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Cover Illustration: *Fenestraria rhopalophylla* subsp. *rhopalophylla* (Window plant). Photograph by Peter Cunningham

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Vegetation of the Eastern Communal Conservancies in Namibia: III. Annotated Checklist

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Abstract
A reconnaissance survey of the vegetation of the communal conservancies Otjituuo, Okamatapati, Ozonahi, African Wild Dog, Otjinene, Epukiro, Otjombinde, Omuramba Ua Mbinda, Eiseb and Ondjou, as well as the farming areas of Otjinene and Epukiro, was conducted in 2004. These data were used to compile a species checklist which was later expanded according to herbarium records. The total of 442 listed species is considerably higher than the previously estimated 150 to 300 species for the area. Yet, the species list is considered as incomplete, as the area is generally under sampled both in terms of herbarium specimens and vegetation relevés. At least 680 species are estimated to occur in the area. In addition to the listing of species, information is provided on the status, growth forms, plant functional attributes, distribution and abundance of the plants.

Keywords: Namibia; Kalahari; plant functional attributes; Raunkiaer life form; species diversity

Introduction

Since Namibia's independence, several conservancies have been established in communal areas to assist communities in managing their natural resources sustainably, with great success (Weaver & Skyer, 2005; Weaver & Petersen, 2008). The Desert Margins Programme in Namibia aimed at supporting the emerging conservancies in the eastern communal areas (the Otjituuo, Okamatapati, Ozonahi, African Wild Dog, Otjinene, Epukiro, Otjombinde, Omuramba Ua Mbinda, Eiseb and Ondjou communal conservancies – Figure 1) in developing management plans. Within this context, a vegetation survey was undertaken in the area (Strohbach *et al.* 2004), also covering the farming areas of Epukiro and Otjinene.

The vegetation falls largely within the Tree Savannah and Woodland (Northern Kalahari) (Giess 1998), but especially the southern part is strongly ecotonal towards the Camelthorn Savannah (Central Kalahari), whilst the western part fringes on the Thornbush Savannah. This results in rather homogenous landscapes in the central parts with very gradual changes in composition towards the far south-east, and more distinct changes towards the west and south-west, as the vegetation changes into Thornbush savannah. In the far north, near Otjituuo, the study area falls within the southern extent of the Karstveld. The vegetation of the eastern communal conservancies has been fully described (Strohbach, submitted), and the environmental drivers of this vegetation were described in a second paper (Strohbach & Kutuahuripa, submitted). In this third paper of the series, an annotated species list of these conservancies and farming areas is presented.

The plant diversity of the study area is estimated to be between 150 and 299 species (or "low-medium" diversity), based on incomplete herbarium records due to the general inaccessibility of the area (Craven, 2001; Mendelsohn *et al.* 2002). Based on this assessment, the area is classed as of lesser importance for plant conservation purpose (Hofmeyr, 2004). Yet, management problems, like illegal wood harvesting for fencing posts, exist in these conservancies and farming areas (Hofmann, 2013), and these could lead to severe desertification (Midgley *et al.* 2005; Thomas *et al.* 2005). This study presents a unique opportunity of improving the knowledge of the floristic diversity of the area, which is, in itself, an important management and monitoring tool.

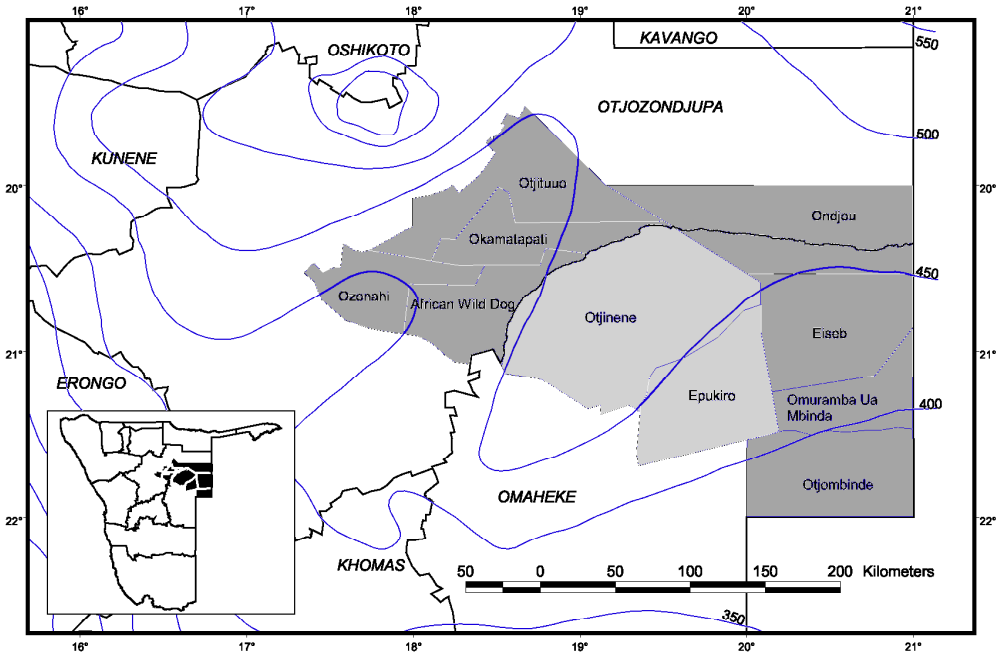

Figure 1. Overview map of the communal conservancies within the Omaheke and Otjozondjupa Regions in Namibia. The average annual rainfall is indicated by the isohyets, with their values in mm, on the right. Source data: NARIS, 2001; NACSO, 2011.

Methods

The survey for this study followed the general method employed for the Vegetation Survey of Namibia project (Strohbach, 2001). During April and May 2004, 422 plots were sampled throughout the study area. The season was regarded as an average to poor season, meaning that the full diversity of species was not observed. This problem was further compounded by the vastness of the area, and the limited access to it, resulting in the survey being done along roads, tracks and cutline's. Often smaller niche and/or azonal habitats were ignored in favour of covering the larger habitats. At each survey plot of 20 x 50 m, a Braun-Blanquet type relevé was prepared; each occurring species was noted down, as was its typical growth form and estimated abundance (crown cover). From this survey data, an initial species list was compiled. The poor season and limited sampling resulted in apparent shortcomings in the list, which was therefore augmented by an extract from the specimen database of the National Herbarium of Namibia (WIND), of species recorded from the relevant quarter-degree squares covering the study area.

Additional species information, as presented in Appendix 1, was compiled as follows:

Status: This column reflects the biogeographical as well as the protection status of the various species. Biogeographic information includes endemism and exotic plant status. The various exotic plant categories follow Pyšek *et al.* (2004). The status information on these categories was obtained from Klaassen & Kwembeya (2013).

Layer: The layer column indicates the structural layer to which each species normally belongs. The definitions follow Edwards (1983). The following conventions were adhered to:

Tree layer (t): woody plants, single stemmed, >2m, or multi-stemmed, >5m
- short Tree (t3): (single stemmed), >2m <5m
- low Tree (t2): >5m <10m
- high Tree (t1): >10m <20m

Shrub layer (s): woody plant, normally multi-stemmed
high Shrub (s1): >1m <5m
low Shrub (s2): <1m

Herb layer (hl): all non-woody species, irrespective whether annual or perennial. The herb layer was further qualified into grasses (species belonging to the family Poaceae, in many parts of the country constituting the main fodder resource for livestock keeping), geophytes (with underground storage organs), hydrophytes (growing in water) and parasites (living off other plants).

The layer information serves to provide additional information on growth forms (especially differentiating between trees and shrubs, which all belong to the life form "phanerophytes" (See the following columns with plant functional attributes).

Plant Functional Attributes: For the habitat analysis (Strohbach & Kutuahuripa, submitted), plant functional attributes (PFA's) were used for the species observed during the survey. These include the growth form (Raunkiaer, 1934), leaf size, inclination, chlorotype and morphotype, as well as above-ground root adaptations. These attributes follow the definitions of Gillison & Carpenter (1997) (See also Gillison, 2001). For this purpose a variety of sources were consulted, specifically the "Prodromus" (Merxmüller, 1966), herbarium collections, field identification guides (Van Rooyen, 2001; Curtis & Mannheimer, 2005; Heath & Heath, 2009; Mannheimer & Curtis, 2009), but also internet sources ("JSTOR Plant Science," 2012; "Kyffhäuser," 2012; Conservatoire et Jardin Botaniques & South African National Biodiversity Institute, 2012; Hyde *et al.* 2012; Jürgens *et al.* 2013). The list was completed for all species recorded.

Abundance: Using the available classification results (Strohbach, submitted), the list could be subdivided into two mayor habitat types, these being the "Sandveld" and the "Hardeveld", respectively. Species abundance was calculated in two ways:

Overall abundance relates to the number of relevés in which each species occurs, irrespective of its abundance in any specific relevé, per habitat type. The classes are defined as follows:

- Rare: present in <5 % of relevés
- Occasional: present in 5<20 % of relevés
- Common: present in 20<50 % of relevés
- Abundant: present in 50<75 % of relevés
- Widespread: present in >75 % of relevés

Local Abundance refers to the average abundance within the relevés in which the species occur, irrespectively of how often it occurs. The classes are defined as follows:

- Rare: 0 < 0.1 % cover
- Occasional: 0.1 < 1 % cover
- Common: 1 < 10 % cover
- Abundant: 10 < 50 % cover
- Dominant: 50 < % cover

Due to the apparent shortcomings of the species list, an estimate of species numbers was made, using the non-parametric first order Jackknife (Heltshe & Forrester, 1983; Palmer, 1990). This method was tested successfully in the Kavango Woodlands (Strohbach & Strohbach, 2004), performing better than the LOGLIN procedure (which is based on a species-area curve (Palmer, 1990).

The first order Jackknife was calculated as follows:

SR = SO + r(n-1)/n

where: SR is the estimated species richness
SO is the number of observed species
r is the number of species within a particular relevé.
n is the number of relevés
(Heltshe & Forrester, 1983)

Habitat and abundance data are not available for the species listed from the herbarium records, but the Quarter degree squares (QDSs) in which these species were collected, are listed in the final column (See Appendix 1).

Results & Discussion

The relevé data yielded 442 species. To these were added another 199 species from herbarium records, from 93 QDS's. These 641 species belong to 89 families, of which the three most diverse families are the Poaceae (98 species), Fabaceae (82 species) and Asteraceae (40 species). The full species list of this study area is presented in Appendix 1. Nomenclature and arrangement follows Klaassen & Kwembeya (2013).

The vegetation can be divided into two broad types, these being the "Sandveld", dominated by *Terminalia sericea* and *Combretum* species, and the "Hardeveld", comprised of a mixture of savannah dominated by *Acacia* species, Karstveld elements, wetland vegetation, and vegetation on shallow calcareous soils (Strohbach, submitted) (Figure 2). The "Hardeveld" mainly forms a fringe around the sand plains of the Kalahari (the Sandveld), but it also occurs in patches within this sand plateau. Typical "Hardeveld" elements are vleys, calcrete depressions and the *omirimbi* (Strohbach, submitted, 2008).

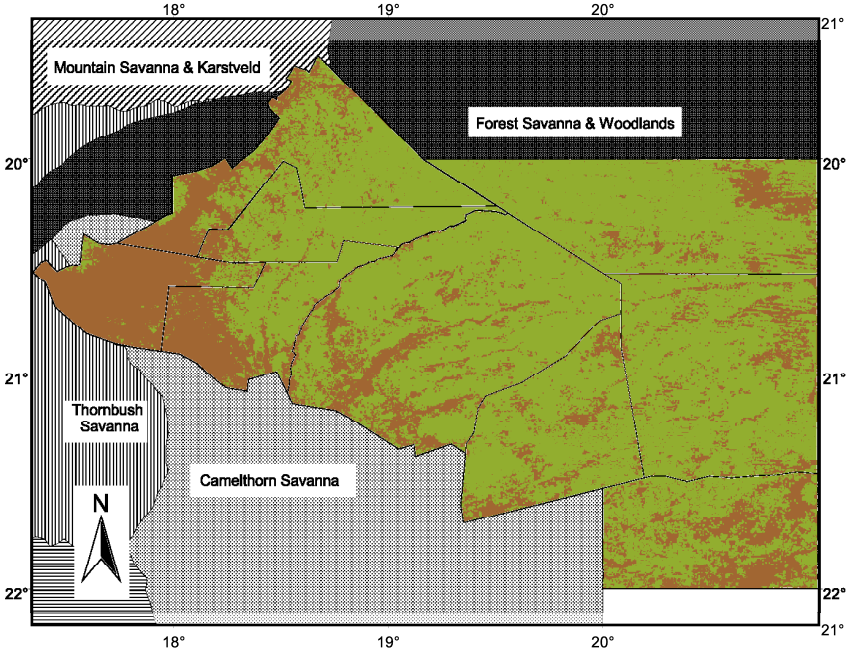

Figure 2. The "Sandveld" vegetation types in green and the "Hardeveld" types in brown, as mapped by Hüttich et al. (2009), in relation to the vegetation types as described by Giess (1998).

For the “Sandveld” vegetation types, a total of 305 species were observed, whilst it is estimated that at least 344 species could occur here. The “Sandveld” is also dominated by various Combretaceae (13.5 %), followed by the Poaceae (7.3 %) and Fabaceae (6.4%).

Conversely, the “Hardeveld” has a far higher diversity, with 404 observed species, and an estimated total of 444 species. These occur on diverse substrates, creating varied habitats and vegetation along the southern, western and north-western fringes, as well as in the far north-eastern parts where Karstveld elements occur in the Gam area. Here the Fabaceae dominate with 14.0 %, followed by the Anacardiaceae (12.4 %), Poaceae (11.6 %), Asteraceae (10.0 %) and Amaranthaceae (9.7 %). A detailed summary of species richness of the different vegetation associations is given in Table 1. The species composition of the different associations is presented in Strohbach (submitted) (see also Strohbach & Kutuahuripa, submitted).

Table 1. Observed and estimated species richness of various vegetation associations in the study area. ‘r’ is the median number of species per relevé, and ‘n’ the number of relevés sampled per association. These numbers have been used in the Jackknife procedure (Heltshe & Forrester, 1983) to obtain an estimate of the number of species per association.

Association		Observed	r	n	Estimated
1	*Acacio fleckii – Terminalietum prunioidis* thickets	92	30	17	120
2	*Acacio tortilis – Combretetum imberbis* woodlands	117	24	6	137
3	*Ptycholobio biflorum – Acacietum luederitzii* floodplain bushlands	107	46	6	145
4	*Eragrostio echinocloideae – Eriocephaloetum luederitziani* low shrublands	114	26	9	137
5	*Acacio melliferae - Catophractetum alexandri* shrublands	201	34	19	233
6	*Acacio melliferae – Hyphaenetum petersianae* thickets	143	43	8	181
7	*Panicum gilvum – Marsilea* vley community	26	26	1	26
8	*Eragrostio rigidioris - Urochloaetum brachyurae* grasslands	182	43	18	223
9	*Tarchonantho camphorati – Acacietum eriolobae* bushlands	176	44	24	218
10.1	*Rhigozo brevispinosi – Acacietosum melliferae* shrublands	203	45	30	247
10.2	*Stipagrostio uniplumis – Acacietosum melliferae* shrublands	214	37	30	250
11	*Terminalio sericeae – Acacietum eriolobae* bushlands	171	42	18	211
“Hardeveld” total		**404**	**40**	**186**	**444**
12.1	*Acacio melliferae – Terminalietosum sericeae* shrublands	222	46	90	267
12.2	*Grewio flavae – Terminalietosum sericeae* shrublands	196	42	45	237
12.3	*Combreto collini – Terminalietosum sericeae* bushlands	185	39	61	223
12.4	*Burkeo africanae – Terminalietosum sericeae* bushlands	145	32	40	176
13	*Terminalio sericieae* – Schinziophytetum rautanenii bushlands	95	34	6	123
14	*Burkeo africanae – Pterocarpetum angolensis* bushlands	101	36	16	135
“Sandveld” total		**305**	**39**	**265**	**344**
Grand total		**442**	**39**	**451**	**481**

The fact that roughly 31 % of the species recorded for the study area were not observed during the vegetation survey can be attributed to the survey being done at a reconnaissance level only, in which most of the azonal vegetation (e.g. vleys, etc.) were ignored or at best under sampled. Yet the collections in the National Herbarium of Namibia (WIND) are also incomplete, with 20 QDS’s not sampled, and a further 43 QDS’s severely under sampled with fewer than 10 species recorded from these. Only one QDS, 2017CB Okakarara, can be considered well sampled with 157 species recorded for the QDS (Figure 3). The total number of species observed during the survey, combined with those from herbarium collections, exceeds the estimated number by 160 species. This highlights the incompleteness of both the herbarium collections and vegetation survey. Combined, at least 680 species are expected for the study area.

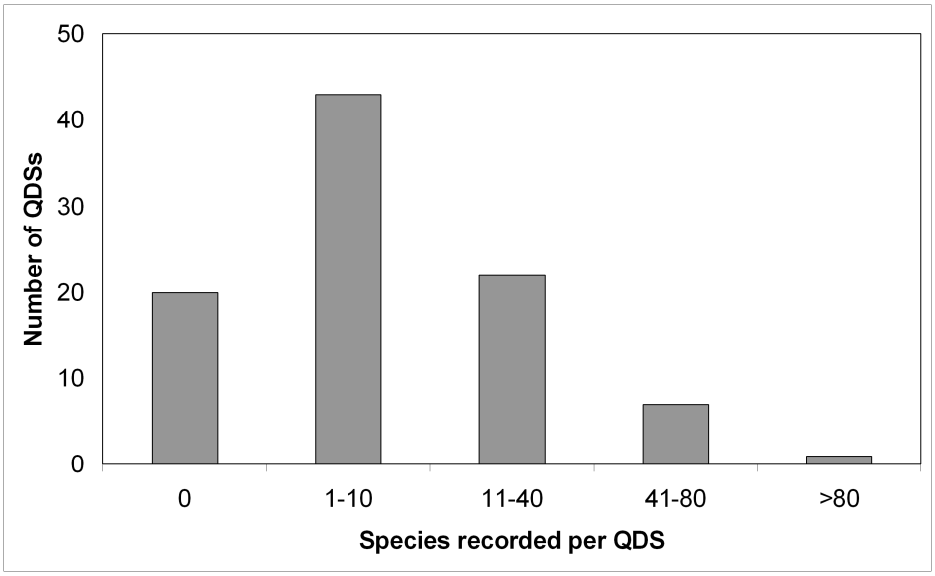

Figure 3. Distribution of collection intensity for the quarter degree squares (QDS's) within the study area.

Seventeen species are regarded as endemic (i.e. occurring only in Namibia), while an additional three species are near-endemic (i.e. occurring mostly in Namibia, with limited distribution in neighbouring countries). Only one species (*Pterocarpus angolensis*) is regarded as near-threatened due to over-exploitation (Loots, 2005), and 14 species are protected either under the Nature Conservation Ordinances (No's 37 of 1952 and 247 of 1977) or the Forestry Ordinance 37 of 1952 and Forestry Act 72 of 1968. The 23 alien species, of which three are regarded as weedy, and seven as invasive (i.e. of concern in habitat conservation) are of no conservation value.

Conclusion

Two aspects regarding the biodiversity come to mind whilst analysing the data:

(a) The study area is severely under sampled – both regarding relevés as well as herbarium records. This is evident from the fact that neither source provided a reasonably complete list of species, and even a combined list contained well under the estimated number of species.
(b) Even though the study area is under sampled, this study showed that the diversity is substantially higher than estimated (Mendelsohn *et al.* 2002). The approached followed by Craven (2001) of classifying the diversity as "low-medium" is thus more appropriate. However, without comparative figures from similar studies elsewhere, it is difficult to judge exactly in what category this vegetation should be classed.

From the above it is clear that the initial survey done in 2004 needs to be intensified and expanded to get a full picture of species diversity in the area, and to manage the resource optimally.

The species diversity, as expressed in numbers of species or numbers of protected / endangered / endemic species, will, however, have little bearing on the overall need for conservation of this vegetation. Although we know little about the ecosystem functioning in this area, the poor nutritional status of the sandy soils (Strohbach & Kutuahuripa, submitted; Baillieul, 1975; Dougill & Thomas, 2004; Wang *et al.* 2007) may result in negative feedback loops associated with decreasing vegetative cover (Schlesinger *et al.* 1990). Such a compounding effect is predicted to lead to a rapid degradation of the vegetation and an ultimate remobilisation of the surface sands (i.e. leading to the formation of a true desert) (Midgley *et al.* 2005; Thomas *et al.* 2005). Thus measures by the Directorate of Forestry to curb illegal harvesting of wood (Hofmann, 2013) are

encouraging, and need to be implemented far more rigorously. Large-scale harvesting of shrubs for biofuel must also be avoided.

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Appendix 1

Annotated species list for the eastern communal conservancy areas Otjituuo, Okamatapati, Ozonahi, African Wilddog, Otjinene, Epukiro, Otjombinde, Omuramba Ua Mbinda, Eiseb and Ondjou, as well as the adjacent Otjinene and Epukiro farming areas

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
Pteridiophyta													
Aspleniaceae													
	Asplenium cordatum			cr	mi	ve	is	fi					2017BC
Dennstaedtiaceae													
	Microlepia speluncae			cr	pl	ve	is	fi					2017CB
Marsileaceae													
	Marsilea macrocarpa		hl	cr/hy	mi	la	is/de			rare		occasional	
	Marsilea nubica var. *gymnocarpa*		hl	cr/hy	mi	la	is/de			rare		occasional	
	Marsilea unicornis			cr/hy	mi	la	is/de						2017CB
	Marsilea vera			cr/hy	mi	la	is/de						1918CD, 2118AB
	Marsilea villifolia			cr/hy	mi	la	is/de						2018CB
Ophioglossaceae													
	Ophioglossum polyphyllum		geo	hc	na	ve	is/de			occasional	rare	occasional	
Angiospermae - Monocotyledonae													
Amaryllidaceae													
	Ammocharis coranica		hl	cr	me	la	is/de	ro/pv		rare		occasional	
	Boophane disticha		hl	cr	me	ve	is/de	ro/pv		rare		rare	
	Nerine laticoma		geo	cr	No	la	is/de	pv		rare		occasional	
Anthericaceae													
	Chlorophytum anceps			cr	mi	ve	is	pv					2020AD
Aponogetonaceae													
	Aponogeton desertorum			cr	me	ve	is	pv	hy				2118AB

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
Arecaceae													
	Hyphaene petersiana		t2/ s1	ph	Mg	la	is	sc		rare		common	
Asparagaceae													
	Asparagus cooperi		s2	ch	Pi	ve	is	ro		common	common	occasional	
	Asparagus nelsii		s2	ch	Pi	ve	is	ro		common	common	occasional	
	Asparagus suaveolens		s2	ch	Pi	ve	is	ro		occasional	occasional	occasional	
Asphodelaceae													
	Aloe hereroensis	P/CII	s2	ch	Pl	ve	is	ro/so / su		rare		common	
	Aloe zebrina	P/CII		ch	Pl	la	is	ro/so / su					2020AB
	Trachyandra laxa		hl	hc	mi	ve	is	pv			rare	occasional	
Colchicaceae													
	Androcymbium roseum			cr	mi	ve	is	pv					2020BD, 2017CB
	Camptorrhiza strumosa			cr	mi	ve	is	pv					2118AA
	Gloriosa superba		geo	cr	mi	la	is/de	pv		rare	rare	rare	
	Ornithoglossum vulgare		geo	cr	no	ve	is/de	pv		rare	rare	occasional	
Commelinaceae													
	Commelina africana var. *krebsiana*		hl	th	mi	la	is	pv		occasional	common	occasional	
	Commelina benghalensis		hl	th	mi	la	is	pv		occasional	rare	occasional	
	Commelina forskaolii		hl	th	mi	la	is	pv		rare	rare	common	
	Commelina livingstonii		hl	th	mi	la	is	pv		rare	rare	occasional	
	Commelina sublobata			cr	na	la	is	pv					2020AD, 2118AA, 2017CB
Cyperaceae													
	Bulbostylis hispidula		hl	th	na	ve	is	pv		common	common	occasional	
	Courtoisina assimilis			th	mi	co	is	pv					2118AB, 2017CB
	Cyperus amabilis		hl	th	na	ve	is	pv		rare	rare	occasional	
	Cyperus compressus			th	mi	ve	is	pv					2017CB

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Cyperus difformis			th	mi	ve	is	pv					2118AB, 2017CB
	Cyperus fulgens		hl	cr	mi	ve	is/de	pv		rare	rare	occasional	
	Cyperus longus var. *tenuiflorus*			cr	no	co	is	pv					2017CB
	Cyperus margaritaceus		hl	hc	mi	ve	is	pv		rare	occasional	rare	
	Eleocharis atropurpurea			th	mi	ve	is	pv					2118AB
	Fuirena pubescens var. *pubescens*			cr	mi	ve	is	pv					2020DB
	Kyllinga alba		hl	hc	mi	ve	is	pv		rare	rare	rare	
	Mariscus confusus		hl	cr	mi	ve	is/de	pv		rare	occasional	rare	
	Pycreus chrysanthus			cr	mi	ve	is	pv					2017CB, 2018CB
	Pycreus macrostachyos		hl	th	no	ve	is	pv		rare		common	
	Schoenoplectiella leucantha			th	na	ve	is	pv					2118AB
	Schoenoplectiella praelongata			th	mi	ve	is	pv	hy				2017CB
	Schoenoplectus muricinux		hl	th/hy	mi	ve	is	pv		rare		occasional	
	Schoenoplectus senegalensis		hl	th/hy	mi	ve	is	pv		rare		occasional	
Dracaenaceae													
	Sansevieria aethiopica		s2	hc	pl	ve	is	ro/so /pv		occasional	occasional	occasional	
	Sansevieria pearsonii		s2	hc	pl	ve	is	ro/so / su/pv		rare		occasional	
Eriocaulaceae													
	Eriocaulon cinereum			th	le	co	is	pv	hy				2020AD
Eriospermaceae													
	Eriospermum mackenii subsp. *galpinii*			cr	mi	ve	is	pv					2017CB
Hyacinthaceae													
	Albuca abyssinica			cr	mi	ve	is	pv					2019CD
	Dipcadi glaucum			cr	pl	ve	is	pv					2018AA
	Dipcadi longifolium			cr	mi	co	is	pv					1918DB
	Dipcadi marlothii		hl	cr	mi	ve	is/de	Pv		rare	rare	rare	

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					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Drimia sanguinea			cr	mi	ve	is	pv					2018AD, 2018CA, 2018CD, 2118AB
	Ledebouria revoluta			cr	me	ve	is	pv					2019BC
	Ledebouria undulata		geo	cr	mi	la	is/de	pv		rare		occasional	
	Pseudogaltonia clavata		geo	cr	me	ve	is/de	ro/pv		rare	rare	rare	
Hydrocharitaceae													
	Lagarosiphon muscoides			hc	le	la	is	pv	hy				2020AD
	Ottelia ulifolia			th	no	ve	is	pv	hy				2118AB
Iridaceae													
	Babiana hypogea var. *hypogea*			cr	mi	ve	is	pv					2120CC
	Ferraria glutinosa			cr	mi	ve	is	pv					2017DA
	Gladiolus magnificus			cr	no	ve	is	pv					1918DA, 2020AD
	Lapeirousia bainesii		geo	cr	mi	la	is/de	pv		occasional	rare	occasional	
	Lapeirousia coerulea			cr	mi	ve	is	pv					2017CB
	Lapeirousia odoratissima		geo	cr	mi	la	is/de	pv			rare	occasional	
Orchideaceae													
	Eulophia speciosa	P/CII		cr	no	ve	is	pv/su					2017BC
Poaceae													
	Andropogon gayanus var. *polycladus*			hc	mi	ve	is	pv					2020AD
	Anthephora pubescens		gp	hc	mi	ve	is	pv		rare	occasional	occasional	
	Aristida adscensionis		ga	th	mi	co	is	pv		common	rare	common	
	Aristida congesta subsp. *congesta*		gp	hc	mi	co	is	pv		common	common	common	
	Aristida effusa		ga	th	mi	co	is	pv		occasional	rare	common	
	Aristida hordeacea			th	mi	ve	is	pv					2017CB
	Aristida meridionalis		gp	hc	mi	co	is	pv		rare	occasional	common	
	Aristida pilgeri		gp	hc	mi	co	is	pv		rare	rare	occasional	
	Aristida rhiniochloa		ga	th	mi	co	is	pv		occasional	rare	common	
	Aristida stipitata		ga	th	mi	co	is	pv		rare	common	occasional	

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	Aristida stipoides		ga	th	mi	co	is	pv		occasional	rare	common	
	Brachiaria deflexa		ga	th	mi	co	is	pv		occasional		occasional	
	Brachiaria eruciformis			th	na	ve	is	pv					2017CB
	Brachiaria grossa			th	mi	ve	is	pv					2017CB
	Brachiaria malacodes			th	mi	co	is	pv					1918DA
	Brachiaria marlothii		ga	th	mi	co	is	pv		rare		common	
	Brachiaria nigropedata		gp	hc	mi	ve	is	pv		occasional	occasional	common	
	Cenchrus biflorus			th	mi	co	is	pv					2119BD
	Cenchrus ciliaris		gp	hc	mi	co	is	pv		occasional		common	
	Chloris virgata		ga	th	mi	co	is	pv		occasional		common	
	Cymbopogon caesius		gp	hc	mi	co	is	pv		rare		occasional	
	Cymbopogon pospichilii		gp	hc	mi	co	is	pv		rare		occasional	
	Cynodon dactylon	Weed	gp	hc	na	ve	is	pv		rare		common	
	Dactyloctenium aegyptium		ga	th	mi	co	is	pv		occasional		occasional	
	Dactyloctenium giganteum		ga	th	mi	co	is	pv		rare	rare	common	
	Diandrochloa pusilla		ga	th	mi	ve	is	pv		rare		common	
	Digitaria milanjiana			hc	na	ve	is	pv					2119AB
	Digitaria seriata		gp	hc	mi	ve	is	pv		occasional	common	occasional	
	Digitaria velutina		ga	th	mi	co	is	pv		rare	rare	occasional	
	Dinebra retroflexa var. *condensata*			th	mi	co	is	pv					2017CB
	Echinochloa holubii			hc	mi	co	is	pv	hy				2118AA, 2017CB
	Elionurus tripsacoides		s2	hc	mi	co	is	pv			rare	occasional	
	Elytrophorus globularis			th	mi	ve	is	pv	hy				1918CD, 2118AB, 2017CB
	Enneapogon cenchroides		ga	th	mi	co	is	pv		occasional	rare	common	
	Enneapogon desvauxii		ga	th	le	ve	is	pv		occasional		common	
	Enneapogon scoparius		gp	hc	mi	co	is	pv		rare		occasional	
	Eragrostis annulata		ga	th	mi	co	is	pv		rare		occasional	

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					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Eragrostis aspera		ga	th	mi	co	is	pv		rare		occasional	
	Eragrostis biflora		ga	th	mi	co	is	pv		occasional	rare	occasional	
	Eragrostis cylindriflora		ga	th	mi	co	is	pv		rare		occasional	
	Eragrostis dinteri		ga	th	mi	ve	is	pv		common	common	common	
	Eragrostis echinochloidea		gp	hc	mi	co	is	pv		rare		common	
	Eragrostis glandulosipedata			th	na	co	is	pv					2119AB
	Eragrostis jeffreysii		gp	hc	mi	co	is	pv		rare	occasional	occasional	
	Eragrostis lehmanniana		gp	hc	mi	co	is	pv		occasional	common	common	
	Eragrostis nindensis		gp	hc	na	ve	is	pv		occasional	rare	occasional	
	Eragrostis omahekensis	En	ga	th	mi	co	is	pv		occasional	occasional	common	
	Eragrostis pallens		gp	hc	mi	co	is	pv		rare	common	occasional	
	Eragrostis pilgeriana		ga	th	na	la	is	pv		rare		common	
	Eragrostis porosa		ga	th	mi	co	is	pv		common	occasional	common	
	Eragrostis rigidior		gp	hc	mi	co	is	pv/sc		common	common	common	
	Eragrostis rotifer		ga	th	mi	co	is	pv		rare		common	
	Eragrostis trichophora		gp	hc	mi	co	is	pv		common	occasional	common	
	Eragrostis truncata		gp	hc	na	ve	is	pv		rare		common	
	Eragrostis viscosa		ga	th	mi	co	is	pv		occasional	rare	occasional	
	Eriochloa fatmensis			th	mi	co	is	pv					2017CB
	Fingerhuthia africana			hc/(th)	na	co	is	pv					2118AB, 2017CB
	Heteropogon contortus		gp	hc	mi	co	is	pv		rare		common	
	Imperata cylindrica			hc/cr	no	ve	is	pv					2020BA
	Megaloprotachne albescens		ga	th	mi	co	is	pv		occasional	common	common	
	Melinis repens subsp. *grandiflora*		ga	th	mi	co	is	pv		common	common	common	
	Melinis repens subsp. *repens*		gp	hc	mi	co	is	pv		rare	common	occasional	
	Microchloa caffra		gp	hc	na	ve	is	pv		rare		rare	
	Oropetium capense		gp	hc	le	ve	is	pv		rare		occasional	
	Oryzidium barnardii			hc	mi	co	is	pv	hy				2017CB

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	Panicum coloratum		gp	hc	mi	ve	is	pv		rare	rare	common	
	Panicum gilvum		ga	hc/hy	mi	ve	is	pv		rare		common	
	Panicum kalaharense		gp	hc	mi	co	is	pv		rare	occasional	occasional	
	Panicum lanipes		gp	hc	mi	ve	is	pv		rare		occasional	
	Panicum maximum		gp	hc	mi	co	is	pv		occasional	rare	occasional	
	Panicum pilgerianum			th	mi	co	is	pv	hy				1918CD
	Panicum simulans	En		th	mi	co	is	pv					2017CB
	Perotis patens		ga	th	mi	co	is	pv		rare	rare	rare	
	Pogonarthria fleckii		ga	th	mi	co	is	pv		common	occasional	common	
	Pogonarthria squarrosa		gp	hc	mi	ve	is	pv		rare	common	occasional	
	Schmidtia kalihariensis		ga	th	mi	la	is	pv		rare		occasional	
	Schmidtia pappophoroides		gp	hc	mi	la	is	pv		common	common	common	
	Setaria pumila		ga	th	mi	co	is	pv		rare		rare	
	Setaria sagitifolia		ga	th	mi	co	is	pv		rare		occasional	
	Setaria verticillata		ga	th	mi	co	is	pv		occasional		occasional	
	Sorghum halepense	weed		hc	mi	co	is	pv					2017CB
	Sporobolus fimbriatus		gp	hc	mi	co	is	pv		rare		occasional	
	Sporobolus ioclados		gp	hc	mi	co	is	pv		rare		common	
	Sporobolus panicoides		ga	th	mi	co	is	pv		rare		occasional	
	Stipagrostis anomala			hc/th	na	co	is	pv					1918DD
	Stipagrostis hirtigluma		ga	th	mi	co	is	pv		rare		occasional	
	Stipagrostis uniplumis var. *uniplumis*		gp	hc	mi	co	is	pv		common	wide-spread	common	
	Tragus berteronianus		ga	hc	mi	ve	is	pv		common	rare	occasional	
	Tragus racemosus		ga	th	na	la	is	pv		occasional	rare	occasional	
	Tricholaena monachne		ga	th	mi	co	is	pv		rare	occasional	rare	
	Trichoneura grandiglumis		ga	th	na	la	is	pv		rare		common	
	Triraphis purpurea		ga	th	mi	co	is	pv		occasional	rare	common	

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					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Triraphis schinzii		gp	hc	mi	co	is	pv		rare	occasional	rare	
	Urochloa brachyura		ga	th	mi	co	is	pv		common	common	common	
	Urochloa mosambicensis			hc	mi	co	is	pv					2017CB
	Urochloa oligotricha			hc	no	co	is	pv					2017CB
	Urochloa trichopus			th	mi	co	is	pv					2017CB
	Willkommia sarmentosa			hc	na	co	is	pv					2017CB
Tecophilaeaceae													
	Walleria nutans		geo	cr	na	ve	is	pv		occasional	occasional	occasional	
Velloziaceae													
	Xerophyta humilis		hl	cr	na	ve	is	ro		rare		occasional	
Angiospermae - Dicotyledonae													
Acanthaceae													
	Barleria albi-pilosa		hl	ch	Mi	pe	is/de			rare		rare	
	Barleria kaloxytona	En		ch	mi	ve	is						1918DA
	Barleria lanceolata	En	s2	ch	mi	pe	is/de			rare		occasional	
	Barleria lancifolia		hl	ch	mi	pe	is/de			rare		occasional	
	Barleria macrostegia		hl	ch	mi	pe	is/de			occasional	rare	occasional	
	Barleria senensis		hl	ch	mi	pe	is/de			occasional		occasional	
	Blepharis diversispina			ch	na	ve	is						2017DA, 2017BC, 2017DD, 2020BD, 2020CC, 2119AA, 2019CD, 2019DA, 2119AB, 2017CB, 2018CB
	Blepharis integrifolia		hl	th	mi	la	is			occasional	rare	occasional	
	Blepharis maderaspatensis		hl	th	mi	la	is			rare	rare	rare	
	Blepharis mitrata			th	na	ve	is						2120DC
	Blepharis obmitrata		hl	th	mi	la	is			occasional	occasional	occasional	

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	Hypoestes forskaolii		hl	th	mi	la	is			rare	rare	common	
	Justicia betonica			ph	no	pe	is						2017CB
	Justicia exigua			th	na	ve	is						2118AB, 2017CB
	Justicia odora		s2	ch	mi	la	is			rare		common	
	Monechma debile		hl	th	mi	la	is			rare	rare	occasional	
	Monechma divaricatum		hl	th	mi	la	is			occasional	rare	occasional	
	Peristrophe hereroensis	En	hl	hc	mi	la	is/de			rare		occasional	
	Petalidium engleranum		s2	ch	mi	la	do			rare		occasional	
	Ruellia species		hl	th	mi	la	is			rare		rare	
	Ruelliopsis damarensis	En		ch	na	ve	is						2118AA, 2118AB
	Thunbergia aurea		hl	th/li	mi	la	is				rare	common	
Aizoaceae													
	Aizoon virgatum		s2	ch	na	la	is	sc		rare		occasional	
	Galenia secunda			ch	le	is	ve	Su					2120DD
	Plinthus sericeus		hl	cr	mi	la	is			rare		occasional	
	Tetragonia calycina			ch	na	la	is	su					2017CB
	Trianthema parvifolia			th	le	la	is	su					2119AB
Amaranthaceae													
	Achyranthes aspera var. *aspera*	Nat		ch	no	la	is						2017DA, 2017BC, 2118AB
	Achyranthes aspera var. *sicula*	Nat	hl	th	mi	la	is			occasional	rare	occasional	
	Aerva leucura		s2	ch	mi	la	do			rare		occasional	
	Alternanthera nodiflora	Nat		th	na	la	is						2017CB
	Alternanthera pungens	Nat	hl	th	mi	la	is			rare		occasional	
	Amaranthus thunbergii		hl	th	mi	la	is			rare	rare	occasional	
	Guilleminea densa		hl	th	mi	la	is			rare		common	
	Hermbstaedtia argenteiformis			th	mi	ve	is						2017DA, 2018BD
	Hermbstaedtia fleckii		hl	th	mi	la	is				rare	occasional	

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	Hermbstaedtia linearis			th	na	ve	is						2020AD, 2118AB
	Hermbstaedtia odorata		hl	th	mi	la	is			occasional	rare	occasional	
	Hermbstaedtia scabra			th	mi	ve	is						1918DC
	Kyphocarpa angustifolia		hl	th	mi	la	is			common	occasional	occasional	
	Leucosphaera bainesii		s2	ch	mi	la	do			rare		common	
	Nelsia quadrangula			th	mi	la	is						2119AB
	Pupalia lappacea	Nat	hl	th	mi	la	is			common	rare	occasional	
	Sericorema remotiflora		hl	th	le	la	is			rare	rare	occasional	
	Sericorema sericea		hl	th	le	la	is			occasional		occasional	
Anacardiaceae													
	Lannea discolor		t3	ph	no	la	do/de				rare	occasional	
	Ozoroa crassinervia			ph	no	la	do/de						2120CA
	Ozoroa insignis			ph	la	do	de/do						2120CA
	Ozoroa paniculosa		s1	ch	no	la	do/de			occasional	occasional	common	
	Ozoroa schinzii	NEn	s1	ch	no	la	do/de				rare	common	
	Searsia marlothii		s1	ph	no	la	is			rare	rare	occasional	
	Searsia tenuinervis		s1/2	ch	no	la	is			common	occasional	occasional	
Annonaceae													
	Annona stenophylla subsp. *nana*			ch	no	ve	is						2020AD
Apiaceae													
	Deverra burchellii			ch	mi	ve	is						2017DA
	Steganotenia aralacea		t3/ s1	ph	me	la	is/de	fi			rare	common	
Apocynaceae													
	Baissea wulfhorstii		hl	cr/li	no	la	is	fi			occasional	common	
	Brachystelma cupulatum			cr	na	ve	is						2118AB
	Ceropegia lugardiae	P	geo	ch/li	mi	la	is	su			rare	occasional	

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	Cryptolepis oblongifolia			ch	na	ve	is						2018BA, 2019AB, 2019AC
	Cynanchum orangeanum		geo	cr	mi	la	is/de	fi		rare		occasional	
	Diplorhynchus condylocarpon		s1	ph	no	pe	is				rare	common	
	Fockea angustifolia		geo	cr	mi	la	is/de	sc		rare	rare	occasional	
	Gomphocarpus tomentosus		hl	ch	mi	ve	do			rare	rare	occasional	
	Marsdenia sylvestris		s1	ph/li	no	la	is			rare		occasional	
	Orthanthera jasminiflora			cr	mi	la	is						1918DC
	Pentarrhinum insipidum			th	mi	pe	is						1918DA
	Pergularia daemia		hl	ch/li	no	la	is			occasional	occasional	occasional	
	Raphionacme velutina		geo	cr	mi	la	is/de			occasional	occasional	occasional	
	Sarcostemma viminale		s2	ch/li	pl	ve	is	so/su		occasional	occasional	occasional	
	Tavaresia barklyi	P	hl	ch	pl	ve	is	so/su		rare	rare	rare	
Asteraceae													
	Acanthospermum hispidum	Inv	hl	th	mi	la	is			rare	rare	occasional	
	Bidens biternata	Inv	hl	th	mi	la	is			rare	rare	rare	
	Bidens pilosa	Inv	hl	th	mi	la	is					rare	
	Calostephane divaricata		hl	th	mi	ve	is			rare		occasional	
	Conyza aegyptiaca			th	na	la	is						2017CB
	Conyza albida	Inv		hc	na	la	is						2019CB, 2019DA
	Cotula anthemoides			th	na	co	is						2017CB
	Dicoma schinzii		hl	th	mi	la	do			common	common	occasional	
	Dicoma tomentosa		hl	th	mi	ve	do			occasional	rare	occasional	
	Emilia ambifaria			th	mi	ve	is	su					2020BB, 2017CB
	Eriocephalus luederitzianus		s2	ch	pi	la	is	sc		rare		occasional	
	Erlangea misera		hl	th	mi	la	is			rare	rare	occasional	
	Felicia anthemidodes			th	na	ve	is						2119AB
	Felicia clavipilosa subsp. *clavipilosa*		s2	th	le	la	is			occasional	rare	occasional	

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Felicia muricata subsp. *muricata*			ch	le	ve	is						2120CC, 2119AB
	Felicia smaragdina	En		th	le	co	is						2017CB
	Flaveria bidentis	Inv	hl	th	mi	la	is			rare		occasional	
	Geigeria odontoptera	En		th	mi	la	is						2018BD
	Geigeria ornativa		hl	th	mi	ve	is			occasional	rare	occasional	
	Geigeria schinzii subsp. *schinzii*			hc	mi	co	is						2017CB
	Helichrysum argyrosphaerum		hl	th	na	la	do			rare		occasional	
	Helichrysum candolleanum		hl	th	na	la	do				rare	occasional	
	Helichrysum cerastioides			hc	na	co	is						2119AA
	Helichrysum lineare			hc	le	co	is						2018BA
	Hirpicium gazanioides		hl	th	mi	la	is			occasional	rare	occasional	
	Kleinia longiflora		s2	ch	me	ve	is	so/su		common	occasional	occasional	
	Laggera decurrens			hc	na	co	is						2020CA, 2119AB, 2017CB
	Nicolasia nitens var. *nitens*			th	na	co	is						2017CB
	Nidorella resedifolia			th	na	ve	is						1918DC, 2017CB, 2018BD, 2018CB, 2019BC, 2019CD, 2020CA
	Nolletia gariepina		hl	ch	le	la	is				rare	occasional	
	Nolletia tenuifolia	En	s2	ch	le	la	is			rare	rare	occasional	
	Pegolettia senegalensis		hl	th	le	la	is			rare	rare	occasional	
	Pentzia calcarea			ch	le	la	is						2017BC
	Pentzia pinnatisecta			ch	na	ve	is						2119DA
	Philyrophyllum schinzii			hc	mi	la	is						2017DA, 2020AD
	Polydora poskeana		hl	th	na	ve	do			common	common	common	
	Sphaeranthus peduncularis subsp. *rogersii*			hc	na	ve	is						2017CB
	Tagetes minuta	Inv	hl	th	mi	la	is	fi		rare		occasional	

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					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Tarchonanthus camphoratus		s1	ph	no	ve	do			occasional	occasional	common	
	Vernonia fastigiata		hl	th	na	ve	do			rare		occasional	
Bignoniaceae													
	Catophractes alexandri		s1	ph	mi	la	do			occasional	rare	common	
	Rhigozum brevispinosum		s1	th	na	la	is			common	common	common	
Boraginaceae													
	Ehretia alba		s1	ch	mi	la	is/de	sc		common	occasional	occasional	
	Heliotropium ciliatum			hc	na	la	is						2017CB, 2018BD, 2118AA, 2120CA
	Heliotropium marifolium		hl	th	na	la	do			rare		rare	
	Heliotropium nelsonii			hc	na	la	is						2017DA
	Heliotropium ovalifolium		hl	ph	mi	la	is			rare		occasional	
	Heliotropium steudneri		hl	th	na	la	do			occasional	occasional	occasional	
	Heliotropium strigosum subsp. *strigosum*			th	na	la	is						1918DA
Brassicaceae													
	Lepidium africanum subsp. *divaricatum*			hc	na	la	is						2119AB
	Lepidium desertorum			th	na	la	is						2119AB
Burseraceae													
	Commiphora africana		s1	ch	no	la	is/de	ct		occasional	occasional	occasional	
	Commiphora angolensis		s1	ch	mi	la	is/de	ct		common	common	common	
	Commiphora glandulosa			ph	mi	co	is	ct					1918CD
	Commiphora pyracanthoides		t3	ph	mi	la	is/de	ct		common	rare	common	
	Commiphora tenuipetiolata		s2	ph	no	la	is/de	ct		rare	rare	common	
Cactaceae													
	Opuntia species	Inv	s2	ch	pl	ve	is	so/su		rare		occasional	

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Capparaceae													
	Boscia albitrunca	F	t3	ph	mi	la	is	sc		common	common	common	
	Boscia foetida		s1	ph	na	la	is	sc		rare		common	
	Cleome angustifolia subsp. *petersiana*			th	le	la	is						2020CA
	Cleome gynandra			th	mi	la	is						2017CB, 2018CB
	Cleome monophylla			th	mi	la	is						2018CB
	Cleome oxyphylla			th	mi	la	is						1918CD
	Cleome rubella		hl	th	na	la	is			common	common	occasional	
	Maerua juncea		s2	ph	mi	pe	is	sc		rare	rare	occasional	
	Maerua schinzii	F	t3/ s1	ph	mi	la	is			rare		occasional	
Caryophyllaceae													
	Pollichia campestris		s2	ch	le	la	is			common	occasional	occasional	
	Polycarpaea corymbosa		hl	th	le	la	is			rare		rare	
Celastraceae													
	Elaeodendron transvaalense		t3	ph	mi	la	is	sc		rare		common	
	Gymnosporia buxifolia		s1	ch	mi	la	is	sc		rare		occasional	
	Gymnosporia senegalensis		s1	ch	mi	la	is	sc		occasional	rare	common	
	Salacia luebbertii		geo	cr	me	la	do/de	fi			occasional	common	
Chenopodiaceae													
	Chenopodium petiolariforme		hl	th	mi	la	is			rare		occasional	
	Chenopodium pumilio	Nat	hl	th	na	la	is			rare		occasional	
	Salsola tuberculata		s2	ch	pi	la	is	ro		rare		common	
Combretaceae													
	Combretum apiculatum subsp. *apiculatum*		s1	ph	no	la	is			rare	rare	occasional	
	Combretum apiculatum subsp. *leutweinii*			ph	no	la	is						2017CB
	Combretum collinum		t3	ph	no	la	is/de			occasional	common	common	
	Combretum engleri		s1	ph	mi	la	is/de			rare	occasional	rare	

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	Combretum hereroense		s1	ph	mi	la	do/de			occasional	rare	common	
	Combretum imberbe		t2	ph	mi	la	do			rare		common	
	Combretum psidioides		t3/ s1	ph	mi	la	is/de				common	common	
	Combretum zeyheri		t2/3	ph	no	la	is				rare	common	
	Terminalia prunioides		t1-s1	ph	mi	la	is/de			occasional		common	
	Terminalia sericea		s1	ph	no	la	do/de			occasional	wide-spread	common	
Convolvulaceae													
	Evolvulus alsinoides		hl	th	na	la	is			common	common	occasional	
	Ipomoea adenioides		s2	ch	no	la	is/de	sc		rare		occasional	
	Ipomoea bolusiana		hl	cr/li	mi	la	is/de			occasional	occasional	occasional	
	Ipomoea chloroneura		hl	th	mi	la	is			occasional	common	common	
	Ipomoea coptica		hl	th/li	mi	la	is			occasional	rare	occasional	
	Ipomoea coscinosperma		hl	cr/li	mi	la	is/de			rare		rare	
	Ipomoea crassipes		hl	cr/li	mi	la	is/de			rare		rare	
	Ipomoea hackeliana		hl	th/li	mi	la	is			occasional	common	common	
	Ipomoea hochstetteri		hl	th/li	mi	la	is			rare	rare	occasional	
	Ipomoea holubii			ch/li	mi	pe	is						1918DC
	Ipomoea magnusiana		hl	cr/li	mi	la	is/de			occasional	common	occasional	
	Ipomoea oblongata		hl	cr/li	no	la	is/de			occasional	rare	common	
	Ipomoea obscura		hl	th/li	mi	la	is			occasional	common	occasional	
	Ipomoea sinensis subsp. *blepharosepala*		hl	th/li	mi	la	is			rare		common	
	Ipomoea verbascoidea		hl	ch/li	no	la	do/de			rare	occasional	occasional	
	Ipomoea welwitschii		hl	cr/li	no	la	do/de	sc		rare	rare	occasional	
	Jacquemontia tamnifolia		hl	th/li	mi	la	is			rare	rare	occasional	
	Merremia palmata			hc/li	no	la	is						2020AD
	Merremia verecunda		hl	cr/li	mi	la	is/de			common	common	occasional	
	Seddera suffruticosa		s2	th	na	la	is			occasional		occasional	

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	Xenostegia tridentata subsp. *angustifolia*		hl	th/li	mi	la	is			occasional	common	occasional	
Crassulaceae													
	Kalanchoe brachyloba		hl	ch	no	la	is	su		rare		occasional	
	Kalanchoe lanceolata		hl	th	mi	la	is	su		occasional	rare	occasional	
	Kalanchoe rotundifolia		hl	th	mi	la	is	su		rare		occasional	
Cucurbitaceae													
	Acanthosicyos naudinianus		hl	cr/li	no	la	is/de			common	common	common	
	Citrullus lanatus		hl	th/li	me	la	is			occasional	occasional	occasional	
	Coccinia sessilifolia			hc/li	no	ve	is						2020CA
	Corallocarpus bainesii			hc/li	no	ve	is	su					1918DA, 2019DC
	Corallocarpus schinzii			hc/li	mi	pe	is	su					2018CB, 2020CA
	Corallocarpus triangularis		hl	cr/li	mi	la	is/de			rare	rare	occasional	
	Cucumis africanus		hl	th/li	no	la	is			rare	rare	occasional	
	Cucumis anguria var. *longaculeatus*			th/li	no	la	is						2020CA
	Cucumis humifructus			th/li	me	la	is						1918DA
	Cucumis kalahariensis		hl	th/li	no	la	is			rare	rare	occasional	
	Cucumis meeusei		hl	th/li	no	la	is			rare		occasional	
	Dactyliandra welwitschii		hl	th/li	mi	la	is			rare		rare	
	Momordica balsamina		hl	cr/li	mi	la	is/de			occasional	common	occasional	
	Trochomeria debilis		hl	cr/li	no	la	is/de			rare	rare	occasional	
	Trochomeria macrocarpa subsp. *vitifolia*		hl	cr/li	no	la	is/de			rare		rare	
	Zehneria marlothii		hl	th/li	mi	la	is			rare	rare	occasional	
Dichapetalaceae													
	Dichapetalum cymosum		s2	cr	no	ve	is			rare	occasional	occasional	
Ebenaceae													
	Diospyros lycioides		s1	ch	mi	la	do			rare	rare	occasional	

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					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Euclea undulata			ph	na	ve	is						2017DA
Euphorbiaceae													
	Acalypha ciliata			th	mi	la	is						2017CB
	Acalypha indica		hl	th	mi	la	is			rare		occasional	
	Acalypha segetalis		hl	th	mi	la	is			rare	rare	occasional	
	Cephalocroton mollis		s2	ch	no	la	is/de			occasional	rare	occasional	
	Croton gratissimus		s1	ph	no	pe	do			occasional	common	common	
	Euphorbia austro-occidentalis			hc	le	la	is						1918DD, 2020AD, 2019AC, 2019DA, 2119AB
	Euphorbia crotonoides		hl	th	na	la	is				rare	occasional	
	Euphorbia forskalii		hl	th	le	la	is			rare	rare	rare	
	Euphorbia hirta			th	na	la	is						2017CB
	Euphorbia inaequilatera		hl	th	mi	la	is			common	occasional	occasional	
	Euphorbia prostrata	weed		th	le	la	is						2119DA
	Euphorbia spartaria	En	s2	ch	no	ve	is	so/su		rare	rare	common	
	Flueggea virosa subsp. *virosa*			ph	na	la	is						2017BC, 2017CB
	Jatropha erythropoda		hl	cr	mi	la	is/de			rare	rare	rare	
	Phyllanthus maderaspatensis		hl	hc	na	la	is			occasional	rare	occasional	
	Phyllanthus omahekensis		hl	th	na	la	is			rare	occasional	rare	
	Phyllanthus pentandrus		hl	th	na	la	is			common	common	occasional	
	Schinziophyton rautanenii		t1	ph	ma	la	do/de				rare	common	
	Tragia dioica		hl	th/li	mi	la	is			occasional	occasional	occasional	
	Tragia lancifolia	En		ch	mi	la	is						2017CB, 2019AC
	Tragia okanyua		hl	th/li	mi	la	is			rare		rare	
Fabaceae													

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Acacia ataxacantha		s1	ph	no	la	is/de	fi		rare	common	common	
	Acacia erioloba	F	t2	ph	mi	la	is/de	fi		common	occasional	common	
	Acacia erubescens			ph	na	pe	is	de					2020BB
	Acacia fleckii		t3	ph	no	la	is/de	fi		common	common	common	
	Acacia hebeclada subsp. *hebeclada*		s1	ph	mi	la	is	fi		common	rare	common	
	Acacia karroo		s1	ph	mi	la	is/de	fi		rare		common	
	Acacia luederitzii		t2	ph	mi	la	is/de	fi		common	occasional	common	
	Acacia mellifera subsp. *detinens*		s1	ph	mi	la	is/de	fi		Wide-spread	common	common	
	Acacia nebrownii		s1	ph	mi	la	is/de	fi		rare		common	
	Acacia tortilis subsp. *heteracantha*		t2	ph	mi	la	is/de	fi		occasional	rare	common	
	Albizia anthelmintica		t2	ph	mi	la	is/de	fi		occasional	rare	common	
	Baphia massaiensis subsp. *obovata* var. *obovata*		s1	ph	no	la	is/de				rare	common	
	Bauhinia petersiana subsp. *macrantha*		s1	ph	me	la	is/de			occasional	common	common	
	Bolusia amboensis	En		th	mi	co	is						2018CB, 2019BC
	Burkea africana	F	t2	ph	no	la	is/de	fi			common	common	
	Chamacrista biensis		hl	th	mi	la	is	fi		rare	common	rare	
	Chamaecrista absus		hl	th	mi	la	is			occasional	rare	occasional	
	Chamaecrista falcinella var. *parviflora*		hl									occasional	
	Crotalaria barkae subsp. *barkae*			th	mi	ve	is						2017CB
	Crotalaria damarensis			th	mi	ve	is						1918CD
	Crotalaria flavicarinata		hl	th	mi	la	is	fi		rare	rare	common	
	Crotalaria pisicarpa		hl	th	mi	la	is	fi		rare	rare	occasional	
	Crotalaria platysepala			th	na	ve	is						2020CA
	Crotalaria podocarpa		hl	th	mi	la	is	fi		occasional	rare	occasional	
	Crotalaria sphaerocarpa		hl	th	mi	la	is	fi		occasional	occasional	common	
	Crotalaria steudneri		hl	th	mi	la	is	fi		rare		common	
	Cyamopsis senegalensis			th	mi	ve	is						2017CB

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	Cyamopsis serrata		hl	th	mi	la	is	fi		rare	rare	occasional	
	Dichrostachys cinerea		t3/ s1	th	mi	ve	is	pv		common	common	common	
	Elephantorrhiza elephantina		s2	cr	me	la	is/de	fi		occasional	occasional	occasional	
	Entada arenaria		geo	cr	pl	la	is/de	fi			rare	occasional	
	Erythrina decora	En/F		ph	me	ve	is	de/su					1918CD
	Guibourtia coleosperma	F		ph	no	pe	is						2018AB, 2020AD
	Indigastrum costatum			th	na	ve	is						2018BC
	Indigastrum parviflorm subsp. *occidentalis*		hl	ch	mi	la	is	fi		rare		common	
	Indigofera alternans var. *alternans*			hc	na	ve	is						2119DA
	Indigofera arenophila		hl	ch	mi	la	is	fi			rare	occasional	
	Indigofera auricoma			th	na	ve	is						2017CB
	Indigofera bainesii		s2	ch	mi	la	is	fi		occasional	common	occasional	
	Indigofera baumiana		hl	ch	mi	la	is	fi		rare	occasional	rare	
	Indigofera charlieriana var. *charlieriana*		hl	th	mi	la	is	fi		common	occasional	occasional	
	Indigofera colutea			hc	na	co	is						2119AB, 2018CB
	Indigofera daleoides var. *daleoides*		hl	th	mi	la	is	fi		occasional	occasional	common	
	Indigofera filipes		hl	th	na	la	is	fi		rare	common	rare	
	Indigofera flavicans		hl	th	mi	la	is			occasional	occasional	common	
	Indigofera hochstetteri subsp. *streyana*	NEn	hl	ch	mi	la	is	fi		rare		rare	
	Indigofera pechuelii		hl	cr	mi	la	is	fi			rare	common	
	Indigofera vicioides		hl	th	na	la	is	fi		occasional	rare	occasional	
	Lablab purpureus subsp. *uncinatus*	Cas		hc	mi	co	is						1918DA
	Leobordea platycarpa		hl	th	no	la	is			occasional	rare	rare	
	Leobordea schoenfelderi			th	no	la	is						2020BB
	Lessertia benguellensis			ch	mi	ve	is						2020CA
	Listia heterophylla		hl	th	no	la	is			rare		common	

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	Macrotyloma axiliare		hl	ch	mi	la	is				rare	common	
	Mundulea sericea		s1	ch	no	la	is/de	fi		occasional	occasional	common	
	Neorautanenia amboensis		s2	ch	me	la	is/de			occasional	occasional	occasional	
	Neorautanenia mitis		hl	ch	me	la	is/de			rare	rare	rare	
	Neptunia oleracea			th/hy	mi	ve	is	fi					1918CD
	Otoptera burchellii		s2	ch	mi	la	is/de			common	rare	occasional	
	Peltophorum africanum	F	t3/ s1	ph	me	pe	is	fi		rare	rare	common	
	Philenoptera nelsii		t2/ s1	ph	me	la	is/de	de/sc		common	common	common	
	Pomaria burchellii		hl	th	mi	la	is	fi		rare	occasional	occasional	
	Pterocarpus angolensis	F/NT	t1	ph	ma	pe	is/de	fi			occasional	common	
	Ptycholobium biflorum subsp. *angolensis*		s2	ch	mi	la	do			occasional		occasional	
	Requienia pseudosphaerosperma			hc	mi	ve	is						2018CB, 2020AD
	Requienia sphaerosperma		hl	th	mi	la	is			occasional	common	common	
	Rhynchosia caribaea			hc/li	mi	la	is						2017BC
	Rhynchosia holosericea			hc/li	mi	ve	is						2018BD
	Rhynchosia resinosa		hl	cr/li	mi	la	is			rare	rare	occasional	
	Rhynchosia sublobata		hl	cr/li	mi	la	is			rare	rare	occasional	
	Rhynchosia totta		hl	cr/li	mi	la	is			occasional	common	occasional	
	Rhynchosia venulosa		hl	cr/li	mi	la	is				rare	common	
	Senna italica		geo	cr/li	no	la	is/de			occasional	rare	common	
	Tephrosia burchellii		hl	th	mi	la	is	fi		common	common	occasional	
	Tephrosia cephalantha var. *decumbens*		hl	th	mi	la	is	fi			rare	occasional	
	Tephrosia dregeana		hl	th	mi	la	is	fi		rare	rare	common	
	Tephrosia lupinifolia		hl	th	mi	la	is	fi		occasional	common	occasional	
	Tylosema esculentum		geo	cr/li	me	la	is/de			common	occasional	common	
	Vigna frutescens			hc/li	mi	co	is						2019DA
	Vigna lobatifolia		hl	cr/li	no	la	is				rare	occasional	

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	Vigna unguiculata		hl	cr/li	no	la	is				rare	occasional	
	Zornia glochidiata		hl	th	mi	la	is			occasional	rare	occasional	
Gentianaceae													
	Enicostema axillare subsp. *axillare*			hc	mi	la	is						2020BA
	Sebaea grandis		hl	cr	mi	la	is			rare		rare	
Geraniaceae													
	Monsonia angustifolia		hl	th	mi	ve	is			rare	rare	occasional	
Gisekiaceae													
	Gisekia africana		hl	th	le	la	is	su		common	common	occasional	
Lamiaceae													
	Acrotome angustifolia		hl	th	mi	la	is			common	common	occasional	
	Acrotome fleckii	En		th	na	pe	is						2019DA, 2017CB
	Acrotome inflata			th	mi	pe	is						2017CB
	Clerodendrum ternatum		hl	cr	mi	la	is/de			common	common	common	
	Endostemon tereticaulis		hl	th	mi	la	is			rare		occasional	
	Leucas capensis			ch	na	ve	is						2119DA
	Leucas pechuelii	NEn	s2	ch	mi	la	do			rare		common	
	Ocimum americanum var. *americanum*		hl	th	na	la	is			occasional	rare	occasional	
	Ocimum filamentosum		hl	th	mi	la	is			rare	rare	occasional	
	Plectranthus hereroensis			th	no	pe	is						2017DA
	Plectranthus neochilus			th	mi	la	is	su					2119AB
	Rotheca myricoides		s2	ch	mi	la	is/de			rare	rare	occasional	
	Rotheca uncinata		s2	cr	mi	la	is/de			rare	occasional	occasional	
	Syncolostemon bracteosus		hl	th	na	la	is			rare	occasional	rare	
Lentibulariaceae													
	Utricularia stellaris			hc	le	la	is	ca	hy				2118AB
Loranthaceae													

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Erianthemum ngamicum			ch	mi	ve	is	sc	pa				2018BD
	Plicosepalus kalachariensis			ch	mi	ve	is	pv/sc	pa				2017CB, 2020AD
	Tapinanthus oleifolius		para	ch	mi	la	is	sc	pa	rare		occasional	
Lythraceae													
	Nesaea saluta			th	la	ve	is						2118AB
Malpighiaceae													
	Sphedamnocarpus pruriens subsp. *pruriens*			ch/li	mi	pe	is						2019AC
Malvaceae													
	Abutilon austro-africanum		hl	ch	no	la	is/de			rare		rare	
	Gossypium anomalum subsp. *anomalum*			ch	mi	pe	is						1918DA
	Hibiscus caesius		s2	ch	no	la	is/de			rare		rare	
	Hibiscus calyphyllus		s2	ch	no	la	is/de			occasional		occasional	
	Hibiscus elliottiae		s2	ch	mi	la	is/de			rare		rare	
	Hibiscus engleri			hc	no	pe	is						2017CB
	Hibiscus fleckii	En		hc	no	la	is						2118AA
	Hibiscus meeusei		hl	th	no	la	is			occasional	common	occasional	
	Hibiscus micranthus		s2	ch	mi	la	is/de			occasional		occasional	
	Hibiscus nigricaulis			th	no	pe	is						1918DA, 2019AC
	Hibiscus sidiformis		hl	th	mi	la	is			rare		rare	
	Hibiscus trionum	Nat		th	mi	pe	is						2017CB
	Hibiscus vitifolius		hl	ch	no	la	is/de			rare	rare	occasional	
	Pavonia burchellii		s2	ch	mi	la	is/de			occasional	rare	occasional	
	Pavonia clathrata		s2	ch	mi	la	is/de				occasional	occasional	
	Pavonia senegalensis			th	no	pe	is						1918DA, 2019BC, 2020CA
	Sida cordifolia		s2	th	no	la	is			occasional	occasional	occasional	
	Sida ovata		s2	ch	mi	la	is			occasional	occasional	occasional	

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
Menispermaceae													
	Antizoma angustifolia		s2	ch/li	mi	ve	is	sc		rare	rare	occasional	
	Cissampelos mucronata			ch/li	mi	pe	is						2019CB
Molluginaceae													
	Corbichonia rubriviolacea			hc	na	la	is	su					2019BC
	Hypertelis bowkeriana			th	na	ve	is	su					2119AA, 2119AB
	Limeum arenicolum		hl	th	le	la	is			occasional	rare	occasional	
	Limeum argute-carinatum		hl	th	le	la	is			rare		occasional	
	Limeum fenestratum		hl	th	le	la	is			common	common	occasional	
	Limeum myosotis		hl	th	le	la	is			occasional	rare	occasional	
	Limeum pterocarpum		hl	th	le	la	is			rare		occasional	
	Limeum sulcatum		hl	th	le	la	is			occasional	rare	occasional	
	Limeum viscosum		hl	th	le	la	is			rare	rare	occasional	
	Mollugo cerviana		hl	th	le	la	is			rare		occasional	
	Mollugo nudicaulis	Ex	hl	th	na	la	is			rare		occasional	
Montiniaceae													
	Montinia caryophyllaceae			ph	mi	ve	is						2118AA
Moraceae													
	Ficus sycomorus subsp. *gnaphalocarpa*			ph	mi	co	is/de						2017BC
Nyctaginaceae													
	Commicarpus pentandrus			hc	mi	la	is						1918DA, 2119DA
Ochnaceae													
	Ochna pulchra		s1	ph	no	la	is/de				common	common	
Olacaceae													
	Ximenia americana		s1	ph	mi	la	is	sc		occasional	rare	common	
	Ximenia caffra		s1	ph	mi	la	is				rare	occasional	
Orobanchaceae													

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Alectra orobanchoides		para	th	pi	ve	ac		pa	rare	rare	occasional	
	Alectra sessiliflora		para	th	na	la	is		pa	rare	rare	rare	
	Alectra vogelii			th	na	la	is		pa				2020BD, 2017CB
	Buchnera longespicata			th	mi	ve	is		pa				2020BC, 2020BD, 2017CB
	Hiernia angolensis			ch	na	ve	is						1918DC
	Striga asiatica		para	th	le	la	is		pa		rare	occasional	
	Striga gesnerioides		hl	th	le	la	is		pa	occasional	occasional	occasional	
Passifloraceae													
	Adenia repanda		geo	cr/li	no	ve	is/de	sc		rare		rare	
	Basananthe pedata		hl	th	mi	ve	is			rare	occasional	occasional	
Pedaliaceae													
	Dicerocaryum eriocarpum			ch	na	ve	is						2118BA
	Harpagophytum procumbens subsp. *procumbens*	P	geo	cr/li	na	la	is/de			occasional	rare	occasional	
	Harpagophytum zeyheri		geo	cr/li	no	la	do/de				rare	occasional	
	Pterodiscus ngamicus			hc	mi	la	is	su					2119AA
	Sesamum alatum			cr	mi	la	is						2018BD, 2018CB, 2020AD
	Sesamum capense		hl	th	no	la	is			common	common	occasional	
	Sesamum triphyllum		hl	th	no	la	is			rare		occasional	
Phytolaccaceae													
	Lophiocarpus tenuissimus		hl	th	le	la	is				rare	common	
Polygalaceae													
	Polygala kalaxariensis			ch	na	ve	is						2018BD
	Polygala leptophylla		hl	ch	na	la	is			rare	rare	rare	
	Polygala schinziana		hl	th	na	la	is			rare	rare	rare	
	Securidaca longepedunculata		t3/s1	ph	mi	la	is/de	sc			rare	occasional	
Polygonaceae													

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Oxygonum alatum		hl	th	mi	la	is			common	common	occasional	
	Oxygonum delagoense		hl	th	mi	la	is				occasional	common	
	Persicaria hystricula			th	mi	ve	is						2017CB
	Polygonum plebeium			th	na	la	is						2017CB
	Rumex sagittatus			hc	mi	la	is						2017DA
Portulacaceae													
	Portulaca hereroensis		hl	th	le	la	is	su		rare		occasional	
	Portulaca kermesina		hl	th	le	la	is	su		rare	rare	rare	
	Talinum arnotii		hl	cr	mi	la	is	su		rare	rare	common	
	Talinum caffrum		hl	cr	mi	la	is	su		occasional	rare	occasional	
	Talinum crispatulum		hl	cr	mi	la	is	su		common	occasional	occasional	
	Talinum tenuissimum		hl	cr	mi	la	is	su		rare	rare	rare	
Ranunculaceae													
	Clematis brachiata			hc/li	mi	la	is						2119AB
Resedaceae													
	Oligomeris linifolia		hl	ch	na	la	is			occasional	occasional	occasional	
Rhamnaceae													
	Helinus integrifolius		s1	ph	mi	la	is/de			rare	rare	occasional	
	Helinus spartioides		s2	ch	mi	la	is/de	sc		occasional	rare	occasional	
	Ziziphus mucronata		s1	ph	mi	pe	is			common	occasional	common	
Rubiaceae													
	Crossopteryx febrifuga		hl	ph	no	la	is				rare	occasional	
	Kohautia azurea	En	hl	th	le	la	is			rare		rare	
	Kohautia caespitosa subsp. *brachyloba*		hl	th	na	la	is			occasional	occasional	occasional	
	Kohautia cynanchica		hl	th	na	la	is			rare		occasional	
	Kohautia virgata		hl	th	na	la	is			rare		common	
	Pavetta zeyheri			ph	mi	co	is/de						1918DA

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Psydrax livida		s1	ch	mi	la	is				rare	common	
	Pygmaeothamnus zeyheri var. *zeyheri*			ch	me	la	is						2018CD
	Spermacoce senensis		hl	th	mi	la	is			occasional	rare	occasional	
	Vangueria cyanescens			ph	me	la	is/de						2017CB, 2018BD
	Vangueria infausta		s1	ph	no	la	is				rare	common	
Santalaceae													
	Osyris lanceolata			ph	mi	la	is		pa				1918DB
	Thesium lineatum			ch	le	ve	is		pa				2018BC
	Thesium megalocarpum			ch	le	ve	is		pa				2018BD, 2020AD
Sapindaceae													
	Cardiospermum halicacabum	Nat	hl	ch/li	mi	la	is			rare		occasional	
Scrophulariaceae													
	Aptosimum albomarginatum		hl	ch	na	ve	is	sc		rare		occasional	
	Aptosimum angustifolium		hl	ch	mi	ve	is			rare	rare	rare	
	Aptosimum arenarium	En	hl	th	mi	ve	is			rare		occasional	
	Aptosimum decumbens		hl	th	mi	ve	is				rare	occasional	
	Aptosimum elongatum			th	na	co	is						2018BD, 2020CA
	Aptosimum glandulosum		hl	ch	mi	ve	is			rare		rare	
	Aptosimum lineare var. *lineare*			th	mi	co	is						2119DA
	Aptosimum lugardiae		hl	ch	le	la	is			rare		occasional	
	Jamesbrittenia atropurpurea subsp. *atropurpurea*		hl	hc	le	la	is			rare		occasional	
	Jamesbrittenia elegantissima			hc	na	la	is						1918DA
	Lindernia parviflora		hl	th/hy	na	la	is			rare		rare	
	Manulea dubia			hc	na	la	is						2017DA
	Selago amboensis	En		hc	le	la	is						2017CB
Solanaceae													
	Datura stramonium	Nat	hl	th	no	la	is			rare		rare	

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Lycium bosciifolium		s1	ph	na	la	is	sc		occasional		common	
	Lycium cinereum			ph	le	co	is						2017DB, 2018CA, 2018CB
	Lycium eenii		s2	ph	mi	la	is	sc		rare		rare	
	Solanum burchellii		s2	ch	mi	la	do			occasional	occasional	occasional	
	Solanum catombelense			ch	mi	co	is						2018BC, 2119AB
	Solanum delagoense		hl	th	no	la	do			occasional		occasional	
	Solanum incanum		hl	th	no	la	do			rare		rare	
	Solanum kwebense		hl	ch	mi	la	do			rare	rare	occasional	
	Solanum multiglandulosum			ch	mi	ve	is						2020CA
	Solanum seaforthianum var. *disjunctum*	Nat		ch/li	no	pe	is						2017CB
	Solanum supinum		hl	ch	mi	la	do			rare	rare	rare	
Sterculiaceae													
	Hermannia bicolor		hl	th	na	la	is			rare		rare	
	Hermannia eenii		hl	th/li	na	la	is			rare	occasional	occasional	
	Hermannia guerkeana		hl	th/li	na	la	is			rare	rare	rare	
	Hermannia modesta		hl	th	na	la	is			common	rare	occasional	
	Hermannia tomentosa		hl	th/li	na	la	do			rare	occasional	occasional	
	Melhania acuminata		hl	hc	mi	la	is/de			occasional	rare	occasional	
	Melhania burchellii			hc	mi	la	is						2119DB
	Melhania forbesii		hl	hc	mi	la	is/de			rare		occasional	
	Melhania virescens		hl	hc	mi	ve	is/de			rare	rare	occasional	
	Waltheria indica		hl	ch	mi	la	is/de			occasional	occasional	occasional	
Strychnaceae													
	Strychnos cocculoides		t3	ph	mi	la	is				rare	occasional	
	Strychnos pungens		t3/ s1	ph	mi	la	is/de				rare	common	
Thymelaeaceae													

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Gnidia polycephala		s2	ch	le	la	is/de	sc		rare	rare	occasional	
Tiliaceae													
	Corchorus schimperi		hl	th	mi	la	is			rare	rare	rare	
	Corchorus tridens	Nat	hl	th	mi	la	is			occasional	rare	occasional	
	Grewia avellana		s2	ch	pl	la	is/de			rare	common	occasional	
	Grewia bicolor		s1	ph	no	pe	do/ de			occasional	rare	common	
	Grewia falcistipulata			ph	mi	pe	do						2019CB, 2018BC, 2018BD, 2019AC, 2019DA
	Grewia flava		s1	ph	no	la	is/de			common	common	common	
	Grewia flavescens var. *flavescens*		s1	ph	no	la	is/de			common	common	occasional	
	Grewia retinervis		s1	ph	mi	co	is/de						2017DA, 2018BD, 2018CA, 2018CB, 2019AC, 2019BC, 2019CD, 2019DA, 2020AA, 2020CA, 2119AB, 2120CA
	Grewia tenax		s1	ph	mi	la	is/de				rare	common	
	Grewia villosa		s2	ch	me	la	is/de			rare		occasional	
	Triumfetta annua			th	no	la	is						2017CB
	Triumfetta rhomboidea var. *rhomboidea*			th	mi	la	is						2017CB
Turneraceae													
	Tricliceras schinzii subsp. *schinzii* var. *juttae*		hl	th	no	la	is			rare	rare	occasional	
Vahliaceae													
	Vahlia capensis		hl	th	na	ve	is			rare		occasional	
Verbenaceae													

Family	Species	Status	Layer	Raunkiaer life form	Leaf					Overall abundance		Local Abundance	QDS
					size	inclination	chlorotype	morphotype	root	"Hardeveld"	"Sandveld"		
	Chascanum pinnatifidum		hl	ch	mi	la	is	fi		rare		occasional	
	Chascanum pumilum			ch	mi	la	is						2120CA
	Lantana angolensis		s2	ch	mi	pe	is			common	occasional	occasional	
Violaceae													
	Hybanthus densifolius			th	na	co	is						2118AA
Vitaceae													
	Cyphostemma congestum		s2	cr/li	mi	la	is/de			rare	rare	rare	
Zygophyllaceae													
	Tribulus terrestris		hl	th	mi	la	is	fi		occasional	rare	occasional	
	Tribulus zeyheri		hl	th	mi	la	is	fi		occasional	rare	occasional	

Codes used:

Status (following Klaassen & Kwembeya 2013):

Endemic	En
Near endemic	NEn
Red Data Listed:	
Near threatened	NT
Exotics:	
Non-indigenous (uncertain status)	Ex
Naturalised	Nat
Cassual	Cas
Weed	Weed
Invasive	Inv
Protected species:	
Nature Conservation Ordinance 37 of 1952 and 247 of 1977	P
Forestry Ordinance 37 of 1952 and Forestry Act 72 of 1968	F
CITES Appendix II	CII

Vegetation layer (adapted from Edwards 1983):

Herb layer:	hl

annual grass	ga	
perennial grass	gp	
geophyte	geo	
parasite	para	
Shrub layer:		
low shrub <1m	s2	
high shrub, 1	s1	
Tree layer:		
low tree, 2	t3	
short tree, 5	t2	
tall tree, >10m	t1	
Life form (following Raunkiear 1907):		
phanerophyte	ph	
chamaphyte	ch	
hemicryptophyte	hc	
cryptophyte	cr	
therophyte	th	
hydrophyte	hy	
liane	li	(all creepers and climbers have been included here)
Leaf size (following Gillison & Carpenter 1997):		mm^2
picophyll	pi	<2
leptophyll	le	2 - 25
nanophyll	na	25 - 225
microphyll	mi	225 - 2025
notophyll	no	2025 - 4500
mesophyll	me	4500 - 18200
platyphyll	pl	18200 - 36400
macrophyll	ma	36400 - 18 x 10^4
megaphyll	mg	> 18 x 10^4
Leaf inclination (following Gillison & Carpenter 1997):		
vertical	ve	
lateral	la	
pendulous	pe	
composite	co	
Chlorotype (following Gillison & Carpenter 1997):		
dorsiventral	do	
isobilateral	is	

decidious	de	
cortic	ct	(photosynthetic stem)
achlorophyllous	ac	(without chlorophyll, e.g. parasitic plants)

Leaf morphotype (following Gillison & Carpenter 1997):

rosette	ro	
solid 3-D	so	
succulent	su	
sclerophyll	sc	(not part of Gillison & Carpenter 1997 PFA's)
parallel-veined	pv	
filicoid	fi	(fern-like sensu Gillison & Carpenter 1997. All pinnatified leaves have been included here)
carnivorous	ca	

Root type (following Gillison & Carpenter 1997):	(only above-ground roots)
adventitious	ad
aerating	ae
epiphytic	ep
hydrophytic	hy
parasitic	pa

Overall abundance:
Rare: present in <5 % of relevés
Occasional: present in 5<20 % of relevés
Common: present in 20<50 % of relevés
Abundant: present in 50<75 % of relevés
Wide-spread: present in >75 % of relevés

Local abundance:
Rare: < 0.1 % cover
Occasional: 0.1 < 1 % cover
Common: 1 < 10 % cover
Abundant: 10 < 50 % cover
Dominant: 50 < % cover

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National conservation assessment and management of *Adenia pechuelii*, with specific reference to the Rio Tinto Rössing Uranium Mine

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Abstract

Rössing Uranium Limited's (RUL) biodiversity strategy recognised the importance of managing plant species of conservation importance occurring within the license area of the mine. Based on its conservation importance, Adenia pechuelii *was selected for conservation assessment. Of the 2671 individuals of* A. pechuelii *recorded over its distribution range in Namibia, some 226 are from RUL. This account for approximately 8% of the total number of plants recorded and shows that the RUL population is the third-most important with respect to population size. In terms of density, however, this population is rated one of the lowest, as the plants are scattered over a large area. The conservation status for* A. pechuelii *is here down-listed from Near Threatened to Least Concern. Recruitment in populations of* A. pechuelii *should be monitored and a study to investigate the reasons for the poor seed setting in most populations should also be conducted.*

Key Words: *Adenia pechuelii*; conservation assessment; Rössing Uranium Mine; monitoring

Introduction

As part of Rössing Uranium Limited's (RUL) Biodiversity Action Plan and their commitment to achieve a positive impact on biodiversity, and consistent with specific recommendations made by Burke (2005), the company undertook to identify and assess plant species of conservation concern within its license area. A partnership was thus formed between the National Botanical Research Institute (NBRI), Rössing Uranium Limited (RUL), the Rio Tinto mining group and the Royal Botanic Gardens at Kew, incorporating the Millennium Seed Bank Project (MSBP) in order to carry out the investigations in this regard.

Among Namibia's wealth of plant diversity, a significant number of species are of conservation importance. Over 1,400 species have been evaluated against the IUCN Red List criteria to date, and of these, some 170 are currently threatened with extinction, Near Threatened (NT) or Rare (R), with an additional 360 taxa being recorded as endemic to Namibia (NBRI 2012; Loots 2005; Craven & Loots 2001).

Undertaking field assessments on populations of species that are of conservation concern enormously contributes to our knowledge, as well as their conservation and management. It is the most reliable way to monitor numbers of plants in a population and provides a basis for scientists to detect changes in population size over time, one of the criteria for Red List assessments (IUCN 2001).

Initial research was carried out on botanical diversity within and around the RUL license area by Burke (2005), but this work was not mandated to focus on any species in detail. Some 140 plant species were recorded, with 68 appearing in Namibia's Red Data Book (Loots 2005). Twenty-four species that are of conservation concern and/or endemic to Namibia from this list were identified as priority species and used to rate biotopes in the mine's license area (Burke 2005). This list

includes *Adenia pechuelii* (Engl.) Harms of the family Passifloraceae also known as Elephant's foot (English) or Wüstenkohlrabi (German) and given its desirability to succulent collectors, its vulnerability to potential habitat destruction, and its current status of Near Threatened (Loots 2005), the species became a subject of conservation concern. These reasons provided the motivation for choosing *A. pechuelii* as a subject of the survey.

The proportion of the global populations of *A. pechuelii* occurring within RUL's license area was not known. Curtis & Mannheimer (2005) validly state that the species is worthy of protection, preferably under the Nature Conservation Ordinance.

A. pechuelii is a dwarf tree with very large, squat, swollen, almost-round trunk and succulent, green, finger-like branches, orientated in all directions. The bark is smooth, cream to light grey-green. Leaves are few, small and grey-green. The flowers are small, greenish and the fruit is a three lobed capsule, red when ripe, and usually with three seeds. The flowers are inconspicuous but the fruit is conspicuous when ripe (Curtis & Mannheimer 2005).

Potential threats to the species include habitat destruction in some populations, especially through mining activities; the international pachycaul trade; plants are unisexual, which could mean skewed sex ratios in some populations and this could result in poor recruitment. In at least some populations, male and female plants seem to flower at different times (pers. obs.), and this would result in female flowers not being pollinated. It is not certain if and to what extent international trade is affecting the species and the impacts of climate change have not been assessed.

Figure 1 indicates the distribution of *A. pechueli* in Namibia, based on specimen records from the National Herbarium of Namibia (WIND 2006). Craven & Vorster (2006) reported that *A. pechuelii* specimens were also recorded in Angola.

The anticipated short-term outcome of the project was to increase knowledge and improve management of *A. pechuelii* recorded on the RUL mine licence area. The long-term goal was to improve conservation, management and restoration of plant diversity, plant communities, and the associated habitats and ecosystems, *in situ* (both in natural and in managed environments), and where necessary to complement *in situ* measures, *ex situ*.

The most important target conservation outcome of the project was to improve awareness of the conservation status and national distribution of *A. pechuelii* and the relevant importance of sites found at RUL. An important output of this project was to develop a simple species management and long-term monitoring strategy for *A. pechuelii* (See Appendix 1).

This paper focuses on comparing the population of *A. pechuelii* at RUL, with populations that were surveyed over the rest of the distribution range of the species, in terms of distribution, abundance, density and relative importance for conservation. Two main questions had to be answered at the end of the survey: 1) What percentage of the national population of *A. pechuelii* occurs within the license area, and 2) How important is the population at RUL compared to the rest of the populations across the distribution range of the species in Namibia?

Methods

The national study area was defined as the natural distribution area of *A. pechuelii* (Figure 1) by querying the Specimen Database of the National Herbarium (WIND 2006). In many cases, people who work or live in the vicinity of the recorded localities were consulted as to the whereabouts of the plants.

The work on biotopes done by Burke (2005) indicated where *A. pechuelii* is present in the RUL license area. This was used to define the study area at RUL and as a guide to sample the area. The study area at RUL was divided into 1 km grid squares and some 68 corresponding waypoints at the grid nodes, hereinafter referred to as "sampling sites", were entered into a GPS (Figure 2).

These 68 sites were then systematically surveyed as described below, to locate and assess *A. pechuelii*. In addition to the sampling sites, *A. pechuelii* specimens were recorded whenever they were encountered within the license area.

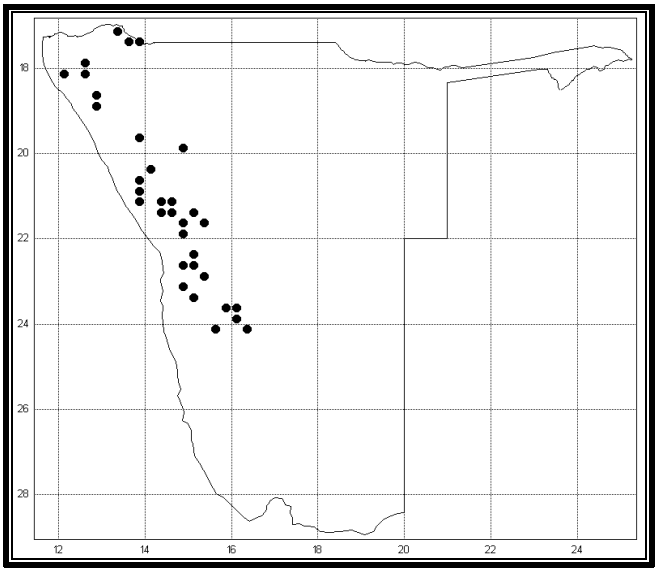

Figure 1. National distribution of *A. pechuelii*.

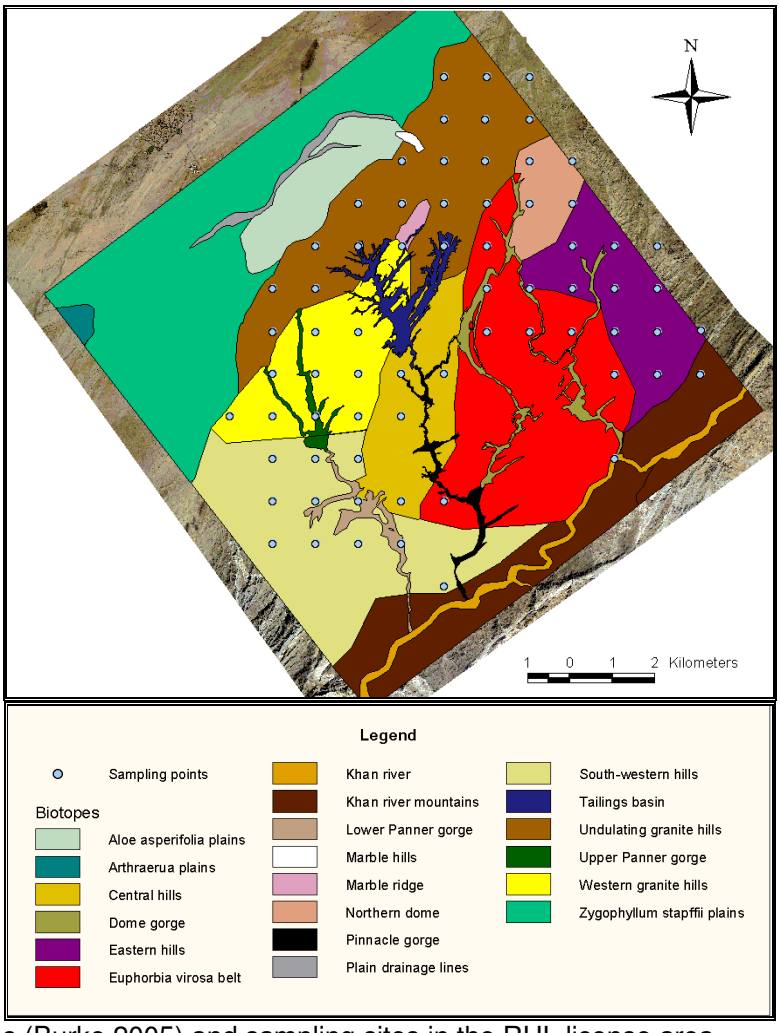

Figure 2. Biotopes (Burke 2005) and sampling sites in the RUL license area.

For the purposes of the survey, it was necessary to distinguish between a site and a population. A site is therefore defined as a group of plants that occur together on the same topographic feature for example a ridge, slope, plain, outcrop or hillside and the plants are not separated by unsuitable habitat. A population is defined as a group of sites occurring together at the same general location for example the RUL license area or the Garden Route. Sites within a population can be separated by unsuitable habitat but cross pollination between the sites is possible, as they are not separated by long distances. Most populations are separated from one another by a distance of at least ten kilometres as well as unsuitable habitat, and the possibility of cross pollination between them is unlikely. In some instances, for example the population of *A. pechuelii* at Leeukop in the Namib Naukluft Park (NNP), there is only one site, and this constitutes a population.

During the course of the project a total of 35 sites of *A. pechuelii* were surveyed across the distribution range of the project (including RUL, regarded here as one population for comparison) and they constitute some 24 populations (Figure 3).

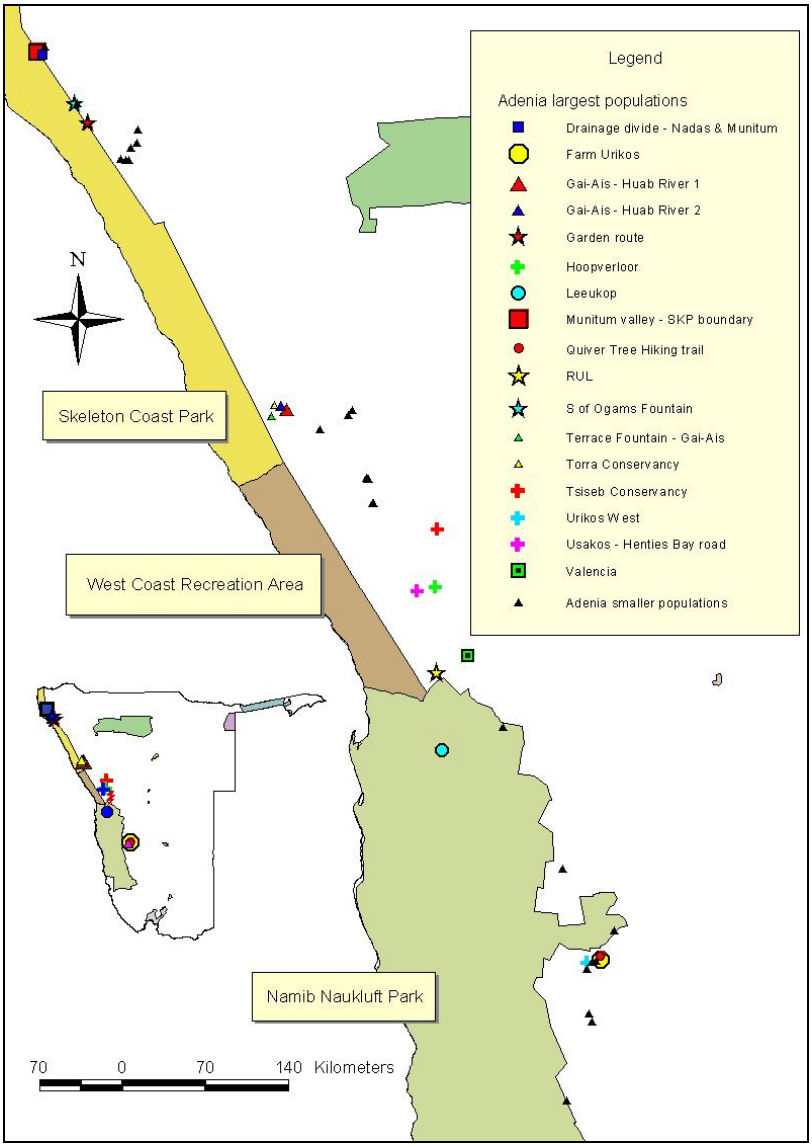

Figure 3. Distribution of surveyed *A. pechuelii* sites.

A data sheet was designed onto which all relevant data for each site were recorded. This included the presence or absence of *A. pechuelii*, as well as a site description and relevant habitat information such as altitude, soil type, soil colour, lithology, aspect and gradient, which were measured consistently in the immediate surrounds of the plant, using a compass and a clinometer,

respectively. At a number of sampling sites, specimens were collected and photographs were taken of *A. pechuelii* (See Appendix 2).

The data recorded on the data sheets were entered into the MS Access database that was developed in collaboration with RBG Kew. This allowed the data to be queried for mapping and analysed to produce results. Maps were produced using Arc View GIS version 3.2a. Graphs were generated using MS Excel 2003.

Soil samples were taken at 55 sampling sites and brought back to the NPGRC where they were analysed for colour, texture and pH. Soil texture was determined using a manual process according to a standard procedure used by ICRAF. Soil pH was determined using a Hannah microprocessor pH meter. These data were used to help determine the habitat preference of *A. pechuelii* over its distribution range.

Within a sampling site or a population, *A. pechuelii* plants were recorded individually, unless more than one plant occurred at the same coordinates, in which case only one set of coordinates were recorded with the number of plants present there. Photographs were taken of the habitat and some plants from close-up to demonstrate the growth habit and habitat as well as damage to the plants. Associated plant species were recorded and where the plants could not be identified, specimens were collected and deposited in WIND according to standard practice.

The density of *A. pechuelii* populations was calculated using the Nearest Neighbour method (Cottam & Curtis 1956), a plot-less sampling method. Henderson & Seaby (1999) developed Density from Distances, a software programme that calculates density using plot-less density estimators upon entering of the data. Density was not calculated for sites with fewer than 40 plants. For sites such as the "Garden Route" where only a proportion of the population was counted, density was calculated only for that proportion of the population.

For populations outside the RUL license area, sampling started as soon as specimens of *A. pechuelii* could be located. Each new site was given a new site number. Some 400 *A. pechuelii* individuals from four populations were tagged with metal tags to facilitate future monitoring. An additional 100 plants were tagged at RUL in 2010 as part of the management and monitoring plan.

Small plants were observed in all populations, but details were only recorded if they were tagged for monitoring. Plants were considered "small" when the height of the main stem was measured to be less than 20 cm. This does not necessarily mean that they are not mature yet. Establishing whether a plant is mature or juvenile was not part of the mandate of the survey as information on determining the current age of the plants, the age at which they start to flower, set seed and their size upon maturity is not currently available.

Field work and data analyses were conducted from April 2006 to December 2008.

Results

A. pechuelii was found to occur along the escarpment; mostly on hillsides and mountain slopes, rocky ridges and outcrops; on all aspects of moderate to very steep slopes; sometimes wedged between rocks in very little soil or growing out of cracks in bare rock; often on banks of dry river courses; very occasionally on plains. Plants are mostly found in exposed situations, but sometimes in half shade under overhanging rocks. Figure 4 indicates the vegetation types (Giess 1971) in which the surveyed populations of *A. pechuelii* occur.

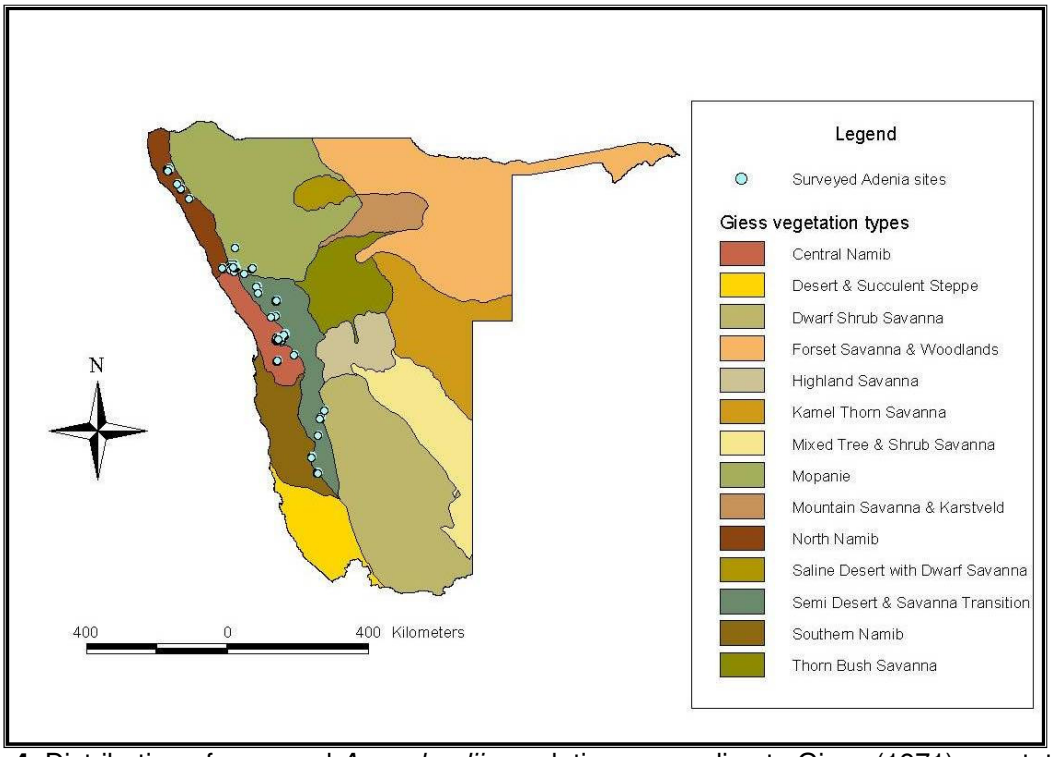

Figure 4. Distribution of surveyed *A. pechuelii* populations according to Giess (1971) vegetation types.

Over its entire distribution range, *A. pechuelii* occurs in association with a wide range of plant species, including *L. ruschiorum*, a range of *Aloe*, *Commiphora*, *Euphorbia*, *Zygophyllum* and other species as well as *Welwitschia mirabilis*. Plants are often covered in ants, especially when in flower and occasionally with hairy caterpillars, which browse the leaves. Branches are often browsed by animals, especially rodents and the main stems are often damaged, possibly by porcupine. This should not be confused with dents and hollows in the main stem caused by rocks that were pushed out over time.

Some 226 *A. pechuelii* plants were recorded at 30 of the 68 sampling sites surveyed in the RUL licence area and on roads and tracks between sampling sites, which were then assigned new site numbers. All the plants recorded at RUL are regarded as belonging to a single population. Figure 5 indicates the distribution of *A. pechuelii* in the RUL license area.

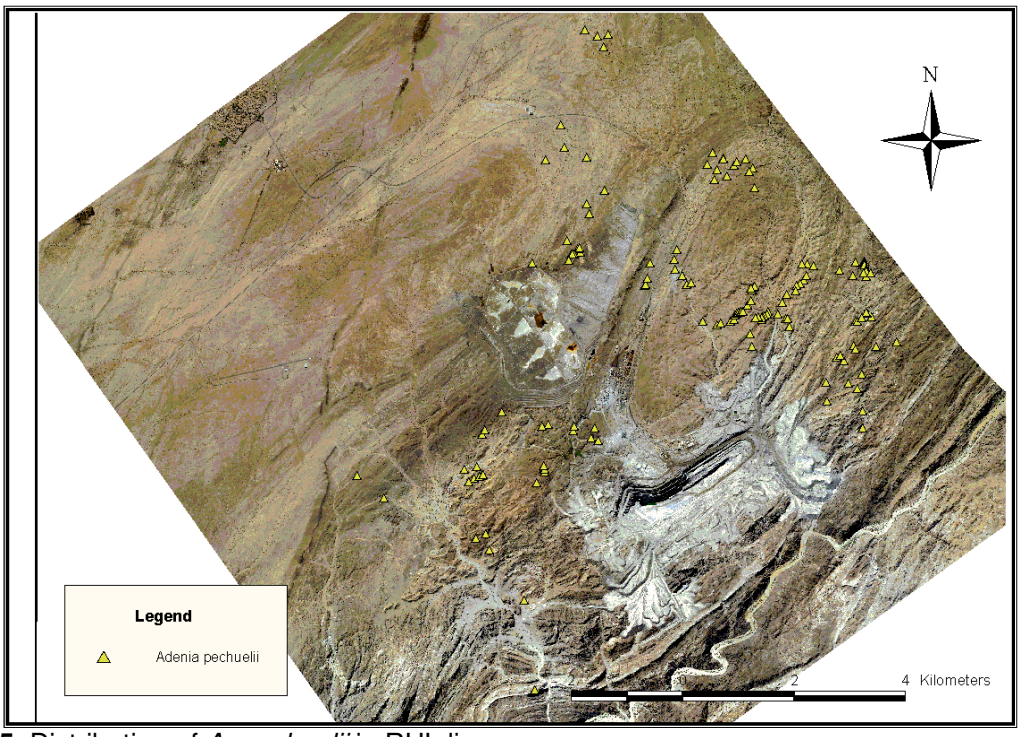

Figure 5. Distribution of *A. pechuelii* in RUL license area.

Field work revealed that individual plants at RUL occur mostly alone or in small groups of up to nine plants (Figure 6). Only six sampling sites had ten or more plants (Figure 6). Within RUL these six sites contain some 113 individuals in total. The density of *A. pechuelii* in the RUL license area was calculated as 7.024 plants per km². Small populations like the ones in the Namib Rand Nature Reserve therefore do not feature in the comparisons, but they are important in indicating the extent of the distribution of the species. The populations in the Namib Rand Nature Reserve possibly indicate the southern boundary of the species' range, at close to 26° latitude (Figure 3). Over the plant's range most sites had fewer than 100 plants, as indicated for the 13 largest *A. pechuelii* populations (Figure 7). In terms of numbers of plants recorded, RUL rated third.

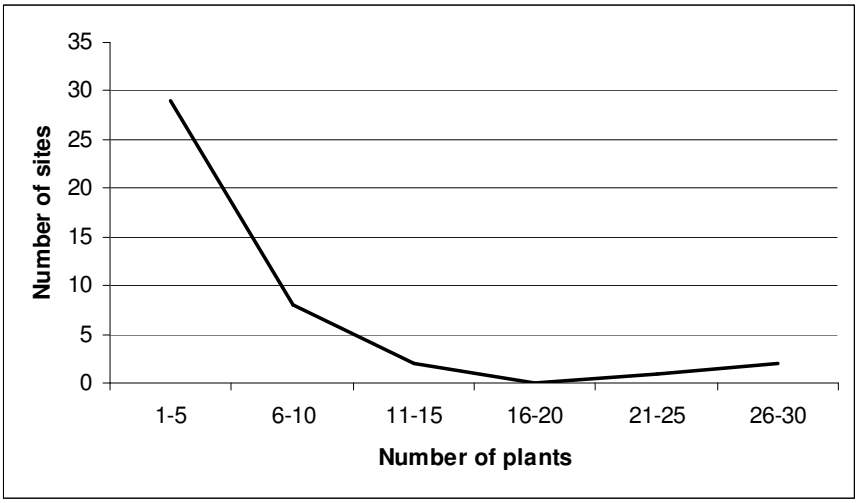

Figure 6. Number of *A. pechuelii* plants per sampling site as a frequency distribution.

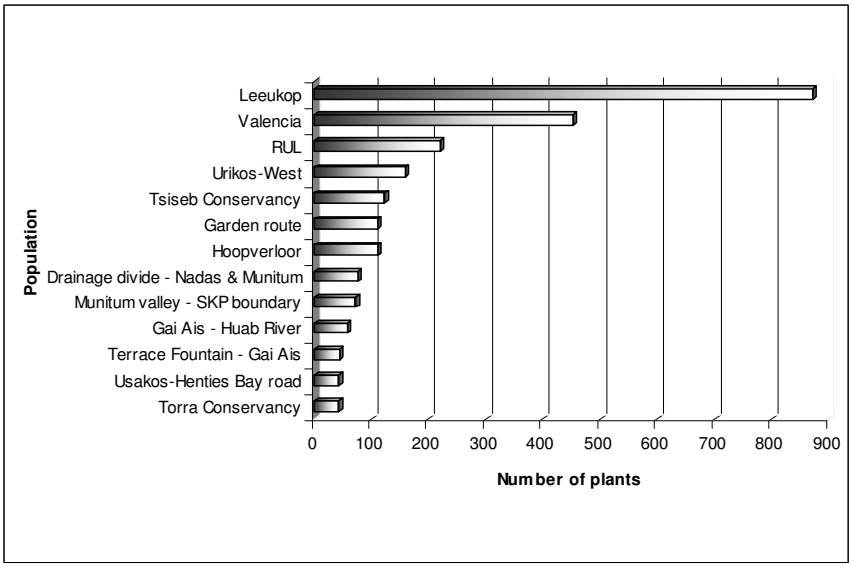

Figure 7. Number of *A. pechuelii* plants recorded at the largest sites.

A total of 2671 individuals of *A. pechuelii* were recorded over the distribution range of the species, of which 226 are from the RUL license area. This gives the proportion of *A. pechuelii* at RUL as approximately 8% of the total population in Namibia.

The density of the 12 sites where more than 40 plants were recorded was calculated in order to establish how RUL compares with other sites (Figure 8). Most sites had between 100 and 200 plants per km² and only two sites had more than 400 plants per km². The population at Leeukop in the Namib Naukluft Park has both the highest density and the most individuals recorded. It also has the highest percentage of small plants recorded among the 100 plants that were tagged in 5 populations (Figure 9).

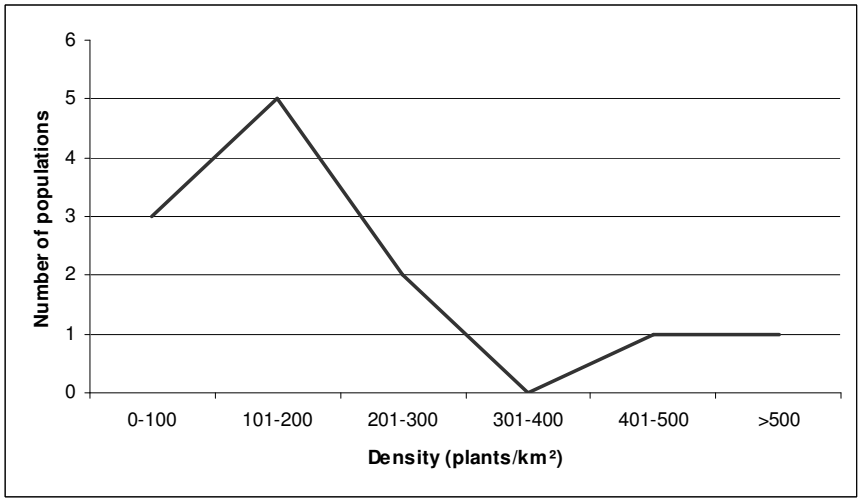

Figure 8. Density of *A. pechuelii* plants expressed as a frequency distribution.

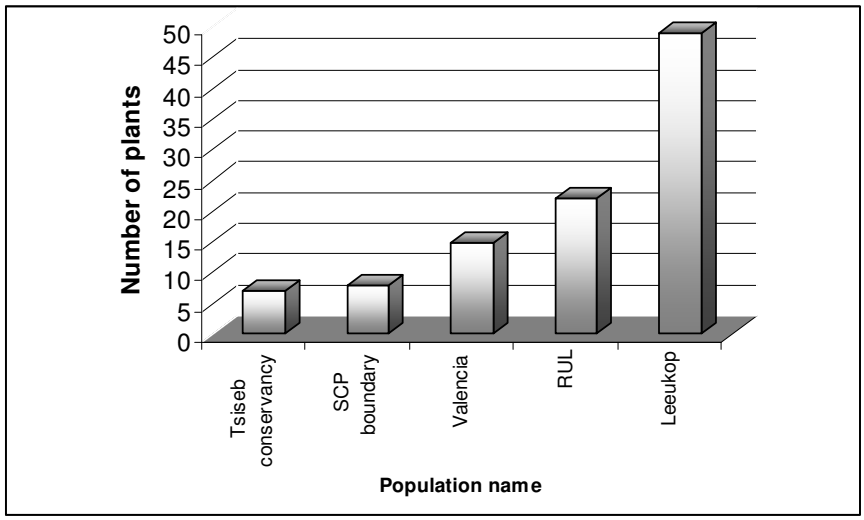

Figure 9. Percentage of small tagged *A. pechuelii* plants in selected populations.

Figure 10 shows the rock types, in which *A. pechuelii* occurs over its distribution range, indicating that granite is overwhelmingly preferred over any other lithology. *A. pechuelii* occurs on all aspects, but has a preference for NW- and W- facing slopes (Figure 11) and most plants prefer to grow on slopes with a gradient of less than 20° (Figure 12). Most plants were found between 501m and 750m above sea level, which can be explained by the fact that most of the largest populations are distributed within that range (Figure 13).

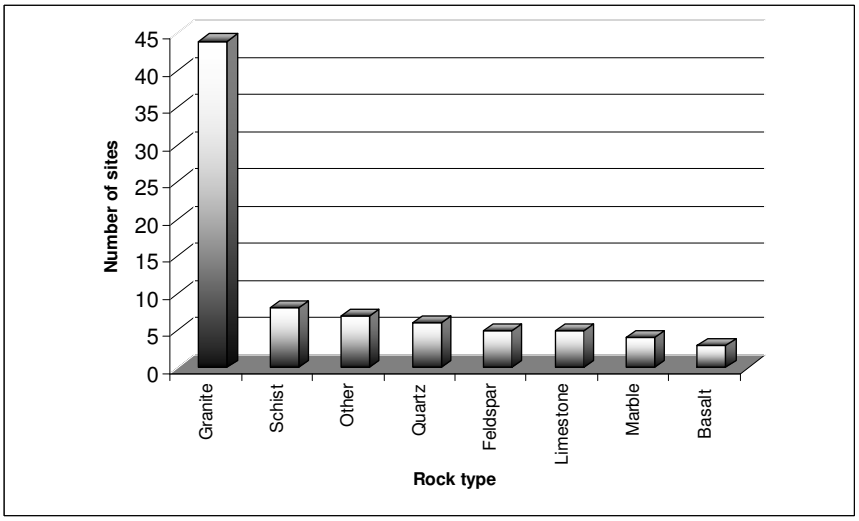

Figure 10. Lithology preference for *A. pechuelii*.

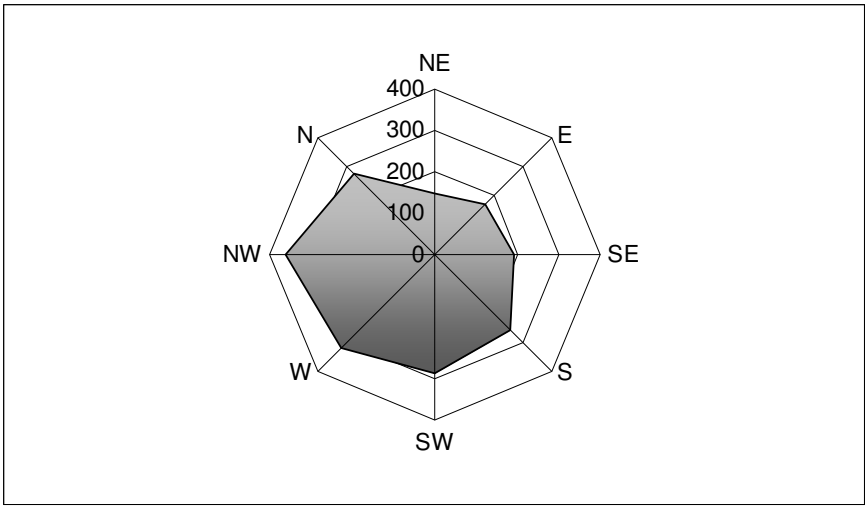

Figure 11. Aspect preference for *A. pechuelii*.

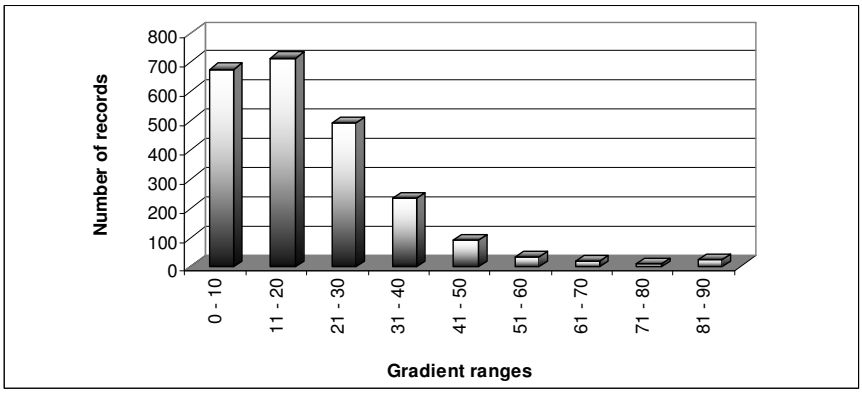

Figure 12. Gradient range preference for *A. pechuelii*.

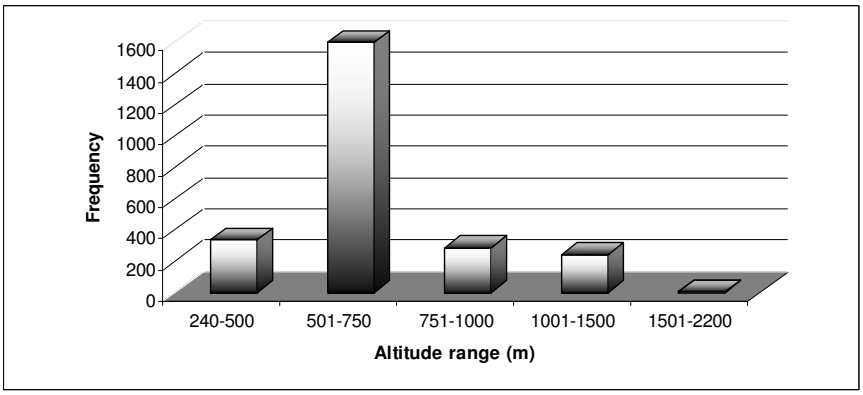

Figure 13. Altitude range preference for *A. pechuelii.*

Soil pH ranged between 7.9 and 9.8 over the distribution range of *A. pechuelii* indicating slight to moderate alkalinity. A strong preference for clay-loam was indicated (Figure 14). Where *A. pechuelii* occurred, the soil predominantly had a light brown colour.

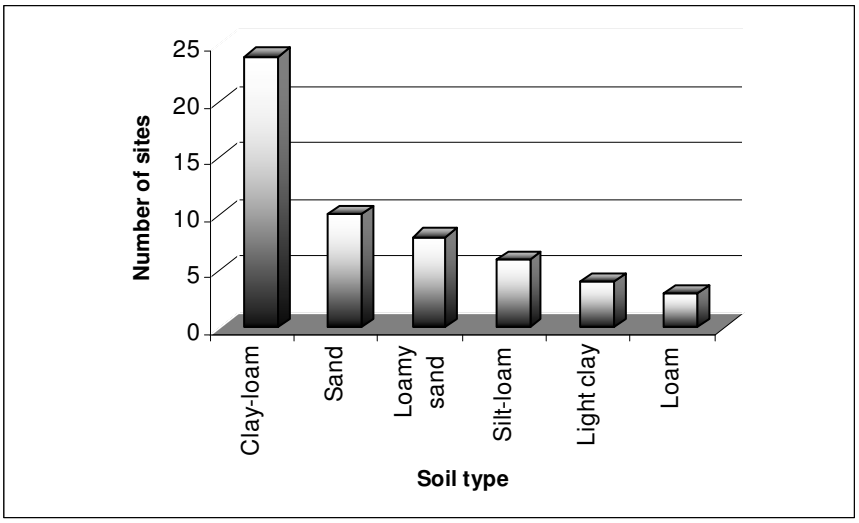

Figure 14. Soil type preference for *A. pechuelii*.

Table 1 lists the 13 most prominent sites of *A. pechuelii*, ranking them according to their density and the number of plants recorded. They are all regarded as important for conservation. Only four populations have a high density as well as a large population size (highlighted in green). RUL and Hoopverloor do not have high densities but they do have a relatively large population size (highlighted in yellow). Sites with a high density but a small population size are highlighted in blue.

Table 1. Sites of *A. pechuelii* that should be targeted for conservation.

Population name	Density (plants / km²)	Number of plants recorded
Torra Conservancy	4.669	43
RUL	7.024	226
Hoopverloor	48.37	111
Garden route	110.7	111
Drainage divide - Nadas & Munitum	123.6	76
Terrace Fountain - Gai Ais	133.3	45
Gai Ais - Huab River	149.3	58
Tsiseb Conservancy	179	123
Valencia	213.8	412
Munitum valley - SKP boundary	282.1	72
Usakos-Henties Bay road	443.7	43
Leeukop	2111	871
Urikos-West	Not calculated	159

Green: High density/Large population
Yellow: Low density/Large population
Blue: High density/Small population

Appendix 3 maps the distribution of *A. pechuelii* on ETM Landsat 7 images. Figure f maps RUL and the prospective Valencia Uranium mine, respectively, and demonstrates how the densities at the two populations compare. From this image it appears that the distribution of the plants at Valencia is highly clumped, as opposed to the plants at RUL which appear to be widely scattered at this distance. At ground level, *A. pechuelii* plants occur in small groups of usually between 2 and 10 plants, and in many cases solitary. In the population at RUL, these groups or single plants are much further apart than those in the Valencia population and this is evident in the satellite images.

Discussion

Accurate information pertaining to factors threatening plant populations as well as their distribution and abundance is usually very scant. The time and resources required to conduct a detailed survey on any species of conservation concern makes it expensive to undertake. The funding received for this project therefore presented a rare opportunity to conduct a detailed survey on *Adenia pechuelii.* The project also highlighted the importance of conducting field assessments. At the start of the project, it was thought that individuals of *A. pechuelii* are few and far between, but current information reveals that there are large populations in terms of numbers of individuals and the size of the area that they occupy (Figure 3, Table 1). However, it should be noted that in addition to herbarium records (WIND 2006), few new localities of *Adenia pechuelii* were investigated. It is therefore most likely that other populations exist, especially in more remote areas.

Surveying populations of *A. pechuelii* was revealed to be more challenging than anticipated at the start of the project. At the time when the concept note was developed, the available information about *A. pechuelii* indicated that plants are few and scattered. This created the impression that it would be feasible to count all individuals in a population. This idea was enhanced when field work at RUL started because within the license area, *A. pechuelii* does indeed occur either individually, or in small groups of 2-10 plants. It was therefore possible to get a fairly accurate indication of the number of *A. pechuelii* plants within the RUL license area, despite the fact that workers had to cover long distances over rugged terrain in order to survey the population. However, once assessments started in other areas, it became apparent that most populations extend over several kilometres, covering large areas, and it became very difficult to record every single individual. The populations at Leeukop in the Namib Naukluft Park, RUL and Valencia were the only large populations for which an attempt was made to record all the plants. The population at Leeukop could be extensively surveyed because the plants are confined to a relatively small inselberg. Despite its relative small size and isolation, it took ten days to survey this population. It became clear then that recording individual plants is extremely time consuming and that this would be difficult to achieve for all populations that were surveyed. Absolute counts were obtained for only four populations, namely Leeukop, Valencia, RUL and the one in the Munitum valley on the Skeleton Coast Park (SCP) boundary.

The high density of *A. pechuelii* at Leeukop can be explained by the fact that all the plants occur on a single inselberg which covers a very small area. In contrast, the population at RUL, with most plants being far apart, has the second-lowest density of the surveyed populations (Table 1).

The population at the Valencia Uranium mine is the only one for which the height of all the individuals were measured and therefore the percentage of small plants recorded here (17%) is fairly accurate. It is reasonable to say that the recruitment in this population seems to be fairly healthy.

The way that *A. pechuelii* plants are distributed over the RUL license area naturally spreads the risk of the plants being damaged or destroyed. This is not the case at Valencia, where the impacts of mining activities could have a devastating effect on that important population.

Red List / Conservation status of *A. pechuelii*:

The Red List assessment that was conducted on *A. pechuelii* for the Red Data Book (Loots 2005) was largely based on data from literature, herbarium specimens and expert opinion. It suggested that plants are mostly uncommon to rare and occur in small groups. It was inferred that there are at most 2,500 mature individuals in the species, and it was estimated that there has been a population reduction of up to 25 % in the past. It was also suspected that there is a continuing decline in the number of mature individuals and that no sub-population contained more than 70 mature plants. Based on this information, a Red List status of NT was assigned.

The more detailed knowledge that was accumulated during this survey revealed that there are at least 2,671 individual plants left in the wild and that the largest population contains more than 800 plants. Strengthened by the current knowledge that some populations occupy extensive areas, the number of mature plants left in the wild is now estimated to be between 3,000 and 5,000. The mining activities at RUL may have resulted in a small population reduction, but it is highly unlikely that it was as high as 20-25%. There is currently no evidence that there is a continuing decline in the number of mature individuals in any population, although this is still possible. Based on this new information, the national Red List status is therefore down-listed from NT to LC. This simply means that a taxon has been evaluated against the current IUCN criteria and does not qualify for the Critically Endangered, Endangered, Vulnerable or Near Threatened categories (IUCN 2001). A regional assessment will strengthen this status as the species is not endemic to Namibia.

The fact that *A. pechuelii* is not threatened with extinction, does not mean that it is not of conservation importance. On the contrary, although it is difficult to determine the age of *A. pechuelii* plants, it is reasonable to assume that they are extremely slow growing and that large individuals may be several hundreds of years old. In addition, field work that was conducted suggests that seed setting is poor (Jankowitz & Loots 2008) in all the populations that were surveyed which would result in poor recruitment of juvenile plants as well. Indeed in most populations, less than 10% of the plants were small and in the long term, this may prove to be a threat to the survival of the species. Populations with poor recruitment will be vulnerable to illegal collecting, trade in pachycauls and possibly climate change (Loots 2005). The IUCN Red List classification system does not currently take poor recruitment into account.

The work conducted through the partnership has resulted in an increase in important information on *A. pechuelii*. The more detailed knowledge that now exist means that population size can be estimated with a fair degree of accuracy, whereas previously these numbers had to be guessed.

The support provided by Rio Tinto, RUL, the NBRI and RBG (Kew) to conduct Red List assessments has been particularly beneficial to the Namibian National Plant Conservation objectives as it provided a basis for the monitoring of populations of *A. pechuelii*. The trend to tag plants as a means of monitoring populations can be applied to other species of conservation concern, especially threatened species, as an ongoing activity of the Threatened Plants Programme of the NBRI.

The support provided by RUL enabled them to make a valuable contribution to the conservation and management of *A. pechuelii*, both inside and outside their license area. It is hoped that the commitment by RUL and Rio Tinto will serve as an example to be followed by other mining companies.

The recruitment in populations of *A. pechuelii* should be monitored, as poor recruitment will lead to a population decline in the long term, a potential threat. Recent work conducted on *Aloe pillansii* in the south of Namibia concluded that the species is more threatened than previously thought because no small plants could be found (T. Hoffmann *Pers. comm.*).

More work could be conducted on population biology and demography, for example determining the age of plants, at what age they begin their reproductive cycle and what the size of the main stem is at this stage. A study could be carried out on the differences between the flowering times of male and female plants to shed light on the reasons for poor seed setting in many populations.

Further studies could be carried out to determine population boundaries in *A. pechuelii*. This would aid in estimating population sizes which in turn would be valuable in reviewing the conservation status of the species.

Molecular studies could reveal the degree of genetic diversity within and between populations of *A. pechuelii,* which is important in genetic conservation. Populations that are genetically very diverse have a better chance of survival than those that are genetically more uniform or that have lost a significant portion of their gene pool.

Conclusion

The following key findings should be noted:

- Some 2671 individuals of *A. pechuelii* were recorded during the survey;
- RUL harbours approximately 8 % of these, scattered over a large area;
- The prospective Valencia Uranium mine harbours approximately 17% of these, all concentrated in a rather small area;
- Leeukop harbours approximately 32 % of these, also concentrated in a very small area;
- Conserving these three populations, which together harbour almost 60 % of the plants recorded during the survey, is critical;
- The national Red List status is changed from Near Threatened to Least Concern;
- *A. pechuelii* remains a conservation concern due to its slow growth rate, poor seed production and subsequent poor recruitment;
- It is higly likely that there are more populations yet unrecorded;
- Research efforts are needed to investigate various aspects, including genetic diversity, demographic aspects and monitoring survival rate.

Acknowledgements: I am grateful to Rio Tinto who provided the funds to conduct the field work and obtain equipment for the work. RUL provided financial support for field work that was conducted within their license area. RUL staff provided logistical assistance during assessments in the license area. They also provided data in the form of maps for the RUL license area and are gratefully acknowledged for their support. Ben Strohbach of the NBRI assisted with mapping and data analyses, for which I am extremely grateful. Most of the transport costs as well as much of the daily subsistence allowances were covered by MAWF. Support from the SADC Plant Genetic Resources Centre (SPGRC) is also acknowledged. The following people are gratefully acknowledged for various inputs: E. Klaassen, E. Lucas, E. Kwembeya, R. Moses, S. Rügheimer, G.Maggs-Kölling, J. Irish, M. Hochobes, H. Haufiku, D. Lutombi, A. Engelbrecht, H. Kolberg, T. Tholkes, Y. Mupupa, R. Schneeweiss, S. Bachman, G. Marchant, S. Laws, C. Mannheimer, A. Burke, L. Menge, D. Shaw, M. Tsoubeb, S. Groves, K. Nott, J. Mannheimer, A. Loots, B. Calitz and M. Rusch.

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Appendix 1

Management and monitoring plan for *A. pechuelii*

Background

This study provided more clarity with respect to where the densest and some of the largest populations of *A. pechueilii* are located and how the populations at RUL compare to other populations across the distribution range of this species.

An important output of this project was to develop a simple species management and long-term monitoring strategy for *A. pechuelii.*

The species management and monitoring plan aims to capture the results from both conservation assessments and seed conservation activities and make specific *in-situ* and *ex situ* management recommendations. The long-term monitoring strategy will enable the assessment of changes in the status of populations. This will include, but not be limited to, follow-up field assessments between 2013 and 2015. It will enable the NBRI to review the Red List status, and, if possible, evaluate any reasons for changes in the populations of target species and make subsequent recommendations to RUL and MET accordingly.

Management, Conservation and Monitoring Recommendations

These recommendations focused on protecting the plants *in situ*, as the preferred conservation measure, complemented by *ex situ* conservation actions and the long term monitoring of the species.

In situ management and conservation:

The following recommendations are made:

1. RUL management should consider special protection of areas that were identified as important for *A. pechuelii* (Figure 5).

2. Maps should be distributed and appropriate staff or contractors informed on locations of important areas for *A. pechuelii*, in order to ensure that as many as possible plants are protected from destructive activities like bulldozing for road construction, sand and gravel harvesting etc.

3. The Ministry of Environment and Tourism should be made aware of the importance of the population at Leeukop in the Namib Naukluft Park. This responsibility should be taken up by the NBRI.

Ex situ management and conservation:

During the course of the project, 5 accessions of *A. pechuelii* were collected and banked at either the NPGRC or the Millennium Seed Bank in the UK, but none of them contained more than 50 seeds, which is nowhere near the international standard of 1,000 seeds to be banked by the NPGRC and duplicated at the MSB in the UK. To facilitate future restoration work (post mine closure) and to provide a long-term insurance strategy for these plants, banking of seeds is a high priority.

The field work conducted from 2006 to 2008 proved that finding enough seeds per population to bank according to international standards is a challenge and events where most plants in a population are setting fruit at the same time are rare. In addition, capsules are often empty or seeds not fully developed (*pers. obs*). Flowering occurs between February and June (Curtis & Mannheimer 2005), but was also observed during July and August (*pers. obs*). Plants were found

in fruit in March, May, June and August. Plants will probably flower and fruit after good rains, but it is possible that flowering and fruiting can take place on a small scale throughout the year.

The following recommendations are made:

1 Finding a sufficient number of seeds to bank would mean monitoring of the population at RUL on a regular basis, e.g. once a month to ensure that optimal use can be made of the opportunity when a population is in fruit, especially after every rainy season. Following that, seeds should be collected whenever they are available. It should also be kept in mind that the large red fruit is attractive to birds.

2 If any *A. pechuelii* plants are in the way of development taking place at RUL – i.e not be possible to leave them in their natural habitat – they should be carefully removed so that the root system remains as intact as possible. Arrangements should then be made with the NBRI, for them to be planted in the desert house, or distributed to other botanic gardens or to be transplanted on the site.

3 A good number of plants are easily accessible along routes and tracks in the license area and they could be pointed out to RUL environmental staff if necessary.

Long-term monitoring of *Adenia pechuelii*

After the project started it was deemed necessary to be proactive with regards to the monitoring of populations of *A. pechuelii*. Some 400 plants from four of the larger populations were fitted with metal tags in order to detect changes in these plants over time. A maximum of 100 plants per population were tagged, with each tag having a unique number. This number and the GPS coordinates were recorded so that they can be easily located. In addition to tagging the plants, the height of the main stem was measured in order to try to determine the growth rate of the tagged plants in the long term.

After the project ended, 100 plants were tagged at RUL in 2010. The tagged plants are spread over several different zones of use e.g. the Tailings area, the visitors parking area, the sand pit area and the dome gorge. This ensured that the tags are distributed over several biotopes. A field data sheet was designed to capture data for each of the plants that were tagged at RUL. A photograph was taken of each tagged plant for later comparisons during monitoring sessions. A RUL staff member participated in this exercise.

The following recommendations are made for the *A. pechuelii* population at RUL:

1. The data sheet should be adapted for future monitoring sessions. The NBRI should take responsibility for this.

2. The first round of monitoring of the tagged plants should be conducted between 2013 and 2015 and thereafter every five years. This should also be done in other populations that were tagged at roughly the same time. RUL and the NBRI should take responsibility for this.

3. A map should be produced of all the tagged plants at RUL and forwarded to RUL. The NBRI will take responsibility for this.

Appendix 2

Photographs of *Adenia pechuelii* taken at various populations over the distribution range of the species

a)

b)

c)

d)

e)

f)

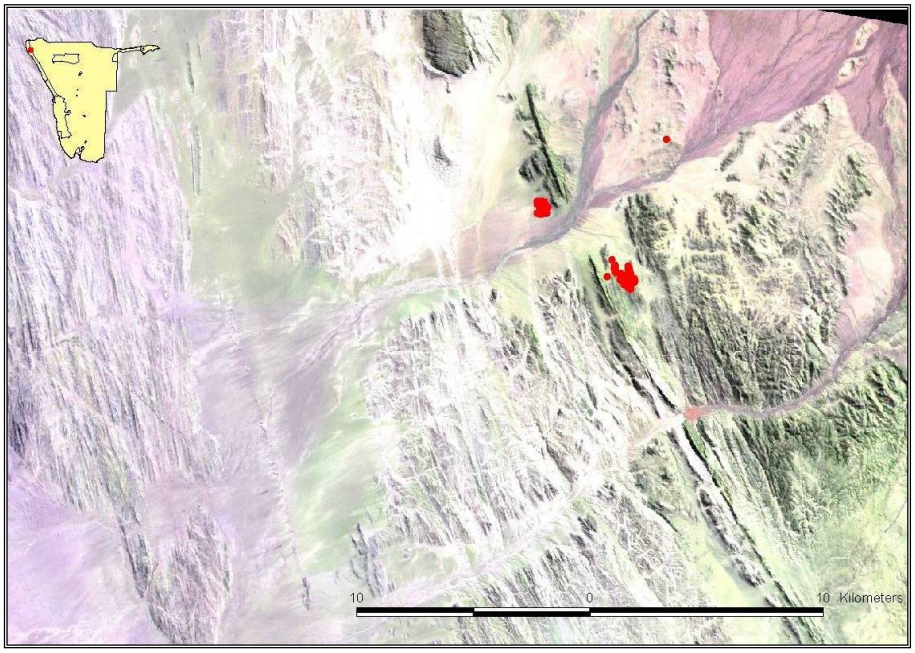
g)

a) Caterpillar browsing on leaves of *Adenia*, b) One of the larger specimens at RUL, c) A small plant at Rössing, d) Specimens with leaves are not often observed, e) An unusual form, growing out of a rock face, f) A very small plant, growing out of a rock face, & g) View onto Munitum valley with *Adenia*.

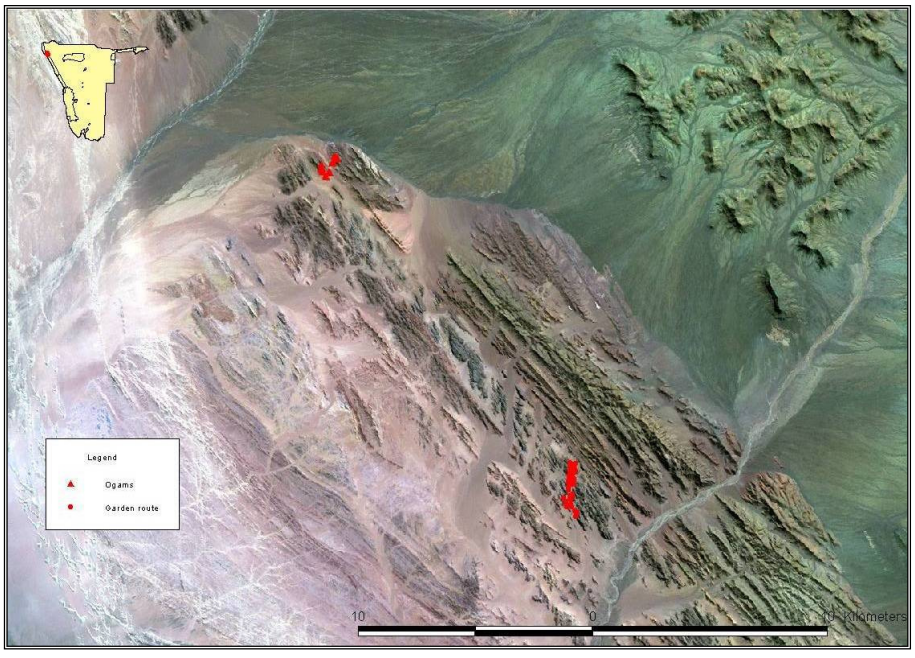
Appendix 3

Satellite images indicating the location of surveyed populations of *Adenia pechuelii*

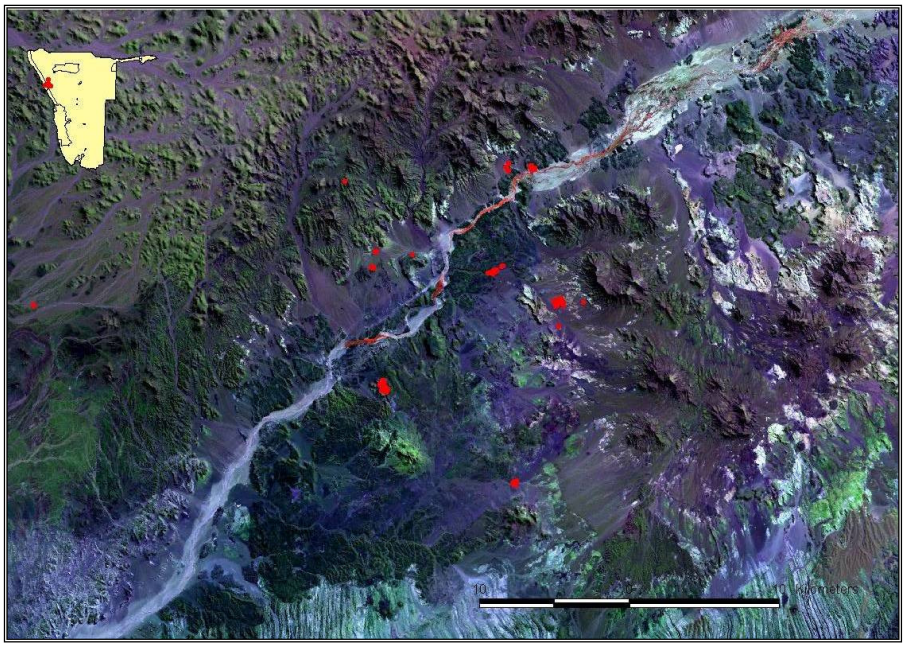
Figures a to g indicate the location of some of the surveyed populations of *A. pechuelii* as they were mapped on ETM (Landsat 7) satellite images, starting from the northernmost populations and then proceeding southward.



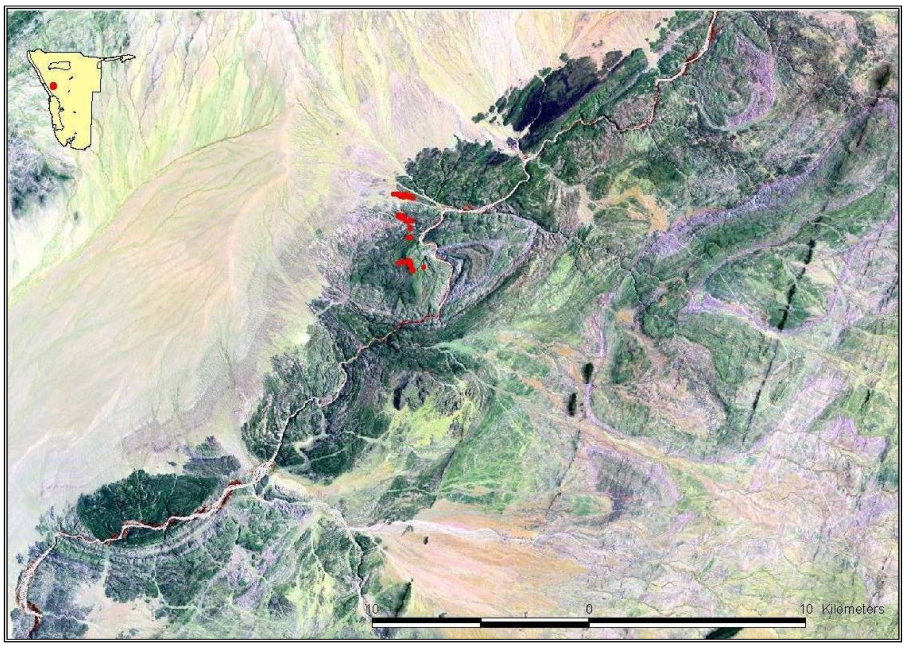
a. Populations of A. *pechuelii* north of the Munitum River on the SKP boundary and between the Munitum and Nadas Rivers



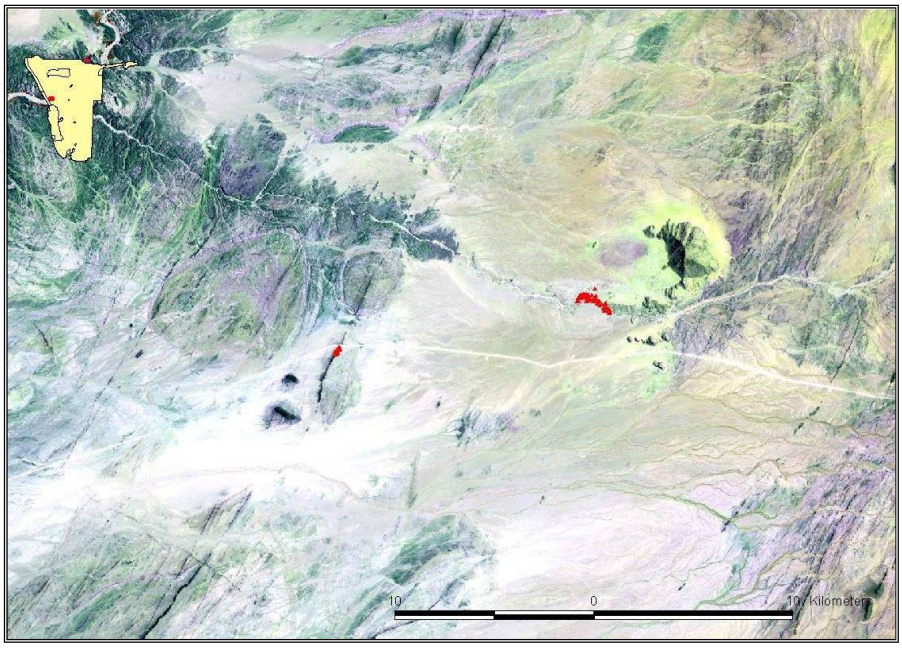
b. Populations of *A. pechuelii* in the “Garden Route” north of the Khumib River and south of the Ogams Fountain



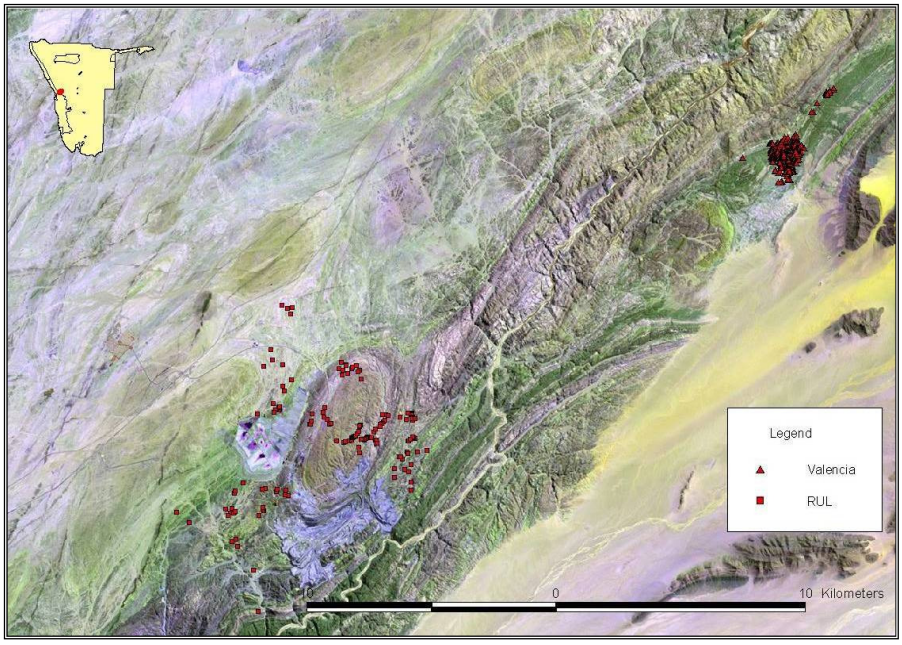
c). Populations of *A. pechuelii* in the vicinity of the Terrace Fountain north and south of the Huab River



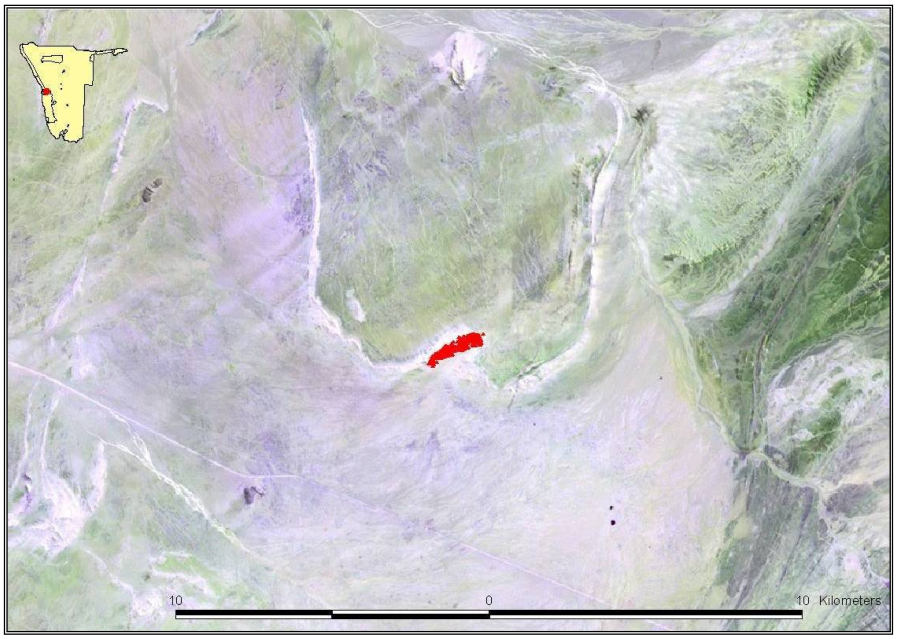
d) Population of *A. pechuelii* north of the Omaruru River in the Tsiseb conservancy



e) Populations of *A. pechuelii* south-west of the Spitzkoppe and on the road between Hentiesbay and Usakos



f) Populations of *A. pechuelii* at RUL and the Valencia Uranium mine



g) Population of *A. pechuelii* at Leeukop in the NNP, NE of the Vogelfederberg

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Short Communication

An annotated plant checklist of the southern Nubib Mountains (2516AA)

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Plant collecting in the southern Nubib Mountains in the western Hardap Region in March 2012 by the National Botanical Research Institute nearly tripled the plant species list for this quarter degree square. Some of the species recorded indicate that the mountain range forms an important link between two species-rich areas along the central escarpment – the Naukluft Mountains and the granite koppies at Aus.

The central-southern escarpment in Namibia – the area between the Naukluft Mountains and Aus – has been highlighted as an area that warrants more botanical collecting. It is expected to form a corridor between these two botanically well-known and species-rich areas (Maggs *et al.* 1994). Establishing whether plants show continuous distributions or occur in isolated populations is an important biogeographic question with implications for the conservation of rare species (Murray & Lepschi 2004). Knowledge about plant distributions is required in landscape-level planning and to facilitate the zonation of areas according to different conservation priorities (Wilson *et al.* 2009). This helps to optimize decisions on appropriate land uses. The Nubib Mountains fall into one of the pilot areas of the Namibia Protected Landscape Conservation Areas Initiative – the Greater Sossusvlei-Namib Landscape (MET 2011). To have good spatial information on plant species in this area at this early stage is important.

Methods

Study area
The Nubib Mountains form part of the south-western escarpment in Namibia. They are composed of biotite granite of the same age as the Gamsberg granite, 1100 million years old and belong to the Rehoboth Sinclair Complex (Grünert 2000; Miller 2002). The Nubib Mountains range between 1900 and 2000 m above mean sea level, and rank 15th in terms of importance amongst Namibia's 39 key mountain areas based on topography (Irish 2002).

Plant collecting took place during the period 19-23 March 2012, largely on the mountains and in a valley between two mountain ridges. Species lists were compiled for the quarter degree square that contains the southern portion of the Nubib Mountains, largely on the farms Uitkyk, Nubib and Eckberg. The farm had experienced an average rainy season, with the last recorded rainfall prior to the field survey in early February 2012. No rainfall records were available from the mountain area, but four showers were observed by the owners in the mountain in late January and early February 2012.

Results and Discussion

63 plant species had been collected in this quarter degree square during previous collections. 143 plant species were added to the Herbarium collection during the 3 days of plant collecting in 2012. An additional 34 additional observational records were added to the plant species list (e.g. Figure 1). The plant species lists for this grid now totals 240 species (See Appendix 1).

Figure 1. This member of the mint family, *Mentha longifolia* subsp. *capensis* is rare in Namibia and grows largely in mountain areas (Photo by S. Rügheimer).

New distribution records of interest are a record of the recently re-instated *Cyphostemma seitzianum* and *Selago lepida* (Figures 2 & 3). *Cyphostemma seitzianum* was formerly lumped with *C. bainesii*, but has now been recognized as a separate species (E. Retief, in prep). A record of the attractive herb *Selago lepida* confirms that the plant's range extends along the central-southern escarpment, forming a connection between the populations in the Huns Mountains and those on the Brandberg.

Figure 2. Very similar to *Cyphostemma bainesii*, this low stem succulent has recently been re-instated as *C. seitzianum* in Namibia (Photo by S. Rügheimer).

Figure 3. Growing in higher altitudes in the Nubib Mountains, *Selago lepida* is an attractive perennial herb (Photo by A. Burke).

Some species that had previously been recorded in this grid are also worth mentioning. The rare climber *Cucumella clavipetiolata* is restricted to this section of the escarpment, and inselbergs to the west in this area, but there is also an isolated population on the Brandberg. The dwarf stem succulent *Euphorbia namibensis* has its northern-most distribution boundary here, while the southern Namib sand-sea endemic *Sesamum abbreviatum* has its eastern-most distribution in this quarter degree square.

Although the dedicated effort of a team of botanists tripled the previous plant collections for this quarter degree square, the inventory is by no means complete.

Implications for management

The compiled plant species list can assist to identify areas of conservation importance along the central-southern escarpment and can inform the development of guidelines for management. Apart from the relatively high plant diversity for this arid area, a number of Namibian endemic plant species occur which contribute to the importance of the Nubib Mountains for conservation. Some introduced species were also recorded, largely near the farm houses and where water is available permanently. However, some large *Ricinus communis* plants were also recorded in the valleys in the mountains and these should be eradicated to prevent them from spreading. It is likely that birds had dispersed the seeds to these areas.

Acknowledgements: We are grateful to our host Christoph Schumann who provided logistic support and encouraged work on his farm, and to an anonymous reviewer whose comments helped to improve the manuscript.

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Appendix 1

Plant species of the southern Nubib Mountains recorded in quarter degree square 2516AA

Plant species	Growth form	Common name(s)	Distribution
Abutilon dinteri	Perennial herb		
Abutilon pycnodon	Perennial herb		
Acacia erioloba	Tree	Camelthorn	
Acacia hebeclada subsp. hebeclada	Shrub	Candlepod acacia	
Acacia hereroensis	Tree	Mountain thorn	
Acacia karoo	Tree	Sweet thorn	
Acacia mellifera subsp. detinens	Tree / shrub	Blackthorn	
Achyranthes aspera	Herb		Introduced
Acrotome pallescens	Shrub		
Adenolobus garipensis	Shrub	Butterfly leaf/Gariep neat's foot	
Adenolobus pechuelii	Shrub		
Aloe dichotoma	Tree	Quiver tree	
Amaranthus thunbergii	Herb	Pigweed, Red devil	
Amphiasma divaricatum	Dwarf shrub		Endemic
Anthephora pubescens	Grass	Wool-grass	
Antiphiona pinnatisecta	Shrub		Endemic
Aptosimum lineare	Shrub		
Aptosimum lugardiae	Herb		
Aptosimum spinescens	Shrub		
Argemone ochroleuca	Herb		Introduced
Aristida adscensionis	Grass		
Asparagus pearsonii	Perennial herb		
Barleria lanceolata	Dwarf shrub		Endemic
Berkheya chamaepeuce	Shrub		
Berkheya spinosissima	Shrub		
Blepharis grossa	Herb	Little desert thistle	
Blepharis mitrata	Herb		
Blepharis pruinosa	Shrub		
Boerhavia hereroensis	Herb		
Boerhavia repens subsp. repens	Herb		
Boscia albitrunca	Tree / shrub	Shepherd's tree	

Boscia foetida	Tree / shrub	Smelly shepherd's tree	
Brachiaria glomerata	Grass		
Brownanthus pseudoschlichtianus	Shrub		
Cadaba aphylla	Shrub		
Calicorema capitata	Shrub	Star of the Namib	
Calostephane divaricata	Herb		
Cardiospermum pechuelii	Shrub		
Catophractes alexandri	Shrub	Trumpet thorn	
Cenchrus ciliaris	Grass	Bloubuffel grass	
Chascanum garipense	Herb	White chascanum	
Cheilanthes marlothii	Fern		
Chenopodium amboanum	Herb		Endemic
Cladoraphis spinosa	Grass	Spiny love grass	
Cleome angustifolia subsp. diandra	Herb	Yellow mouse-whiskers	
Cleome elegantissima	Herb		
Cleome suffruticosa	Perennial herb	Shrubby cleome	
Codon royenii	Perennial herb		
*Codon sp nov **A***	Perennial herb		Endemic
Commicarpus fallacissimus	Herb		
Commiphora glaucescens	Tree	Blue leaved corkwood	
Commiphora tenuipetiolata	Shrub	Satin-bark corkwood	
Corallocarpus welwitschii	Climber		
Crotalaria damarensis	Herb	Rattle bush / wild Lucerne	
Crotalaria leubnitziana	Herb		
Cryptolepis decidua	Shrub		
Cucumis africanus	Herb		
Cucumella cinerea	Climber		
Cucumella clavipetiolata	Herb		Endemic
Cucumis cf. africanus			
Cucumis meeusei	Herb		
Cucumis sagittatus	Herb		
Cymbopogon pospischilii	Grass		
Cyperus fulgens	Sedge		
Cyperus marginatus	Sedge		
Cyperus schinzii	Sedge		
Cyphostemma seitzianum	Succulent	Gouty vine	Endemic
Dactyliandra welwitschii	Herb		

Dicoma capensis	Herb		
Dimorphotheca polyptera	Herb		
Dipcadi platyphyllum	Lily		
Dombeya rotundifolia	Tree / shrub	Wild pear	
Drosanthemum lique	Dwarf shrub		
Drosanthemum subcompressum	Dwarf shrub		
Dyerophytum africanum	Shrub	Desert statice	
Emilia marlothiana	Herb		
Enneapogon cenchroides	Grass	Common nine-awned grass	
Enneapogon desvauxii	Grass		
Enneapogon scaber	Grass	Rock nine-awned grass	
Enneapogon scoparius	Grass		
Eragrostis annulata	Grass		
Eragrostis biflora	Grass		
Eragrostis nindensis	Grass	Perennial love grass / Whether love-grass	
Eragrostis porosa	Grass		
Eragrostis scopelophila	Grass		Endemic
Eriocephalus scariosus	Dwarf shrub		
Euclea undulata	Shrub	Common guarri	
Euphorbia avasmontana	Succulent	Slender candelabra-euphorbia	
Euphorbia glanduligera	Herb		
Euphorbia guerichiana	Shrub		
Euphorbia lignosa	Shrub		Endemic
Euphorbia mauritanica var. mauritanica	Shrub		
Euphorbia namibensis	Succulent		Endemic
Euphorbia virosa	Succulent		
Euryops subcarnosus subsp. vulgaris	Shrub		
Felicia smaragdina	Herb		Endemic
Ficus cordata	Tree	Namaqua fig	
Ficus ilicina	Shrub	Rock-splitting fig	
Fingerhuthia africana	Grass		
Forsskaolea hereroensis	Herb	Namib nettle	
Galenia africana	Dwarf shrub		
Galenia dregeana	Herb		
Galenia papulosa	Herb		
Garuleum schinzii subsp. schinzii	Herb		
Geigeria acaulis	Herb		

Geigeria alata	Herb		
Geigeria ornativa	Herb	Vermeerbossie	
Gisekia africana var. africana	Herb		
Grewia flava	Shrub		
Grewia tenax	Shrub	Small-leaved white cross-berry	
Helichrysum candolleanum	Herb		
Heliotropium ciliatum	Herb		
Heliotropium hereroense	Herb		
Hermannia helianthemum	Herb		
Hermannia minutiflora	Dwarf shrub		
Hermannia modesta	Herb		
Hibiscus elliottiae	Shrub		
Hibiscus engleri	Forb		
Hirpicium gazanioides	Herb		
Pomaria lactea	Herb		
Hypertelis salsoloides	Herb		
Indigastrum argyrea	Herb		
Indigofera charleriana	Perennial herb		
Indigofera auricoma	Herb	Pink desert indigofera	
Indigofera cryptantha	Herb		
Indigofera vicioides	Herb		
Jamesbrittenia glutinosa	Herb		
Kissenia capensis	Shrub	Sandpaper bush	
Kleinia longiflora	Succulent	Sjambokbos	
Kohautia caespitosa subsp. brachyloba	Herb		
Laggera decumbens	Perennial herb		
Lantana dinteri	Shrub		
Launaea intybacea	Herb		
Lepidium africanum	Herb		
Leucosphaera bainesii	Dwarf shrub	Wolbos / silwerbossie	
Leucas pechuelii	Perennial herb		Endemic
Limeum argute-carinatum	Herb		
Limeum myosotis	Herb		
Lithops gesineae var. gesineae	Succulent		Endemic
Lophiocarpus polystachyus	Herb		
Lotononis falcata	Herb		
Lycium bosciifolium	Shrub		

Maerua schinzii	Tree		
Manulea dubia	Herb		
Melhania damarana	Herb		
Melinis repens subsp. grandiflora	Grass	Natal red top	
Mentha longifolia subsp. capensis	Herb		
Mollugo cerviana	Herb	Namibian Gypsophyllum	
Mollugo walteri	Herb		Endemic
Monechma cleomoides	Dwarf shrub	Namib perdebos	
Monechma divaricatum	Perennial herb		
Monechma leucoderme	Dwarf shrub		Endemic
Monsonia senegalensis	Herb		
Montinia caryophyllacea	Shrub	Wild clove-bush	
Moringa ovalifolia	Tree	African moringa	
Myrothamnus flabellifolius	Dwarf shrub	Resurrection bush	
Nelsia quadrangula	Herb		
Nemesia fruticans	Herb		
Neorautanenia mitis	Herb		
Nerine laticoma	Lily		
Nymania capensis	Shrub	Chinese Lanterns	
Ocimum americanum var. americanum	Herb		
Ornithogalum stapffii	Lily		Endemic
Orthanthera albida	Shrub		
Osyris lanceolata	Shrub		
Otoptera burchellii	Shrub		
Ozoroa crassinervia	Tree	Namib resin tree	
Panicum maximum	Grass		
Parkinsonia africana	Tree		
Pavonia rehmannii	Dwarf shrub		Endemic
Pechuel-Loeschea leubnitziae	Shrub		
Peliostomum leucorrhizum	Perennial herb		
Pellaea calomelanos	Fern		
Pentarrhinum insipidum	Climber		
Pentatrichia petrosa	Shrub		
Pentzia pinnatisecta	Herb		
Pergularia daemia var. leiocarpa	Climber		
Petalidium setosum	Shrub	Namib petal-bush	
Phaeoptilum spinosum	Shrub		

Phyllanthus maderaspatensis	Herb		
Phyllanthus pentandrus	herb		
Polygala guerichiana	Herb		Endemic
Portulaca oleracea	Herb		Introduced
Prosopis glandulosa	Tree		Introduced
Psiadia punctulata	Shrub		
Pteronia cylincracea	Dwarf shrub		
Pteronia eenii	Dwarf shrub		Endemic
Pteronia lucilioides	Dwarf shrub		
Pteronia polygalifolia	Shrub		Endemic
Ptycholobium biflorum	Perennial herb		
Pupalia lappacea	Herb		Introduced
Phyllanthus fraternus	Perennial herb		Introduced
Requienia sphaerosperma	Herb		
Rhigozum trichotomum	Shrub	Driedoring	
Searsia burchellii	Shrub		
Searsia marlothii	Shrub		
Ricinus communis	Shrub	Caster oil plant	Introduced
Salsola aphylla	Shrub		
Sarcocaulon marlothii	Shrub	Bushman's candle	Endemic
Sarcostemma viminale	Shrub	Bobbejaantou	
Schinus molle	Tree		Introduced
Schmidtia kalahariensis	Grass	Annula bushman grass	
Selago kurtdinteri	Shrub		
Selago lepida	Perennial herb		Endemic
Senecio flavus	Herb		
Senecio inaequidens	Herb		
Senna italica subsp. arachoides	Herb		
Sericocoma heterochiton	Herb		
Sericorema sericea	Herb		
Sesamum abbreviatum	Herb	Wild sesame	Endemic
Sesamum capense	Herb		
Setaria appendiculata	Herb		
Setaria verticillata	Grass	Bur bristle-grass / rough bristle-grass	
Sida ovata	Herb		
Solanum burchellii	Shrub		
Solanum nigrum	Herb		Introduced

Solanum rigescens	Shrub	
Stipagrostis ciliata var. capensis	Grass	
Stipagrostis namaquensis	Grass	River bushman-grass
Stipagrostis obtusa	Grass	
Stipagrostis uniplumis var. uniplumis	Grass	
Striga gesnerioides	Root parasite	
Talinum caffrum	Herb	
Tapinanthus oleifolius	Parasite	
Tephrosia dregeana	Herb	
Tetragonia calycina	Shrub	
Thamnosma africana	Shrub	
Thesium lineatum	Shrub	
Tragus racemosus	Grass	
Trianthema parvifolia var. parvifolia	Herb	
Tribulus cristatus	Herb	Dubbeltjie / Devil's thorn
Tribulus terrestris	Herb	
Tribulus zeyheri	Herb	
Trichodesma africana	Herb	
Tricholaena monachne	Grass	
Tripteris microcarpa subsp. microcarpa	Herb	Tall desert daisy
Triraphis purpurea	Grass	
Triraphis ramosissima	Grass	
Trochomeria debilis	Herb	
Withania somnifera	Herb	
Ziziphus mucronata	Tree	Buffalo thorn
Zygophyllum pubescens	Shrub	

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Book Review

111 Roadside plants

By Antje Burke

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The popularity and success of any quick reference field guide depends upon it striking a balance between providing too little information, and trying to be comprehensive and all inclusive. Antje Burke's *111 Roadside plants* documents 34 tree species, 32 shrubs and dwarf shrub species, 22 short lived species and 13 grass species and promises to be a handy travelling companion.

The book is soft covered, A5 size, 148 pages in content and each species is succinctly profiled on one page. Equal weight is given to the general description, distribution and uses and adaptations of each species. In addition there are at least two photographs illustrating each species' general form and its flowers, leaves or fruits. Ghosted behind the text is a map of Namibia depicting the broad general distribution of each species. At first glance this seems distracting but, once tuned in, these maps provide an effective quick reference tool which has allowed the book to remain a light-weight, compact product.

The first thirty pages provide a brief insight into the biomes, vegetation types and ecological challenges facing the flora of Namibia including comments on specially adapted and unusual species, endemics, invasive aliens, plant harvesting, habitat rehabilitation, fire and climate change. This book, by definition, is not designed for the hard core botanists. With Palgrave's *Trees of Southern Africa*, the *Tree Atlas of Namibia,* Le Roux and Müller's *Field guide to trees and shrubs of Namibia* and Müller's *Grasses of Namibia*, comprehensive botanical works are available. This book is designed for the lay person, tourist and researcher wishing to enhance their enjoyment and appreciation of the Namibian outdoors. While many ecologists are familiar with the more common tree species how many can profess a knowledge of many (or any) of the dwarf shrubs and grasses? For those with no previous experience, attempting to acquire a working knowledge of trees, grasses or special plants in Namibia can be a daunting prospect. Burke's book provides an entry point into a discipline often coveted by scientists as a reserved arena and as such is a welcome addition to the literary resources available in the country. It complements some of the author's previous works (*Wild Flowers of the Central Namib* and *Wild Flowers of the Southern Namib*) as well as the guide books by Craven and Marais (*Namib Flora* and *Damaraland Flora*). *111 Roadside plants* has its place in the book case next to these and other field guides such as Newman's and SASOL's field guides to birds and Smither's *Mammals of Southern African* … ready to be scooped up and taken on the next expedition into the heart of Namibia.

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Book Review

Wildflowers of the Central Highlands of Namibia

By Coleen Mannheimer

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This book is the second of a series of guides to the flowering plants of Namibia planned by the National Botanical Research Institute. The first covered the biodiversity hotspot of the southern Namib and it is fitting that the second covers the central highlands of Namibia. As clearly explained by John Irish at the beginning of this book, the central highlands by virtue of its diverse geology, topography and climate provides a variety of habitats and niches for numerous plants and animals. This area that supports this high diversity of plants, including many endemics, is also one of the most highly populated and rapidly growing areas of the country. It is therefore important that an awareness of and interest in these plants is created because the area is vulnerable to development.

Wildflowers of the Central Highlands of Namibia covers over 450 species. As the name suggests, it focuses on wildflowers – herbs, small and dwarf shrubs and bulbs. Only the most common of woody shrubs are described, as well as the more conspicuous ferns, grasses and sedges. No trees are described – but these and other woody plants are comprehensively covered in *Le Roux and Müller's Field Guide to the Trees and Shrubs of Namibia* (Mannheimer & Curtis, 2009). Each species described in *Wildflowers of the Central Highlands of Namibia* is illustrated with photographs, usually showing the whole plant, as well as a close-up of flowers and/or fruits. Almost all of these photographs are of a high quality and for many of us, who are not necessarily plant specialists, provide a useful and first point of departure in identifying a wildflower.

The plants are presented in phylogenetic order, starting with terrestrial ferns and grasses and working through more than 70 families to the daisies, and alphabetically within each family. For those not familiar with the characteristics of each family, the thought of paging through the whole book in identifying a wildflower, is a little daunting. Nevertheless, I tried it – and to my delight found it works and I managed to identify a number of flowers I collected around Windhoek after the rains that fell over the Easter weekend of 2013, and I'm certainly no plant expert. Presenting the species in this order has the benefits of being able to provide brief descriptions of the families and the more common genera close to the species and enables you to easily compare similar species and those of the same genera. This would not be as easy in flower guides that group species according to colour or growth form. A simple key to guide you to the relevant family or section of book would, however, be a useful addition.

Each species description provides not only the known common names of the plant in Namibia's main languages, but also the derivation of the scientific names (Latin or Greek). These derivations are very often useful in helping to remember identifying features of the plant. For example, *aptosimum* is Greek for 'not falling off', which aptly describes the genus of cheerful, purple flowers commonly seen even during the driest times; the species names, just as appropriate, refer to the white leaf edges (*albomarginatum*), preference for sandy habitats (*arenarium*) or long, slender leaves (*lineare*). Coleen further helps us in identifying the plants by generously sharing her knowledge gained from following her long-time passion by providing very useful hints to tell one species apart from others.

The species are comprehensively described, but with her vast knowledge, Coleen has been able to describe each species using the most important characteristics and keeping technical terms to a minimum. Those technical terms that are used are defined in the illustrated glossary at end of the book preceding the full index of scientific and common names. Useful information on flowering times of the plants in the central highlands, occurrence, and habitat preferences, as well as interesting facts on its conservation status, use and toxicity are incorporated into the discussion of each species.

In spite of covering so many plants in detail, the book is a manageable A5 size and weight for carrying in the field. It has a durable, flexible cover, which is strengthened by folded leaf extensions of the front and back covers and a glossy varnish finish. The book is a must for everyone with an interest in Namibia's flora – especially those residing in central Namibia – and provides an excellent training tool for environmental students and reference for tourism professionals.

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Other books in the series: Mannheimer, C, Maggs-Kölling, G, Kolberg, H & Rügheimer, S. 2008. *Wildflowers of the southern Namib*. Windhoek: Macmillan Namibia (Pty) Ltd. 312 pp.

Author's Guidelines

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Authors bear sole responsibility for the factual accuracy of their papers. Referees will review submitted papers and on their advice the Editor will accept or reject contributions. All refereeing is strictly confidential. Articles that contain less than 2,000 words may be considered for publication as a Short Communication, in which case no separate Introduction, Methods, Results and Discussion are necessary. Short Notes must contain References however, and Acknowledgements may be made if necessary.

Presentation: Contributions must be written in English. Authors can (optionally) publish a second abstract in a language of their choice. Please supply an electronic copy in Arial 11 font, single spacing, justified of the manuscript using WORD (6.0 or later). Photographs, figures, drawings and graphs can optionally be submitted in a general graphical form such as Windows Metafiles (*.wmf), GIF (for graphs), JPG or TIF. Please **do not embed** illustrations into the text.

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JANKOWITZ, W. J. 1983. Die plantekologie van die Waterberg Platopark. PhD thesis, University of the Orange Free State, Bloemfontein.

MENDELSOHN, J. & ROBERTS, C. 1997. An Environmental Profile and Atlas of Caprivi. Directorate of Environmental Affairs, Windhoek, Namibia.

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STOKING, M. A. 1994. Assessing vegetative cover and management effects. In: Lal, R. (ed.), Soil Erosion Research Methods, 2nd edition, pp. 211-232. Soil and Water Conservation Society and St. Lucie Press, Akeny / Delray Beach.

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