Chapter 13

Threats of Mining and Urbanisation on a Vulnerable Ecosystem in the Free State, South Africa

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Additional information is available at the end of the chapter

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1. Introduction

The Free State province is located in the central part of South Africa (Figure 1) and is approximately 1 300 m above sea level. The northern boundary is formed by the Vaal River with the Orange River forming the southern border. The Province covers an area of approximately 130 000 square kilometers comprising 10.6% of the total area of South Africa and has a population of almost 3 million people (southafrica.info 2012). Bloemfontein is the capitol with almost 370 000 residents and is located in the southern part of the Province.

Mining and agriculture are the major contributors to the province's economy. Various, coal, diamonds and bentonite mining activities occur throughout the province while approximately 120 000 square kilometres of land is used by the agricultural section for crop production and grazing purposes (southafrica.info 2012). These activities as well as the continued increase in human population numbers with resultant development of new infrastructure places stress on the natural environment.

A country's ability to conserve and sustainably manage its natural vegetation and water resources is reflected by its industrial potential and the standard of living of its people. Any injudicious utilisation of these natural resources will disturb the balance between the different components of the ecosystem and can have disastrous results for both humans and animals (Aucamp & Danckwerts 1989).

The environment consists of complex ecosystems within which a balance exists. Any disturbance in an ecosystem will affect the interactions between different species and therefore the natural resources available to different organisms. Vegetation is the most physical representation of the environment (Kent & Coker 1992; Kent 2012). Any changes environment whether

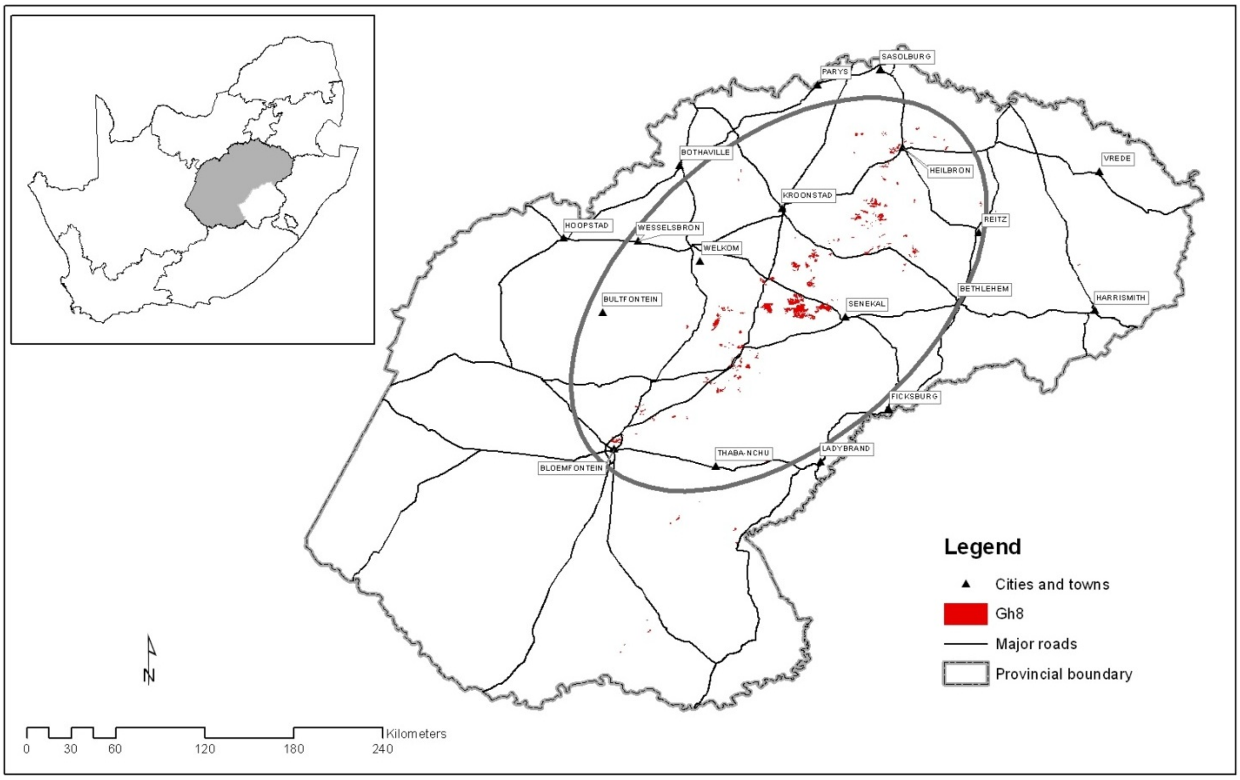

Figure 1. Locality of the Free State Province and the distribution of the Bloemfontein Karroid shrubland vegetation type (Gh8) in the Province.

it is as a result of pollution, development, droughts etc. is first seen in the vegetation and its species diversity and composition.

The term biodiversity refers to the diversity and number of plant and animal species on earth. Biodiversity conservation not only refers to the protection of all species, but also habitats, ecosystems and biomes (Brower *et al.* 1990; Van As *et al.* 2012). The diversity of species within an ecosystem is partly a reflection of the diversity of the physical environment. The more diverse the environment the higher the species richness is expected to be due to different microhabitats available for different plant and animal species (Van As *et al.* 2012). A diverse ecosystem contains a variety of genetic material that will ensure long-term stability and survival and also are less likely to be invaded by alien or pioneer species. Biodiversity conservation is very important for the survival of humans on earth. Each and every species on earth is important and crucial in an ecosystem. The loss of one species could lead to the loss of various others that in turn will have a chain reaction of events that could cause the destruction of one or many ecosystems.

The impact of humans on the environment is widespread and a cause for concern (Botha 2003). As the human population increased over time, people started to exert a bigger influence on nature (Grime 1997). The demand for land for housing, agriculture, mining and industries are increasing and so is demand for more food and water. The depletion of our natural resources to sustain our life styles causes large scale destruction of the environment. According to Van As *et al.* (2012) and Keddy (2007) the average ecological footprint of humans has reached

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a critical level and humans are destroying Earth at an unprecedented rate. Humans need to be aware of their actions and the effects it is having on our ecosystems and ultimately survival as a species.

The vegetation of the Free State Province of South Africa falls within the Grassland, Savanna and Nama-karoo biomes with grasslands forming the largest component. The Province has 34 different vegetation types (Mucina & Rutherford 2006). As previously mentioned large areas of these vegetation units are threatened and degraded due to various human actions (e.g. mining, development, agriculture). One of these vegetation units, the Bloemfontein Karroid Shrubland vegetation type (Gh8) (Mucina & Rutherford 2006) occurs as small islands scattered throughout the Province comprising a total area of 473.09 km^2 ha (0.004% of the Province). This very small vegetation unit's existence is under threat from mining, road construction and residential developments. If not properly protected and managed these areas and its unique plant species associations will be permanently destroyed.

The purpose of this chapter is to provide a broad description of the plant species associations and the species diversity of the Bloemfontein Karroid Shrubland vegetation type (Gh8) (Mucina & Rutherford 2006) and to provide guidelines to conserve this sensitive ecosystem. In this chapter we follow a broad plant phytosociological and floristic approach to describe the unique plant species and assemblages within this vegetation type.

2. Study area and methods

The Bloemfontein Karroid shrubland vegetation type (Gh8) (Mucina & Rutherford 2006) occurs as an archipelago of isolated patches on shallow dolerite outcrops within the Highveld grassland region of the Free State Province of South Africa (Figure 1). The vegetation is characterised by small-leaved dwarf karroid and succulent shrubs underlain by dolerite sheets of igneous origin (Figure 2). The soil is very shallow and gravelly with exposed rock outcrops prominent. In-between the rock crevices slightly deeper and less gravelly soil occur. A large proportion of the soil present on the rock sheets and those formed from the weathering of the rocks is washed into the adjacent lower-lying areas and depressions (Dingaan & Du Preez 2002).

The province is located within the summer rainfall area of South Africa and experiences warm to hot summers and cool to cold winters. Maximum temperatures are experienced in December and January (30.2°C) while June and July are the coldest months when the average daily temperature could drop to -1.6°C (Dingaan & Du Preez 2002). The eastern areas are prone to snowfalls especially on the higher-lying mountains while the western areas are more arid. The province receives approximately 580 mm of rain per annum with the highest rainfall between November and February.

In order to obtain a representative sample of the Bloemfontein Karroid Shrubland, a total number of 68 relevés (16 m^2) were surveyed within randomly stratified units of this vegetation type in various parts of the province. The data obtained is representative of five different stands of this vegetation type stretching from Bloemfontein in the south-west to the Willem Pretorius Nature Reserve in the north-east. The plot data were grouped into the five groups namely the Bloemfontein stand, the Winburg stand, the Willem Pretorius Nature Reserve stand, the Skoongesig stand and the Kareefontein stand. Habitat as well as floristic data was captured using TURBOVEG (Hennekens 1996; Hennekens & Schaminee 2001) and exported to JUICE (Tichý 2002) from where a raw table (Table 1-Annexure 1) was created for basic floristic interpretation. No formal phytosociological classification was done since the purpose of this study was not to obtain a formal classification, but to compare the different groups in terms of species richness and diversity.

Many people regard species richness and diversity as similar to species diversity. Species richness however refers to the number of species within an area or community (Kent & Coker 1992; Magurran 1988; Magurran 2005; Spellerberg & Fedor 2003). For this study species richness was calculated by determining the total number of species in each stand surveyed.

Species diversity refers to the diversity that occurs within a plant community or area and incorporates both species richness and the evenness of species' abundances (McGinley 2013). Species diversity is one component of the concept of biodiversity and is influenced by the relative abundances of different plant species present within the community. Various indices exist that measure both evenness and species richness into a single measure of species diversity (Stirling & Wilsey 2001). For the purpose of this study the Simpsons Index (Simpson 1949) as well as the Shannon-Wiener Species Diversity Index (Smith & Wilson 1996) was used to determine species diversity for each stand of the Bloemfontein Karroid shrubland surveyed in this study as expressed in the following formulas:

Simpson Index:

$$D = \sum \left(\frac{ni\,[ni - 1]}{N\,[N - 1]} \right) \tag{1}$$

Shannon-Wiener Index:

$$H' = -\sum_{i=1}^{S} pi(\ln pi) \tag{2}$$

Species richness (S), Simpson index if diversity (-ln (D)) and the the Shannon-Wiener index of diversity (H’) were calculated for each stand:

S=Richness (Number of species per community)

pi=is the proportion of individuals of a species (relative proportion)

D=Simpson’s index of diversity. It represents the likelihood that two randomly chosen individuals will be different species.

A the Chi-Square Test (Welman *et al.* 2007) was performed on the data to determine whether significant associations exist between the different stands.

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3. Results and discussion

3.1. Habitat and growth forms

In 1937, Potts and Tidmarch published an article recognizing a vegetation type near Bloemfontein which has “marked affinities with the Karoo”. In 1991, Du Preez and Bredenkamp (1991) named this vegetation unit the *Oropetium capense* community on rock sheets and classified it as a separate vegetation class. Dingaan and du Preez (2002) surveyed this vegetation unit near Bloemfontein and identified three different plant communities, namely the *Eragrostis trichophora–Aristida congesta, Heliophylla carnosa–Senecio radicans* and the *Stomatium braunsii–Avonia ustulata* Communities. In Mucina and Rutherford (2006) this vegetation unit, although small in size, is recognized as a separate vegetation type and has been described as the Bloemfontein Karroid shrubland (Gh8). Due to the presence of the scattered dolerite sheets this vegetation type has an archipelago appearance that occurs mainly in the Dry Highveld grassland.

Dolerite is of igneous origin and forms extensive sheets which vary in thickness. During the cooling process various horizontal cracks develop (Duncan and Marsh 2006; Holmes 2012). These cracks create areas where water infiltrates the rock. This allows chemical weathering to take place which in turn allows more water infiltration. Eventually the cracks develop into crevices into which soil and organic matter accumulates. Areas with deeper soil (50mm – 250mm) accommodate deep rooted species such as shrubs, perennial grasses and geophytes. Depressions occur on the exposed dolerite sheets where soil accumulates, These areas, although very shallow (10mm – 50mm), house a few species especially succulents and annuals. The two main environmental factors that differentiate the different plant communities on these dolerite outcrops are soil depth and soil moisture availability.

These dolerite sheets create an unusually arid habitat in a relatively high rainfall area due to the high loss of potentially available water. The loss of rainwater is caused by the poor water retention abilities of the coarse textured soil, poor infiltration, high evaporation tempos and high runoff. This unique habitat creates physiological drought conditions (Snyman 1984). The presence of these archipelagos of dolerite sheets with their shallow soils in a “sea” of deep soil and grass covered plains create a mosaic of scattered and isolated patches of arid habitats (Figure 2) which are relatively hostile environments for typical grassland species.

The physiological drought environment that is being created by the dolerite sheets and the shallow soil, is unsuitable most of the Grassland biome species but for a number of Nama-karoo biome species, which can tolerate the high temperatures and arid conditions present on these dolerite sheets, it creates a suitable habitat. This habitat can therefore be regarded as unique and in a certain sence can be regarded as an azonal vegetation type, Due to the lack of water, it is deviating strongly from the typical surrounding zonal vegetation (Mucina & Rutherford 2006)

The percentages of the number of plant species present per growth form recorded on these rocky sheets are indicated on Figure 3.

Figure 2. Typical appearance of the Bloemfontein Karroid shrubland vegetation type (Gh8). Succulents are limited to shallow crevices in the dolerite sheets while the grasses and low shrubs occur on slightly deeper soil.

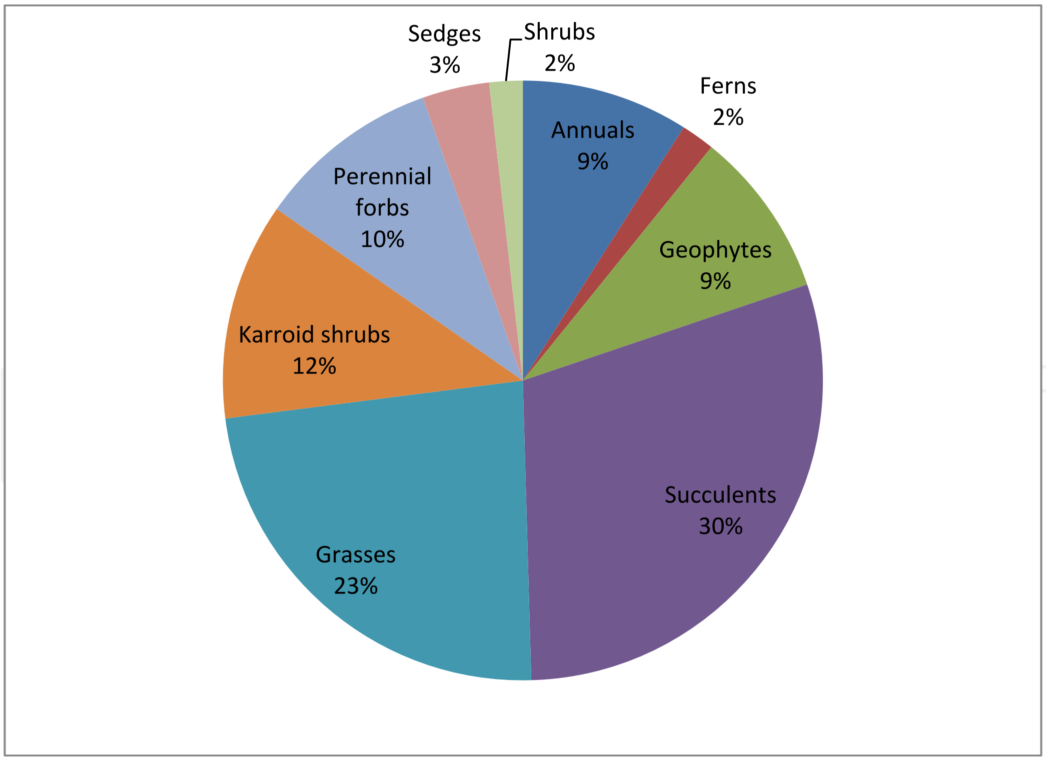

Figure 3. The percentages of the number of plant species per growth form present on the dolerite sheets.

It is interesting to note that number of succulents (30%) is the highest out of a total of 111 plant species noted on these dolerite sheets. This differs from the surrounding grasslands where less than 10% of the species are succulents. The second most important growth form is grasses (23%) followed by Karroid shrubs (12%). Perennial forbs make up 10% of the total species list while annuals and geophytes represent almost the same percentage (9%). Shrubs (3%), sedges and ferns (2%) struggle to survive on these arid habitats and are not well represented.

A number of species are endemic to this arid habitat. They are the succulents *Anacampserus filamentosa, A. telephiastrum, Avonia ustulata, Crassula tetragona, Euphorbia catervifolia, Hereroa species, Othonna protecta, Rabiea species, Ruschia unidens, Stomatium braunsii*, the *geophytes Brachystelma dimorphum subsp. gratum, Strumaria tenella subsp. orientalis* and the drought tollerant sedges *Cyperus bellus* and *Mariscus indecorus* (Annexure 1). It is only Brachystelma dimorphum subsp. gratum which is currently listed as a Red data species. According to POSA (2009) its status is rare.

3.2. Species richness and diversity

The Bloemfontein stand of the Bloemfontein Karroid Shrubland vegetation type (Gh8) has the highest species richness (81) with the Willem Pretorius Nature Reserve stand the second most namely 68 different species. That is followed by the Skoongesig stand with the Winburg and Kareefontein stands the lowest (Figure 4).

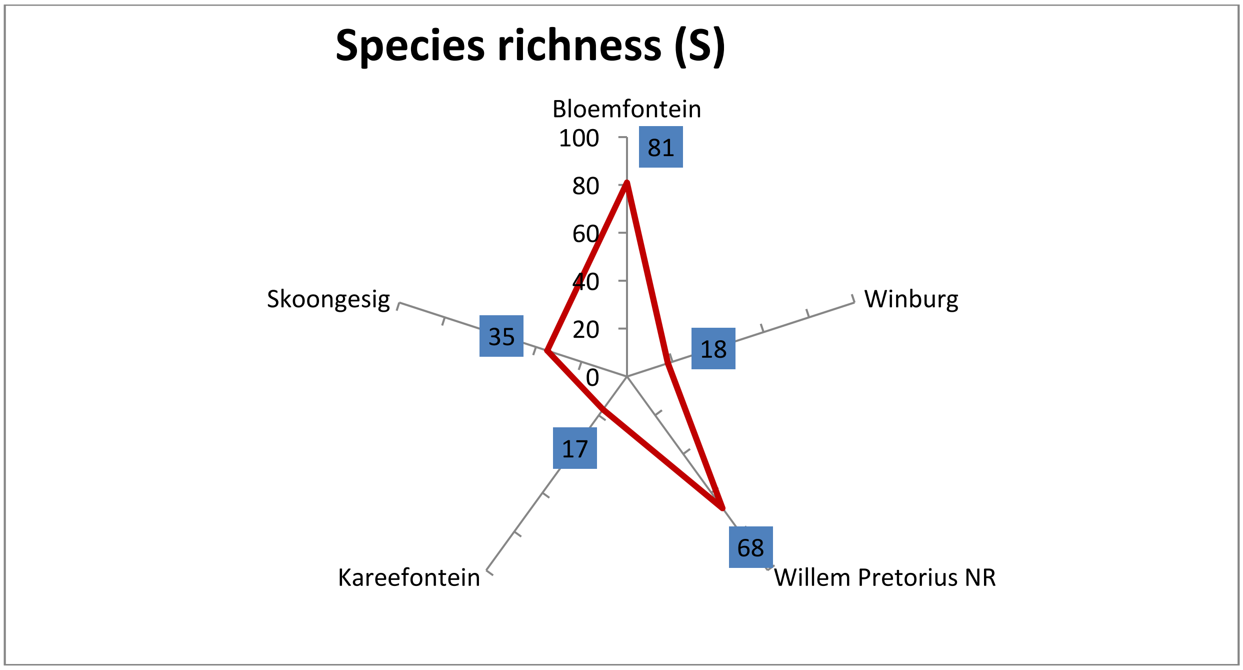

Figure 4. Species richness of the different stands of the Bloemfontein Karroid Shrubland (Gh8).

According to the Shannon-Wiener Index (Smith & Wilson 1996) values the Willem Pretorius Nature Reserve population of the Bloemfontein Karroid Shrubland vegetation type (Gh8) has the highest diversity followed by the Bloemfontein population (Figure 5). They are significantly different from the other three populations with the Kareefontein population the third most diverse. These results are confirmed in the Simpsons Index (Figure 6).

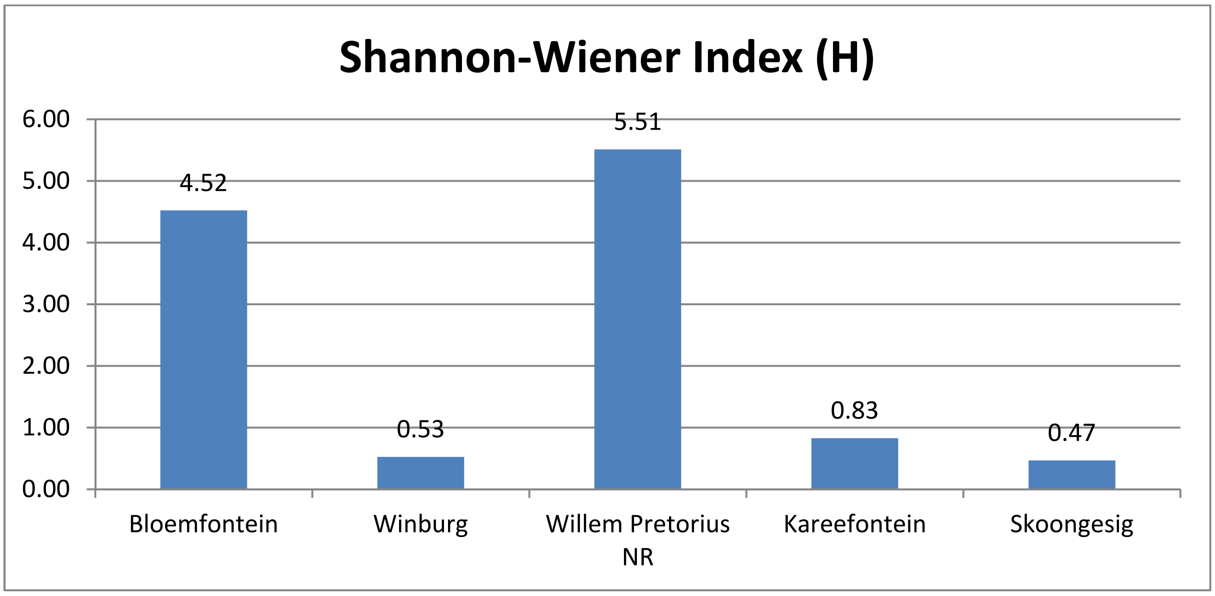

Figure 5. Shannon-Wiener index values for the five stands of the Bloemfontein Karroid Shrubland vegetation.

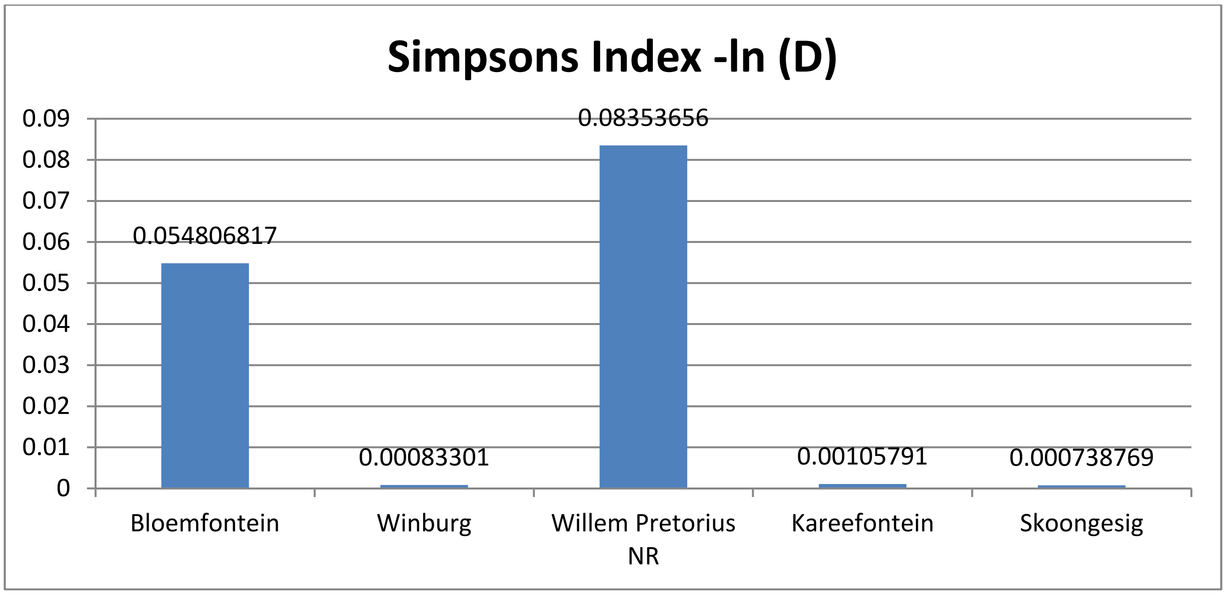

Figure 6. Simpson index values for the five stands of the Bloemfontein Karroid Shrubland vegetation.

There was a significant association between Shannon-Wiener Diversity Index values and areas surveyed X2(4)=10.06, p=0.039. Based on the standardized residuals, Willem Pretorius Nature Reserve is over represented (+2.04) and the main contributor to the association.

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The species diversity of a plant community refers to the different plant species and the relative abundance of each species. It is widely believed that the more diverse a community the more complex it is and the higher its production will be (Brower *et al.* 1990). Some ecologists also believe that the more diverse a community, the more stable it would be, but this assumption would not be true in all cases (Brower *et al.* 1990) for example a degraded community could have a high diversity of pioneer species, but would not be regarded as a mature or stable ecosystem. Thus the total species composition and ecological status of the species should be evaluated when interpreting species diversity indices.

In the case of the Bloemfontein karroid shrubland (Gh8) the species comprises mostly of climax and secondary succesional species indicating the vegetation to be in a mature and stable condition.

The Willem Pretorius Nature Reserve and Bloemfontein stands have the highest species richness and are also the two most diverse stands of this vegetation type (Figures 4 & 5). Not only are these two stands the largest in area size compared to the other three, but the Willem Pretorius stand occurs within the Willem Pretorius Nature Reserve which is a protected area that fall within the jurisdiction of the Free State Department of Economic, Tourism and Environmental Affairs (DETEA). Although the Bloemfontein stand has a higher species richness (81 species - figure 4) it is not as diverse as the Willem Pretorius Nature Reserve stand with 68 different species (Figures 5 & 6). The higher number of species of the Bloemfontein stand is most probably the result of the different habitats surrounding the area which have resulted in the presence of single individuals of different species. Both stands do however have a high biodiversity and species richness compared to the other stands.

The Skoongesig and Winburg stands have the lowest diversity values (Figures 4 & 5). The Skoongesig stand however, has 35 different species compared to the 18 of the Winburg stand and the 17 of the Kareefontein stand. Both the Skoongesig and the Winburg stands are located in areas that are subjected to degradation. The Winburg stand is surrounded by local communities that utilise the whole area for grazing by domestic stock, while the N1 highway also passes through this vegetation type. The Skoongesig stand is also a small area that is surrounded by formal agricultural land with deep soil that has mostly been ploughed and the rest are grazed. Both these stands are small in size and are affected by surrounding human associated impacts that has led to low diversity and isolation of these stands.

In contrast the Kareefontein stand is very small with a low species richness (Figure 4) but a somewhat higher species diversity compared to the Winburg and Skoongesig stands (Figures 5 & 6). This stand is located within a private nature reserve with various game species utilising the vegetation. Whereas private game reserves are focused on tourism and hunting to ensure it to be economically viable compared to large provincial nature reserves, these reserves do many times have a higher number of animals stocked on their farms. Thus although protected it could be slightly more trampled than similar areas in larger nature reserves. Thus the higher diversity compared to the degraded stands is expected, but the lower species richness can be attributed to its small size in the private reserve as well as the effect of grazing by antelope.

The diversity and species richness of the three smaller stands (Kareefontein, Skoongesig and Winburg) were significantly lower than those of the larger stands (Bloemfontein and Willem Pretorius Nature Reserve) (Figures 4, 5 & 6). Factors that could contribute to the lower species richness as discussed above include small size and degradation of the habitat and surrounding areas. The larger areas although also surrounded in same places by various human related activities and degraded areas seem to have a more stable species composition and higher diversity. Thus these areas are better adapted to withstand and survive any threat to their ecosystem. The impacts of fragmentation and human related activities has influenced the smaller and more isolated areas of this vegegtation type.

3.3. Threats to the Bloemfontein Karroid Shrubland (Gh8) vegetation type

To survive, humans need continuous access to clean water, air, food and shelter (Van As *et al.* 2012). This can only be assured if the environment is utilised and managed in a sustainable way. If the environment is managed and utilised in an unsustainable way both our renewable an non-renewable resources would become depleted that could cause total degradation of our ecosystems. That in turn could lead to the mass extinction of all organisms on earth including humans (Van As *et al.* 2012). One of the results of habitat exploitation and degradation is the fragmentation of habitats. Franklin *et al.* (2002) maintain habitat fragmentation to be a primary concern in conservation biology. The disruption of large sections of an ecosystem into smaller intact units, usually as a result of human activity is also referred to as fragmentation (Franklin *et al.* 2002). Humans are responsible for large scale habitat fragmentation due to pollution, urban development, agriculture, the introduction of alien species, forest plantations and especially mining activities (MacDonald 1989; Hogan 2013). Although not true in all cases it is generally regarded that the larger an area the more diverse and sustainable it will be. The general view is that the ecological effects of habitat destruction and fragmentation are negative (Franklin *et al.* 2002). From the results of this study the larger areas are more diverse and species rich, however the smaller areas contain certain species not present within the larger areas (Table 1 – Annexure 1).

Due to the extensive dolerite layers associated with the Bloemfontein Karroid Shrubland they are frequently mined for road building material (Figure 7) while other areas are used for the development of houses. Most of these areas are left unrehabilitated causing further degradation of the ecosystem. As a result these abandoned areas are either developed or left to become species poor transformed areas.

Another threat to the existence of this unique vegetation type is severe grazing of the area (Figure 8). Due to the sparse vegetation cover and shallow soil layers in some areas on rock sheets, overgrazing by domestic and other animals results in a reduction of the vegetation cover and the trampling of the shallow soil. High rainfall events therefore leads to erosion washing all the soil to the adjacent vegetation communities on the lower-lying valley bottom areas. This in turn leads to even lower vegetation cover and recruitment of plant species that leads to the exposed rock areas becoming larger with more pioneer species present.

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(a)

(b)

Figure 7. (a) Mining of the dolerite sheets of the Bloemfontein Karroid Shrubland vegetation type (Gh8) leads to total destruction and transformation of the area. (b) Mining of the dolerite hills of the Bloemfontein Karroid Shrubland vegetation type (Gh8).

The low vegetation structure and open rocky areas in-between the different plant species also leaves the impression that this vegetation type is generally degraded. As a result people often develop on these areas or use it for grazing without regard for the sensistivity ofthis ecosystem.

Figure 8. Degradation and reduction of vegetation cover of Bloemfontein Karroid Shrubland vegetation type (Gh8) as a result of overgrazing by domestic animals in the Winburg area..

4. Conclusion

Changes in ecosystems throughout the world are done to increase the flow of energy to one species only namely humans. Human populations continue to increase at the expense of other species (Keddy 2007). Not only has that resulted in large scale destruction of habitats, but also in immeasurable loss of species and ecosystem functions.

The results of this study provide more information on the distribution as well as species composition of the Bloemfontein Karroid Shrubland (Gh8) as described in Mucina & Rutherford (2006). A number of plant species unique to this vegetation type occurs while one red data plant was also found to be present. The effect of degradation and fragmenta-

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tion on this vegetation type is clearly illustrated by the lower species diversity of the isolated and overgrazed patches. The important role that large nature reserves and the conservation of large sections of this vegetation type play in the conservation of the species diversity is also illustrated by the high species richness of the Bloemfontein and Willem Pretorius Nature Reserve stands. Although degraded and low in species diversity in some areas, these islands all are important and contribute to the larger community composition. Bond (1989) states that in some cases smaller islands of vegetation cover a wider area than a nature reserve. In such a case their combined species total could be greater than the smaller section conserved in a nature reserve. These smaller islands may also act as refugia for formerly widespread species even from the surrounding threatened ecosystems (Crawley 1997). The results from this study also indicate that the smaller stands contain plant species not present in the larger stands studied, thus their conservation and ecosystem value should not be underestimated.

It is important that these islands are conserved as natural communities to ensure continued existence of these unique species assemblages and related ecosystem processes. If uncontrolled development of these areas are allowed it will not only lead to local destruction of this sensitive ecosystem but also to further fragmentation that will lead to the total loss of this ecosystem and related plant species. Keddy (2007) states that the greater the loss of species and related ecosystem services, the more human survival is at risk. This chapter focused on the negative effect of humans on a unique vegetation type in the Free State Province of South Africa, however these negative effects is also applicable to other ecosystems in other parts of the world. It is important that nature conservation organisations consider all aspects related to an ecosystem (structure, species assemblages, ecosystem processes and functions, fragmentation, condition of the ecosystem etc.) before decisions are made on whether development can be allowed or not.

The increasing amount of environmental research provides a better understanding of human impact on ecosystems. Further studies are needed to fully understand the extent and distribution of this vegetation type. Every taxon has a specific geographical range of distribution (Van Wyk & Smith 2001). Endemism is a scale related concept and the term "endemic" refers to a taxon that is geographically limited in its distribution, while "near-endemic" refers to a taxon that is marginally present elsewhere (Van Wyk & Smith 2001). For the purpose of this study these terms are applied to the Bloemfontein Karroid Shrubland vegetation type (Gh8) (Mucina & Rutherford 2006). It is proposed that based on the data from this study, the Bloemfontein Karroid Shrubland vegetation type (Gh8) is regarded as an endemic vegetation unit within the Free State Province in need of a high conservation status. In view of the fragmented nature of this vegetation type and the threats such as urbanisation, mining and overgrazing this vegetation unit as a whole must be listed a threatened ecosystem and no development or mining activity may be allowed unless detailed vegetation and ecosystem functioning studies have been conducted. Without a strict policy to protect these fragments, it would be difficult to control the destruction and the eventual loss of an unique vegetation type.

Annexure 1

Total number of releves: 68																																																																					
Stands		Bloemfontein																																				Kareefontein					Winburg				Skoongesig					Willem Pretorius Nature Reserve															
Releve numbers		4	4	4	0	4	4	4	0	0	4	4	4	4	0	0	4	0	0	4	4	4	4	4	4	4	4	4	4	4	4	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		7	7	7	1	7	2	2	0	0	5	5	5	5	0	0	2	0	1	2	2	2	2	2	2	2	2	2	5	5	2	0	0	2	2	2	2	2	2	2	2	9	9	9	3	3	3	3	2	2	2	2	2	2	2	2	6	6	6	6	6	6	6	6	6	6	6	6	6
		2	3	1	6	4	4	3	2	5	2	3	4	1	1	7	0	1	5	8	9	0	1	7	5	7	9	6	8	7	2	3	4	3	4	6	5	7	8	2	1	7	5	0	2	1	3	0	1	2	3	5	4	9	6	8	2	1	3	5	1	4	7	6	9	0	8	2	3
Species	**Growth form**																																																																				
Albuca setosa	Geophyte	+	r	+	.	r	r	r	r	+	+	+	+	r	r	r	+	r	.	.	r	r	+	.	+	.	+	.	.	.	r	+	.	r	+	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	1	.	+	2	.	.	.	.	1	1
Aristida congesta	Grass	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	+	.	.	.	.	.	.	+	.	+	+	+	+	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avonia ustulata	Succulent	.	r	+	.	+	r	.	+	+	r	r	r	.	r	r	+	r	.	.	r	.	r	.	.	+	+	.	.	.	.	.	.	.	.	r	.	.	+	.	.	.	.	.	r	r	r	r	+	+	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chasmatophyllum mustellinum	Succulent	r	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	r	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis nindensis	Grass	+	r	1	.	+	+	+	1	+	2	+	.	2	+	+	1	r	.	2	r	+	1	1	+	2	1	1	1	+	.	1	.	2	.	+	+	+	+	1	r	.	+	+	1	+	+	+	+	+	.	+	.	+	1	+	3	3	1	3	1	3	2	2	3	2	+	.	4
Jamesbrittenia pristicepala	Karroid shrub	.	.	.	.	.	.	.	.	.	r	.	.	r	.	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ledebouria luteola	Geophyte	.	.	.	.	.	+	r	r	+	r	.	r	.	r	.	.	r	.	.	r	.	.	r	.	.	.	+	r	+	.	.	.	.	.	.	+	.	+	.	.	.	.	+	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Melinis repens	Grass	r	r	+	.	r	.	.	1	+	r	+	+	r	+	+	+	r	+	.	.	+	.	.	.	.	.	.	.	.	2	4	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Oropetium capense	Grass	+	r	r	.	r	+	+	1	1	2	2	2	2	1	2	+	+	+	+	+	+	+	1	r	1	+	.	.	.	.	.	.	+	.	+	+	+	+	.	.	+	+	+	+	+	+	1	+	+	+	1	+	+	+	.	.	.	.	.	.	.	.	.	2	.	2	.	.
Stomatium braunsii	Succulent	.	.	.	+	+	.	.	1	+	+	2	1	1	1	1	1	+	+	+	1	1	+	+	.	+	1	.	.	.	.	.	.	.	1	+	+	1	+	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Microchloa caffra	Grass	+	r	+	.	r	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ruschia spinosa	Succulent	.	.	.	.	.	+	+	r	.	.	.	.	.	.	.	.	.	.	1	1	+	.	1	+	.	+	.	.	.	.	+	+	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	2	3	2	3	3	1	1	3	1	.	2
Anacampseros filamentosa	Succulent	r	r	r	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	+	r	r	.	+	r	.	.	.	.	.	.	r	.	.	+	r	.	.	.	.	.	.	.	.	r	r	.	+	r	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aristida canescens	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Bidens bipinnata	annual	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cheilanthes eckloniana	Fern	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	+	.	.	+	.	+	+	1	+	+	.	.	+	.	.	1	1	+	+	+	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Crassula nudicaulis	Succulent	+	.	r	.	.	.	.	.	.	+	.	.	.	r	+	+	.	.	r	1	r	1	.	+	r	r	+	.	.	.	+	.	r	.	.	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	+	2	1	1	+	1	2	1	+	+	1
Digitaria eriantha	Grass	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	r	.	.	.	1	2	+	1	+	1	2	.	2	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	4	4	2	3	3	3	.	3	3	2	.	.
Euphorbia mauritanica	Succulent	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	+	.	.	.	1	.	+	.	.	.	.	+	.	.	1	+	2	.	+	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	4	4	3	3	3	.	4	.	3	2	1
Euryops subcarnosa	Karroid shrub	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	4	.	.	.	1	3	1	4	2
Monsonia angustofolia	annual	.	.	+	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nidorella resedifolia	annual	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Schkuhria pinnata	annual	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Strumaria tenella subsp. orientalis	Geophyte	.	.	.	.	.	+	+	.	1	.	.	.	.	.	.	+	.	.	+	r	.	+	+	+	1	+	.	.	.	.	r	+	+	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	.	.	1	.	2	2	.	1	1	1	.	.	.	.	.
Themeda triandra	Grass	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	4	+	1	+	.	+	.	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	2	2	3	.	3	.	2	2	3	3	4
Tragus koeleroides	Grass	.	.	.	.	.	r	+	.	.	.	r	.	.	.	.	.	.	.	+	.	.	.	.	r	.	+	.	r	+	.	+	.	+	.	.	.	.	+	.	+	+	+	r	r	.	r	+	+	+	.	.	.	.	+	.	.	.	3	2	3	3	2	3	3	2	2	3	4

Aristida diffusa	Grass	1	1	.	.	.	+	1	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	r	.	+	.	2	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	1	+	.	.	.	1	+	+	2	.	.	.	3	.	.	.	.	.	.	3	2
Bonatea speciosa	Geophyte	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Diospyros lyciodes	Shrub	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eriocephalus ericoides	Karroid shrub	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	1	.	.	.	.	.	+	.	1	.	.	1	.	+	1	1	.	.	.	1	.	.	.	+	.	.	1	.	1	1	.	.	.	.	.	+	.	2	2	2	3	.	2	.	.	.	.	1	.	.
Eustachys paspaloides	Grass	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	3	.	.	.	.	.	.	3	2
Heliophia subcarnosa	annual	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	3	3	.	.	1	3	3	1	1	.	.
Searsia ciliata	Shrub	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Sarcostemma viminale	Succulent	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	r	.	.	.	+	+	.	+	+	.	+	r	.	.	.	.	+	r	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	4	4	.	2	3	.	3	3	2	2	1
Senecia radicans	Succulent	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	r	1	.	.	.	.	.	+	.	1	+	+	+	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	5	4	5	.	4	3	3	3	3	3	2	.
Crassula tetragona	Succulent	.	.	.	.	.	+	r	.	+	.	.	+	.	.	r	.	.	.	+	+	+	.	r	r	.	.	.	+	r	.	.	r	.	.	r	.	.	r	.	.	.	.	.	r	+	+	+	.	.	.	+	.	.	.	.	1	1	1	+	.	1	2	+	2	2	+	1	.
Ruschia unidens	Succulent	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Aloe grandidentata	Succulent	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.
Asparagus suaveolens	Karroid shrub	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cotyledon orbiculata	Succulent	+	r	r	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	+	.	.	.	.
Heteropogon contortus	Grass	.	+	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	1	.	.	+	+	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.
Pellaea callomelanos	fern	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phyllanthus parvulus	perennial forb	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	1	.
Tephrosia capensis	perennial forb	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trachyandra saltii	Geophyte	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	+	+	r	.	.	.	+	+	.	+	.	.	r	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	1	r	1	+	.	+	1	1	+	.
Anacamperos telephiastrum	Succulent	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	r	.	+	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crassula lanceolata	Succulent	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crassula setosa	Succulent	r	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euryops empetrifolius	Karroid shrub	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	3	2	4
Opuntia ficus-indica	Succulent	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Commelina africana	perennial forb	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	+	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	r	+	.	.	.	.	.	r	.	.	2	2	3	.	.	2	2	2	1	3	1	.	.
Mariscus indecorus	sedge	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	+	.	.	.	.	.	1	.	.	.	.	.	.	.	2	2	.	3	.	.	3	.	.	.	.	.	.
Pollichia campestris	perennial forb	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Selago albida	Karroid shrub	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	2	+
Tripteris aghillana	perennial forb	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyperus bellus	sedge	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	r	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis trichophora	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis lehmanniana	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1	3	2	2	3	3	.	3	4	.	.
Bulbostylis burchellii	sedge	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphorbia caterviflora	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	.	.	1	1	+	+	.	2	1	1	1	.	1	.	.	.
Euphorbia clavaroides	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geigeria filifolia	perennial forb	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	+	.	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	3	2	.	.	.	1	.	.

Hereroa species	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cynodon hirsutus	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rabiea species	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chamaecyce prostrata	perennial forb	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sutera caerulea	perennial forb	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	.	3	.	.	.	.	.	3	.
Crassula capitella	Succulent	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis chloromelas	Grass	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nenax microphylla	Karroid shrub	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	r	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pterodiscus speciosus	Succulent	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Othonna protecta	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Felicia filifolia	Karroid shrub	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chascanum pinnatifidum	perennial forb	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Conyza podocephala	perennial forb	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cymbopogon pospischillii	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Trichodiadema barbatum	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	3	.	.	.	1	.
Brachystelma dimorphum subsp. g	Geophyte	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stapelia grandiflora	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Orbeopsis lutea	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pachypodium succulentum	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Adromischus tryginus	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crassula coralina	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bulbostylis humilis	sedge	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kalanchoe thyrsifolia	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Oxalis corniculata	annual	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudognaphalium oligandrum	annual	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sporobolus fimbriatus	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	1
Opuntia lindheimeri	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Raphionacme hirsutus	Geophyte	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Duvalia corderoyii	Succulent	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Eragrostis obtusa	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	2	2	3	.	.
Lessertia annularis	Karroid shrub	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	3	3	.	3	3	3	3	2	4	.	.
Oxalis depressa	annual	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	2	5	2	3	2	4	3	2	2	4	3	1
Scilla species	Geophyte	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	2	4	2	3	3	2	2	3	2	3	2	1
Senecio inaquidens	annual	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	.	3	3	2	2	.	1	.	.	.
Tragus berteronianus	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.	.	.	.	.	.	.	.	.	.	.
Senecio burchellii	annual	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2	.	.	.	.	.	.	+	2	1

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Table 1. Releves, species composition and growht form of the Bloemfontein Karroid Shrubland (Gh8) (Values included in the table are according to the Modified Braun-Blanquet cover abundance scale)

Selago densiflora	Karroid shrub	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	+	1	1	.	.
Anthospermum rigidum	Karroid shrub	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1	.	.	.	.	.	.	.	.	3
Eriospermum species	Geophyte	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.
Pelargonium minimum	Karroid shrub	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	r	+	.	.
Eragrostis curvula	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	3	.	3	3
Aristida junciformis	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Ipomoea oenotheroides	geophyte	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Chrysocoma ciliaris	Karroid shrub	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Digitaria argyrograpta	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Eragrostis superba	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Indigofera alternans	perennial forb	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Cymbopogon excavatus	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Enneapogon scoparius	Grass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3

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