcrops referred to in the flora study of the Environmental Impact Assessment as being worth to preserve (Mannheimer 2006).
Isolated marble outcrops also occur south-west of these marble hills and these are included in this mapping unit.

The dwarf shrub *Monechma cleomoides* (Namib perdebos) is dominant, while *Aptosimum spinescens* (spiny aptosimum), *Petalidium lanatum* (woolly petalidium) and *Zygophyllum stapffii* (dollar bush) are common on these outcrops. Grasses such as *Stipagrostis subacaulis* (brush bushman-grass) and the herb *Cleome carnosa* were also abundant after this good rainy season.

These marble hills are the most diverse biotope in the study area and support 80 species, nearly half of the total plant species recorded in the licence area. Some 16 endemic plant species occur, including *Anticharis imbricata, Cleome carnosa, Euphorbia giessii* and *Petalidium lanatum*. This is therefore a critical biotope and data quality was rated as good.

Marble river

Where rivers have carved into underlying rocks, areas with deeper channels, boulders and exposed rock surfaces occur. One such area was observed along the pipeline in the western part of the study area, where mainly marble was exposed. More of these features are expected to occur throughout the study area, particularly following the larger rivers, but these could not be accessed and mapped.

The mapped biotope is dominated by the dwarf shrub *Zygophyllum stapffii* (dollar bush), accompanied by *Arthraerua leubnitziae* (pencil bush), *Aptosimum spinescens* (spiny aptosimum) and *Orthanthera albida*. Of note is the presence of the tree *Tamarix usneoides* (tamarisk), which has not been recorded elsewhere in the study area.

This mapping unit supported 44 plant species, including the endemics *Arthraerua leubnitziae, Cleome carnosa* and *Psilocaulon salicornioides*. The biotope was ranked as general, but data quality as poor.

North-east plains

Largely level, but dissected by several large riverbeds, particularly in the northern part of the study area, the north-east plains are dominated by the grasses *Stipagrostis subacaulis* (brush bushman-grass) the succulent, low-growing herb *Zygophyllum simplex* (simple zygophyllum). The grasses *Eragrostis nindensis* (whether love-grass), *Stipagrostis obtusa* (small bushman-grass) and *Stipagrostis namibensis* (Namib bushman-grass) are locally dominant.

Drainage lines on these plains are dominated by the dwarf shrubs *Monechma cleomoides* (Namib perdebos) or *Monechma genistifolium* (broom-leaf monechma), while the larger riverbeds support trees such as *Acacia reficiens* (red thorn), *Acacia erioloba* (camel thorn) and *Euclea pseudebenus* (false ebony). The tall grasses *Stipagrostis hochstetteriana* (gemsbok-tail grass) and *Stipagrostis damarensis* (Damara bushman-grass) are also commonly encountered. Just over 50% of all plants species (83 species) in the licence area were recorded in this biotope. This includes all three central Namib endemics (*Aizoanthemum galenioides, Cleome carnosa* and *Petalidium lanatum*). The biotope was assigned as critical and data quality is good.

North-west dolerites

The dolerite dykes in the north-western part of the study area harbour vegetation distinctly different from their surroundings. Trending north-east to south-west, these low ridges are characterised by large boulders which are strewn from the ridges downwards on both sides of the slopes.

The succulent shrubs *Brownanthus kuntzei* (Kuntze's brownanthus) and *Hypertelis salsoloides* are the dominant plants, but *Aloe asperifolia* (sandpaper aloe), *Kleinia longiflora* (sambokbossie) and *Euphorbia lignosa* (spiny milk-bush) are also characteristic.

Species richness was 44 species, including the endemic *Cleome carnosa* and *Commiphora saxicola*. *Aloe asperifolia* and *Pelargonium otaviense* occurred here and were not recorded in any other biotope.

The biotope was rated rare and data quality is medium.

North-west plains

Placed between dolerites ridges and extending further towards the north and west, the sandy plains in the north-west of the study area support largely *Stipagrostis ciliata* (tall bushman-grass). Occasional *Arthraerua leubnitziae* (pencil bush) and *Zygophyllum stapffii* (dollar bush) shrubs occur, and *Stipagrostis obtusa* (small bushman-grass) and *Stipagrostis hochstetteriana* (gemsbok-tail grass) are present in drainage lines.

With 16 plant species richness was lower because the mapping unit falls into the drier western part of study area, which was also not well covered. The biotope was assigned general and data quality as poor.

South-east plains

Topographically more diverse than the adjoining central plains, plains in the south-east of the study area are undulating, dissected by many shallow and wide drainage lines, and dotted with low dolerite ridges. These quartz gravel plains are dominated by *Stipagrostis obtusa* (small bushman-grass) and *Stipagrostis subacaulis* (brush bushman-grass), with *Stipagrostis ciliata* (tall bushman-grass) and *Stipagrostis namibensis* (Namib bushman-grass) locally co-dominant.

Zygophyllum stapffii (dollar bush) is prominent in most drainage lines, but some are dominated by other dwarf shrubs, such as *Petalidium lanatum* (woolly petalidium) and stem-succulents such as *Commiphora saxicola* (rock commiphora) and *Commiphora dinteri* (Dinter's commiphora). Larger drainage lines support the trees *Acacia reficiens* (red thorn) and *Acacia erioloba* (camel thorn) and the tall grasses *Stipagrostis damarensis* (Damara bushman-grass) and *Stipagrostis hochstetteriana* (gemsbok-tail grass). With 104 species, which is 64% of all species recorded in the study area, species richness is highest on the south-east plains. All three central Namib endemics as well as almost all regional endemics occur here which resulted in ranking this biotope as critical. Because of the good rains and easy access in this area, data quality was good.

Western plains

The largest part of the study area is covered by the western plains. Although topographically similar to their adjoining mapping units, *Arthraerua leubnitziae* (pencil bush) is dominant throughout this area, which thus resulted in a different biotope. To a large extend this also reflects the extent of regular fog influence as *Arthraerua* is fog-dependent. This biotope is topographically very diverse and includes expanses of quartz and other gravel plains, low ridges of dolerite, granite and marble as well as shallow and wide, sandy drainage lines. Gypsum crusts are particularly common in the western section of this biotope, and largely saxicolous lichens cover these plains. Where rains fell in this biotope during the rainy season *Stipagrostis obtusa* (small bushman-grass) was dominant. However, grass cover changed from continuous to patchy towards the west, where rains were also more patchy. *Salsola* sp. and *Zygophyllum stapffii* (dollar bush) dominate in small drainage lines, while *Galenia africana* (kraalbos), *Salsola swakopmundii*, *Stipagrostis damarensis* (Damara bushman-grass) and *Zygophyllum stapffii* are common in wide drainage lines.

Harbouring nearly half (46% or 76 species) of the species recorded in the study area, species richness is high on the western plains. A number of endemics occurred, such as *Blepharis gigantea, Jamesbrittenia barbata* and *Stipagrostis damarensis* The biotope was rated as rare and data quality as medium.

Recommendations

Managing impacts with the biotope assessment

The biotope assessment provides a means of guiding impact management by identifying areas that require special management if these are impacted.

1. Ideally all critical biotopes should be out of bounds and receive special protection, while particular care should be taken in rare biotopes.

2. Because of the extent of these areas in the licence area, this may not always be possible and mitigating actions need to be considered. These could include measures such as
   - Creating increased awareness of these biotopes amongst the mine and contractor staff
   - Increased monitoring to avert disturbance of these biotopes that could be avoided and
   - Transplanting of endemic species (e.g. *Aloe asperifolia, Commiphora dinteri* and *Euphorbia giessii* are potential candidates), if these are affected by the mine's activities.

3. If critical biotopes are nevertheless impacted, special measures to restore these biotopes should be considered. These would have to be determined on a case-by-case basis, but could include measures like
   - Topsoil storage and application,
   - Re-introducing selected plant species and
   - Collection of seeds from these biotopes for restoration purposes.

Progress reporting with the biotope assessment

This biotope assessment provides an excellent tool to monitor progress in impact management. The data surveyed, gathered and analysed during the biotope assessment can directly be used in corporate reporting, in-house (.e.g. annual reports) and externally, should Areva subscribe to sustainability initiatives such as Global Reporting Initiative (GRI) or Global Impact. Measuring impacts on biodiversity is also a requirement of sustainability indices used on the stock exchanges.

Managing impacts in a constantly changing environment

Mining is a dynamic business and environmental management has to constantly adapt to new situations. In the context of the biotope assessment the status of disturbed areas will change constantly, for example. Furthermore, environmental conditions in a desert fluctuate, possibly exacerbated nowadays by global climate change. A once-off assessment of biodiversity gives a good starting point, but needs to be repeated over the life of mine to take cognisance of natural changes, and thus also protect the mine from claims that these changes are caused by the mine's activities. It is therefore recommended that a biotope assessment is firmly integrated in the mine's environmental monitoring programme and undertaken, if feasible annually, but at least every second year. Follow-up assessments would have a different focus than the initial baseline survey and would concentrate on the disturbed area and a few selected biotopes for comparison. Over time, this could also include assessments of rehabilitated and naturally recovered areas, and thus give a more comprehensive evaluation of the impacts on biodiversity caused by the mine, as well as show some improvement.

As the biotope assessment has not been used for changes over time, especially incorporating rehabilitated and recovering biotopes, this is pioneering work and it may give Areva Resources Namibia a leading edge in managing biodiversity impacts.

Improving biodiversity data collection

Although most areas received exceptional rains and thus data coverage has been rated as fairly good, some data coverage, particularly of the western biotopes could be improved, if surveyed after good rains. Also outstanding identifications should be integrated when these become available. For example, a *Helichrysum* species (AB 09020) which occurred in several biotopes in the in the study area was collected. If this turns out to be the central Namib endemic *Helichrysum marlothianum*, it will likely change the biotope assignations. Similarly, the main plant of the fossil dunes has not been identified and could also well be a central Namib endemic. There are many lilies in the study area with a restricted range (e.g. *Crinum parvibulbosum*) and recording these would not only change the biotope assessment, but also provide important information to institutions concerned with biodiversity conservation.

Plant species-based management

The present biodiversity assessment did not identify a particular plant species that may be impacted by the developing mine to such an extent that it requires special attention. Environmental management should thus rather focus on general measures (as outlined in this chapter), and making the mine staff aware of important plants to be able to obtain better distribution records. For example a pamphlet with photos of plants to look out for and inform environmental staff should be given to all people on site. This could include, for example *Crinum parvibulbosum* and other lilies as well as *Euphorbia giessii*.

Minimising the footprint

Minimising the footprint of the establishing mine will benefit biodiversity and cultural heritage in the area, but will also reduce rehabilitation costs. These should therefore be included in the planning stage of each individual project that will contribute to the development of the mine (including service infrastructure and accessory works infrastructure). Awareness of the costs incurred by disturbing larger areas than necessary is one of the most powerful incentives to keep the mine's footprint as small as really necessary.

Invasive alien plant control

Very few invasive alien plants were recorded during the survey. Only *Ricinus communis* grows in some larger riverbeds. This is a good sign, but should not lead to ignoring the potential spread of unwanted plants of this kind. It also means that control will be possible, as individual plants can be eradicated at emergence. These actions should be firmly integrated in Trekkopje's Environmental Management System.

Integration of other biodiversity indicators

Inclusion of other biodiversity components such as invertebrates, birds and reptiles should be considered to provide a more comprehensive biodiversity assessment. Some thought has to be given to link these to the current biotope map.

A step-by-step approach would be:

1. to develop a transparent process of selecting indicators other than plants which are feasible to map,
2. ranking these according to relevant ecological criteria,
3. determining appropriate thresholds for biotope assignation and
4. developing a process of integrating these assessments with the existing habitat- and plant-based biotope assessment.

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Appendix 1. Cross-tabulated species list for mapped biotopes in the Trekkopje Mine and Exploration Licence Area.

Plant species	Central plains	dolerites	Fossil dunes	Granite ridge	Marble hills	Marble	NE plains	dolerites	NW plains	SE plains	W plains
Acacia erioloba	X				x		x			X	x
Acacia reficiens	X	X			x		x			X	x
Acrotome fleckii	X										
Adenolobus pechuelii	X	X			x			X		X	
Aizoanthemum galenioides	X	X					x			X	
Aizoanthemum rehmannii							x				
Aloe asperifolia								X			
Anacampseros albissima					x					X	
Anticharis imbricata					x			X			
Anticharis senegalensis	X			x		x	x			X	x
Aptosimum lineare		X								X	
Aptosimum spinescens					x	x				X	x
Aristida parvula	X			x	x	x	x	X		X	x
Arthraerua leubnitziae					x	x		X	x	X	x
Asparagus pearsonii	x	X		x	x			X		X	x
Blepharis gigantea	x						x	X		X	x
Blepharis grossa	x	X					x			X	
Boscia foetida	x				x		x			X	x
Brachiaria glomerata	x						x	X		X	
Brownanthus kuntzei								X			x
Calicorema capitata		X			x		x			X	x
Calostephane marlothiana										X	
Cenchrus ciliaris					x						
Chascanum garipense					x					X	
Chenopodium murale	x			x	x		x			X	x
Citrullus eccirrhosus	x					x					x
Cleome diandra		X		x	x	x	x	X			x

Plant species	Central plains	dolerites	Fossil dunes	Granite ridge	Marble hills	Marble	NE plains	dolerites	NW plains	SE plains	W plains
Cleome carnosa	X				X	X	X	X	x	X	X
Cleome foliosa	X	X	X		X		X			X	X
Cleome suffruticosa										X	
Codon royenii					X	X				X	X
Commiphora dinteri		X		X	X	X	X			X	X
Commiphora saxicola		X			X			X		X	
Commicarpus squarrosus					X						
Commiphora virgata		X									
Crinum parvibulbosum										X	
Cryptolepis deciduas		X			X					X	
Cucumis meeusei										X	
Dicoma capensis										X	X
Dipcadi bakerianum					X		X				
Dipcadi glaucum		X								X	
Dyerophytum africanum	X	X			X	X	X			X	X
Enneapogon cenchroides							X				
Enneapogon desvauxii	X	X	X	X	X	X	X	X		X	X
Enneapogon scaber					X						
Eragrostis annulata	X						X				
Eragrostis biflora											X
Eragrostis cylindriflora	X						X				
Eragrostis nindensis		X		X	X		X			X	
Eriospermum rautanenii							X				
Eriospermum sp								X			
Euclea pseudebenus	X						X				
Euphorbia gariepina					X						
Euphorbia giessii		X			X						
Euphorbia glanduligera		X					X			X	
Euphorbia inaequilatera	X										
Euphorbia lignosa		X			X			X			
Euphorbia phylloclade				X	X	X		X	x	X	X

Plant species	Central plains	dolerites	Fossil dunes	Granite ridge	Marble hills	Marble	NE plains	dolerites	NW plains	SE plains	W plains
Felicia anthemidodes	X									X	
Forsskaolea candida	X	X		X	X	X	X	X		X	X
Galenia africana	X		X	X	X	X		X		X	X
Gazania jurineifolia subsp. scabra				X	X					X	X
Geigeria alata		X					X			X	
Geigeria ornativa					X		X			X	
Geigeria rigida							X			X	
Gisekia africana	X						X			X	X
Gomphocarpus filiformis										X	X
Grielum sinuatum	X						X				
Gymnosporia senegalensis	X				X						X
Helichrysum candolleanum	X						X				X
Heliophila deserticola	X									X	
Heliotropium oliveranum	X		X	X	X	X	X	X	X	X	X
Helichrysum herniarioides	X									X	
Hermannia affinis		X		X	X	X	X	X		X	
Hermbstaedtia argenteiformis							X				
Hermannia modesta	X				X		X			X	X
Hermbstaedtia spathulifolia	X					X	X		X	X	X
Hirpicium echinus	X						X				
Hoodia sp					X						
Hypertelis salsoloides			X		X	X		X		X	
Indigofera adenocarpa					X		X			X	X
Indigofera auricoma	X	X			X	X	X	X		X	X
Ipomoea adenioides					X		X	X		X	X
Jamesbrittenia barbata					X		X				X
Jamesbrittenia maxi					X	X				X	
Kissenia capensis	X					X	X			X	X
Kleinia longiflora					X			X			
Kohautia caespitosa	X	X			X	X	X	X	X	X	X
Kohautia cynanchica	X			X	X	X				X	X

Plant species	Central plains	dolerites	Fossil dunes	Granite ridge	Marble hills	Marble	NE plains	dolerites	NW plains	SE plains	W plains
Launea intybacea					X						
Lavrania sp				X							
Liliaceae											X
Limeum argute-carinatum	X				X					X	X
Lophiocarpus polystachyus											X
Lotononis platycarpa	X	X		X	X		X			X	X
Lycium bosciifolium	X	X			X		X			X	X
Lycium cinereum								X			
Maerua parvifolia	X									X	X
Mesembryanthemum guerichianum	X		X							X	X
Mesembryanthemum sp.											X
Mollugo cerviana	X		X				X			X	X
Monechma cleomoides	X	X		X	X	X	X	X		X	X
Monechma desertorum	X		X		X	X	X	X	X	X	X
Monechma genistifolium subsp. genistifolium					X		X			X	
Monsonia umbellate	X	X		X	X			X		X	
Myxopappus acutilobus	X						X			X	
Ornithogalum rautanenii		X									
Ornithogalum stapffii	X		X		X		X	X	X		X
Ornithoglossum vulgare							X				
Orthanthera albida					X	X	X			X	X
Othonna lasiocarpa				X	X	X		X			
Parkinsonia africana										X	
Pechuel-Loeschea leubnitziae										X	
Pelargonium otaviense								X			
Pergularia daemia var. leiocarpa							X			X	
Petalidium lanatum	X			X	X		X			X	
Petalidium variabile										X	X
Phaeoptilum spinosum										X	
Phyllanthus pentandrus							X			X	
Psilocaulon salicornioides		X			X	X				X	X

Plant species	Central plains	dolerites	Fossil dunes	Granite ridge	Marble hills	Marble	NE plains	dolerites	NW plains	SE plains	W plains
Ptycholobium biflorum	X						X				
Ricinus communis	X										X
Rogeria longiflora										X	
Salsola aphylla										X	
Salsola gemmipara					X					X	
Salsola cf. *swakopmundii*			X								X
Salsola sp						X			X		
Salvadora persica							X				
Sarcocaulon salmoniflorum							X	X	X		
Sarcostemma viminale								X			
Schmidtia kalahariensis	X										
Senna italica arachoides										X	
Sesamum capense	X						X			X	X
Sesbania pachycarpa subsp. dinterana	X									X	
Sesuvium sesuvioides	X	X	X		X	X		X		X	X
Setaria verticillata	X						X				
Stipagrostis ciliata	X	X	X	X	X	X	X	X	X	X	X
Stipagrostis damarensis	X					X	X			X	X
Stipagrostis dinteri					X						
Stipagrostis gonatostachys						X					
Stipagrostis hochstetteriana var. hochstetteriana	X				X		X	X	X	X	X
Stipagrostis hochstetteriana var. secalina	X		X		X		X			X	X
Stipagrostis hirtigluma var.. pearsonii										X	
Stipagrostis namibensis	X	X	X		X		X	X		X	X
Stipagrostis obtusa	X	X	X	X	X	X	X	X	X	X	X
Stipagrostis schaeferi	X				X		X			X	X
Stipagrostis subacaulis	X				X	X	X		X	X	X
Stipagrostis uniplumis var. intermedia	X									X	
Stipagrostis uniplumis var. uniplumis					X	X	X			X	
Tamarix usneoides						X					

Plant species	Central plains	dolerites	Fossil dunes	Granite ridge	Marble hills	Marble	NE plains	dolerites	NW plains	SE plains	W plains
Tapinanthus oleifolius							X				
Tephrosia dregeana				X	X	X	X	X		X	X
Tetragonia reduplicate	X				X	X	X	X			X
Tribulocarpus dimorphanthus	X						X				
Tribulus excrucians	X						X			X	X
Tribulus zeyheri							X				X
Trichodesma africanum	X	X			X	X	X			X	X
Tricholaena monachne										X	
Osteospermum microcarpum subsp. microcarpum	X	X		X	X	X	X		X	X	X
Zygophyllum cylindrifolium	X	X	X	X	X	X	X	X		X	X
Zygophyllum simplex	X	X	X		X	X	X	X		X	X
Zygophyllum stapffii	X	X	X	X	X	X	X	X	X	X	X