The Sperrgebiet:
Managing its biodiversity

Antje Burke

December 2006
ISBN 99916-63-78-9

© Antje Burke, 2006

This publication may be reproduced for non-commercial purposes only.

Content and design: Antje Burke
Editing: Carole Roberts
Maps: Tony Robertson

First published in 2006
by
EnviroScience
PO Box 1722
Oranjemund
Namibia

and

Namibia Nature Foundation
PO Box 245
Windhoek

This publication is kindly supported by the Succulent Karoo Ecosystem Programme (SKEP) hosted by the Namibia Nature Foundation with funding from the Critical Ecosystem Partnership Fund (CEPF), a joint initiative of Conservation International, the Global Environment Facility, the Government of Japan, the John D. and Catherine T. MacArthur Foundation and the World Bank. Work that contributed to this planning information was partially funded by the Namibian National Biodiversity Programme (Ministry of Environment and Tourism and Gesellschaft für Technische Zusammenarbeit) and the Global Conservation Fund.

FOREWORD

The diversity of life on earth, both between and within species, and together with their habitats, is called "biodiversity". Biodiversity is what keeps the world alive and healthy. It produces air and fertile soils, it decomposes waste and dead material, it keeps water clean and it provides food. In short, biodiversity provides all the goods and services that we humans need to live and enjoy life. Without all the rest of life, we would not survive. The better the level of health of the globe's biodiversity, the more stable and productive is our planet. Aesthetics aside, from a survival and productivity point of view, protecting and conserving the world's biodiversity is in our interest, and in the long-term interest of humans.

In Namibia, the spotlight is currently on the Succulent Karoo Biome - the extreme southwestern corner of the country. This is one of the top biodiversity "hotspots" in the world. A hotspot is one of exceptional global value. In the case of the Succulent Karoo, it is one of just 25 such sites worldwide. It is also the most diverse desert system in the world. Exceptional biological diversity and remarkable concentrations of range-restricted (endemic) plants and animals, as well as multiple threats, ranging from livestock-farming to urbanisation and mining, have prompted this high standing.

Namibia's largest portion of the Succulent Karoo Biome falls into the Sperrgebiet, an area that has not been accessible to the public for almost 100 years because of the high levels of security required to protect Namibia's diamond resources. Although mining has undoubtedly impacted on biodiversity, the restricted area status has created a buffer to combat other disturbances and created almost virgin wilderness areas in many parts of the Sperrgebiet. These wilderness areas are today priceless natural assets. They are shortly to be protected within a National Park that the Government of the Republic of Namibia has agreed to proclaim - the Sperrgebiet National Park, covering an area of some 2.6 million hectares.

Good biodiversity information is essential in a biodiversity hotspot. It is also essential if good management of the biodiversity is to be achieved within the new Park. However, even where such information is available, it is often not accessible to non-specialists. It needs to be interpreted, so that all interested people can understand the biological wealth of the area and the issues involved in its management and conservation.

This well-researched publication makes the present state of our knowledge on biodiversity in the Sperrgebiet accessible to all people. I am sure that it will stimulate interest in the area and draw attention to gaps in our knowledge. This in turn will encourage people to study the fascinating flora and fauna of the Sperrgebiet to fill these gaps.

The author has masterfully succeeded in conveying her knowledge and passion for the Sperrgebiet and its fascinating landscapes and biodiversity in an exceptionally user-friendly manner. This publication provides a strong foundation to guide the management and development of the future Sperrgebiet National Park and to help ensure that Namibia rises to the challenge of managing one of the world's biodiversity hotspots for the benefit of present and future Namibians and for the global community.

Dr. Chris Brown, Namibia Nature Foundation December 2006
PREFACE

Namibia’s prime biodiversity hotspot – the Sperrgebiet – is in the spotlight ... and for a good reason. Momentum is gathering to investigate options for sustainable land uses other than mining in this envisaged, new, multi-use national park. One crucial pillar of developing sustainable land uses is good information on natural assets on which to base the planning. Biodiversity information in an accessible format is hence of crucial importance.

The information presented in this book is based on biodiversity-related work which I undertook in this area. The work included field surveys, literature reviews, the analysis of accessible data and interaction with other specialists. The field data was gathered over a period spanning the past decade and, in line with my main interest and field of expertise, focuses on plants. The compilation of other biodiversity information has been based on workshops related to conservation planning for the Sperrgebiet and in consultation with relevant experts.

Although this publication attempts to present an account of the status quo of presently available biodiversity information, this is by no means the complete picture. Despite focused efforts in the last few years to improve the coverage of biodiversity data, there are still many gaps. Although managing this natural asset will be based on information available to date, when new information becomes available, management actions need to be reviewed and adapted if new discoveries require this.

Dr Annie Burke
December 2006

Acknowledgements

Financial support through the Global Conservation Fund, the Namibian National Biodiversity Programme (through sponsorship by the Gesellschaft für Technische Zusammenarbeit) and the Namibia Nature Foundation are gratefully acknowledged. Namdeb, particularly staff at the Mineral Resources and Security Departments have provided essential logistical support. Thanks are due to Tony Robertson for assistance with the compilation of maps, the Geological Survey for providing a preliminary geological map and the National Botanical Research Institute for the provision of data from the Herbarium Specimens Database. Further, the Skorpion Zinc Project is thanked for providing weather data and Namdeb for the use of the satellite image, as well as for permission to use information from various environmental impact assessments. The Sperrgebiet Interest Group contributed to mapping the land classes, assessing the research needs and management zoning. Trygve Cooper, Patrick Lane, and Pauline Lindecque and her staff commented on an earlier draft of this manuscript. Special thanks to Coleen Mannheimer, Paul Wood and Carole Roberts who provided considerable input during the write-up. I am grateful for this invaluable input.
<table>
<thead>
<tr>
<th>CONTENTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMMARY ...........................................................................</td>
<td>7</td>
</tr>
<tr>
<td>INTRODUCTION .....................................................................</td>
<td>8</td>
</tr>
<tr>
<td>THE SPERRGEBIET ENVIRONMENT ...........................................</td>
<td>9</td>
</tr>
<tr>
<td>LANDFORMS AND SOILS ................................................................</td>
<td>9</td>
</tr>
<tr>
<td>CLIMATE .............................................................................</td>
<td>10</td>
</tr>
<tr>
<td>LAND USE ...........................................................................</td>
<td>10</td>
</tr>
<tr>
<td>BIOMES AND VEGETATION ................................................................</td>
<td>10</td>
</tr>
<tr>
<td>APPROACH AND METHODS ................................................................</td>
<td>12</td>
</tr>
<tr>
<td>VEGETATION MAPPING ................................................................</td>
<td>12</td>
</tr>
<tr>
<td>INFORMATION ANALYSIS ................................................................</td>
<td>12</td>
</tr>
<tr>
<td>A SUMMARY OF THE FINDINGS .................................................</td>
<td>15</td>
</tr>
<tr>
<td>VEGETATION TYPES ...................................................................</td>
<td>15</td>
</tr>
<tr>
<td>LANDFORMS AND HABITATS ................................................................</td>
<td>15</td>
</tr>
<tr>
<td>PLANT DIVERSITY AND EXTENT OF VEGETATION TYPES ................................</td>
<td>15</td>
</tr>
<tr>
<td>CONSERVATION IMPORTANCE .....................................................</td>
<td>17</td>
</tr>
<tr>
<td>CENTRES OF PLANT ENDEMISM ..................................................</td>
<td>17</td>
</tr>
<tr>
<td>INVASIVE ALIEN PLANT SPECIES .................................................</td>
<td>17</td>
</tr>
<tr>
<td>RESOURCE USE .......................................................................</td>
<td>17</td>
</tr>
<tr>
<td>THREATS ..............................................................................</td>
<td>17</td>
</tr>
<tr>
<td>RECOVERY POTENTIAL ..................................................................</td>
<td>19</td>
</tr>
<tr>
<td>RESEARCH NEEDS .....................................................................</td>
<td>19</td>
</tr>
<tr>
<td>LINKAGES WITH OTHER VEGETATION CLASSIFICATIONS ........................</td>
<td>19</td>
</tr>
<tr>
<td>IMPLICATIONS FOR CONSERVATION AND LAND-USE PLANNING ..................</td>
<td>19</td>
</tr>
<tr>
<td>BIODIVERSITY GAP ANALYSIS ....................................................</td>
<td>20</td>
</tr>
<tr>
<td>BACKGROUND .........................................................................</td>
<td>20</td>
</tr>
<tr>
<td>APPROACH ............................................................................</td>
<td>20</td>
</tr>
<tr>
<td>A RESEARCH FRAMEWORK FOR THE SPERRGEBIET ..............................</td>
<td>21</td>
</tr>
<tr>
<td>Biodiversity inventory and evolutionary processes ................................</td>
<td>21</td>
</tr>
<tr>
<td>Environmental baselines ................................................................</td>
<td>23</td>
</tr>
<tr>
<td>Economic value of resources ................................................................</td>
<td>23</td>
</tr>
<tr>
<td>Monitoring resource use and pressures ................................ ........</td>
<td>24</td>
</tr>
<tr>
<td>Climate change .....................................................................</td>
<td>25</td>
</tr>
<tr>
<td>Information management, ecological assessment and indicators ................</td>
<td>25</td>
</tr>
<tr>
<td>Environmental awareness and training ........................................</td>
<td>25</td>
</tr>
<tr>
<td>THE WAY FORWARD ....................................................................</td>
<td>26</td>
</tr>
<tr>
<td>Environmental baselines ................................................................</td>
<td>26</td>
</tr>
<tr>
<td>Monitoring resource use and pressures ................................ ........</td>
<td>26</td>
</tr>
<tr>
<td>Environmental awareness and training ........................................</td>
<td>26</td>
</tr>
<tr>
<td>Information management ................................................................</td>
<td>26</td>
</tr>
<tr>
<td>CONCLUSION ..........................................................................</td>
<td>26</td>
</tr>
<tr>
<td>THE VEGETATION TYPES ...........................................................</td>
<td>27</td>
</tr>
<tr>
<td>REFERENCES ...........................................................................</td>
<td>96</td>
</tr>
<tr>
<td>SPERRGEBIET INTEREST GROUP ..................................................</td>
<td>97</td>
</tr>
<tr>
<td>OTHER CONTRIBUTING SPECIALISTS ..............................................</td>
<td>97</td>
</tr>
<tr>
<td>ABBREVIATIONS .....................................................................</td>
<td>98</td>
</tr>
<tr>
<td>INDEX ..................................................................................</td>
<td>99</td>
</tr>
</tbody>
</table>
SUMMARY

The Spergebiet is situated in a globally recognised biodiversity hotspot. Restricted access to the area and the absence of widespread land-use activities have left much of the area intact and largely free of alien plant invaders and other disturbances. These factors make the Spergebiet a unique asset for Namibia. The aridity of the area, however, makes it fragile and should the vegetation be disturbed, it is likely to recover very slowly, if at all.

Within the Spergebiet several vegetation types of conservation importance (biodiversity hotspots) have been identified. These important vegetation types are characterised by being very diverse, with many of the plant species being restricted to small areas and include most of the vegetation types on inselbergs, in mountainous areas and along the coast. Areas of very high conservation importance that cover less than 1% of the surface area are considered the most vulnerable. These include the Auas Mountains, Boesegoeberg, Chaminaub, the Kowisberge, Rooiberg, Tsaukhaeb, the Skorpion inselbergs, the Orange River Valley and Ficodiplon, as well as the Lüderitz Peninsula.

This mapping exercise identified 56 vegetation types in the Spergebiet. The characteristics of each vegetation type are described according to the dominant plant species, growth form, size and cover, as well as the extent, locality, habitat and resource value of each type. Each vegetation type is classified according to its level of conservation importance; the threats and recovery potential of each are assessed and recommended management practices outlined. The management practices recommended relate to invasive alien plant control and monitoring of critical plant populations. In terms of research needs, detailed vegetation maps of biodiversity hotspots and development nodes within the area, as well as red-list assessments for plants, are urgently required.

Sound management of a biodiversity hotspot of international importance requires good baseline information, as well as sound monitoring programmes. There are still many gaps that have been identified and need to be filled in the long term. These should be addressed systematically in a well-designed research programme. In the meantime, informed management decisions will need to be made by using sound environmental data, and the following aspects need to be prioritised:

- Environmental baselines in areas of very high conservation value and areas where developments are planned should be completed;
- Resource use and environmental impacts in development areas should be monitored;
- Field biologists should be trained with an emphasis on the Succulent Karoo, and
- An environmental database for the area should be developed.
INTRODUCTION

The Sperrgebiet (translated from German as "restricted area") or Diamond Area 1, as it is otherwise known, is one of Namibia's foremost national assets. Having been inaccessible to the public and largely free of wide-scale land-use activities, such as livestock farming, for nearly a century, today it presents an area of increasing importance for conservation, tourism and research. Moreover, as the area belongs to the Succulent Karoo Biome (Rutherford 1997), it has been identified as one of 25 biodiversity hotspots in the world and thus obtained international recognition as a priority area for conservation (Myers et al. 2000). However, it is not the entire area that is pristine; mining and exploration activities have impacted some areas. Most of these impacts, though severe, are localised and concentrated in areas with economically viable diamond deposits, such as those on the southern Sperrgebiet coast and along the Orange River.

Over the past few years the Sperrgebiet has been the subject of several planning processes in order to determine the appropriate use of land in the area and to develop a strategy that would enable sustainable utilisation of the land and its resources (Ministry of Environment and Tourism 2001, Burke 2002). Partially due to the restrictions of access to the area, which also apply to researchers, baseline information on biological and cultural assets within the area is fragmentary and only adequately detailed for certain aspects (e.g. historic monuments). Particularly biological baseline information has been lacking for most types of biota; plants and larger animals are the only groups that have been documented reasonably well throughout the area. As part of a recent, detailed planning process all available biological inventory data were processed and a clearer indication of the status quo obtained (Burke 2002). This, as well as a recently developed stratification of land classes, prompted the development of a vegetation map. Ideally in an area of such tremendous conservation value, biological inventories should be complete for all biota, and land-use planning should be based on the full complement of plant and animal groups. This, however, could still take many more years to be completed and planning information is now urgently needed.

On the assumption that adequately detailed information on habitats and vegetation could also be used as a surrogate classification for smaller animals (e.g. invertebrates, small mammals, reptiles, etc.), habitats and associated vegetation types were mapped in this study to provide information for planning the management of the Sperrgebiet.

Spatial information of relevance that is available to date for planning purposes, consists largely of information that has been compiled at a national scale, such as the broad classification of agro-ecological zones (de Pauw & Coetzee 1999), the preliminary vegetation map (Giesse 1971) and recent revisions of this vegetation map (Burke et al. 2002). The only map compiled specifically for the area is a map of vegetation zones which was based on altitude and defined five broad vegetation zones (Williamson 1997). More detailed mapping of habitats and vegetation had been undertaken as part of the Succulent Karoo Ecosystem Plan (2002). However, this information had not been finalised and published at the time of this study and it was based on specimen data at quarter-degree resolution without any field observations; it has therefore not been incorporated here.

The main aim of this publication is to provide information on various habitats in the Sperrgebiet, based on a map of vegetation types, for management purposes. It provides a description of the vegetation, but also includes information on the plant resources and their conservation values, uses and recovery potential, as well as the threats to specific habitats, which is useful information for the management of the area.
THE SPERRGEBIET ENVIRONMENT

The area under investigation covers some 21,600 km$^2$ and is positioned in the southwestern corner of Namibia (Figures 1 and 2). It comprises about 2.6% of the land surface of the country.

Landforms and soils

Millions of years of depositional and erosional processes have created the varied landscapes that today form the backdrop for a diverse assemblage of plants and animals. These landscapes have formed on a west to northeast, gently sloping pediplain which reaches altitudes of over 900 m AMSL in the northeastern areas of the Sperrgebiet. Resisting erosion, isolated mountains (Inselbergs) and more prominent mountain chains such as the Aurus and Obib Mountains have formed from hard bedrock. Less prominent, but nevertheless important, are other rocky habitats which occur along the coast and in areas adjoining the coastal sections, particularly in the north towards Luderitz. The southern coastline stretching approximately 120 km north of Oranjemund is more or less linear, while the northern coastline is more complex and provides a mosaic of bays, rocky promontories and sandy beaches (Figure 3). Large salt pans adjoin inland, adding to the great habitat diversity in this coastal zone. There are dunes and vast sheets of sand throughout the entire area which cover large sections, particularly in the south. Some of these dunes are mobile, forming low barchan and linear dunes, others are semi-stabilised and support a sparse cover of vegetation. Constant windy conditions have scoured some of the most wind-swept valleys, exposing bedrock, such as those seen around Pomona. The Orange River, one of only five permanent rivers in Namibia, provides a lifeline to people, animals and plants and the southern boundary of the Sperrgebiet as well as Namibia. Other important drainage areas (though presently not supporting flowing rivers) are Chameis and Kaukaisib in the west, and the Anib and Uguchab in the east.

The diversity of rock types exposed in the Sperrgebiet undoubtedly contributes to the tremendous diversity of habitats. The oldest rocks belong to the Namaqua Metamorphic Complex (>1,000 million years old) and
comprise granitic gneisses, intrusions and metabasic rocks. These are present mainly in the north of the area, from about Bogenfels northwards. Underlying rocks in the central and southern sections are largely part of the Gariep Complex (1,000–570 million years old). The Gariep Complex in the Sperrgebiet comprises a range of rock types including dolomites and schists. Limestones of the Nama Group (570–500 million years) extend from the escarpment into the central eastern section of the Sperrgebiet and formed, for example, the Tsuaus and Swartkloofberge. Of further interest are volcanic intrusions in the Klinghardt area which are of fairly recent origin (37 million years old). These resulted in phonolite intrusions and cappings of older rock formations in the central Sperrgebiet.

Different soil types have developed based on the underlying rock types and prevailing climatic conditions. These include gypsum-rich soils along the coast, soils rich in other salts and calcrite on gravel plains and sandy soils in areas of dunes and sand sheets.

Climate

The climate of the study area is arid with a largely moderate temperature regime. Average annual rainfall ranges between zero and approximately 80 mm. The annual mean rainfall at Lüderitz, for example, is 17 mm, at Otjimund and Rosh Pinah around 50 mm, and at Aus (just to the east of the Sperrgebiet), 85 mm. Higher mountain areas in the Sperrgebiet receive more rain than surrounding lower areas, and annual averages at high altitudes may well exceed 100 mm (Burke et al. 2004). The Sperrgebiet falls within a transitional zone between winter and summer rain, hence rains may fall at any time of the year. Within the Sperrgebiet, a rainfall gradient of decreasing rain from southwest to northeast, related to winter rains originating in the Cape, is indicated (Burke et al. 2004). Summer rains become increasingly more important towards the northeast, winter rains towards the southwest. Another extremely important source of moisture in this area is fog. It is an almost daily occurrence along the coast, its frequency decreases eastwards (Olivier 1995). The Orange River provides an important conduit, as fog often moves eastwards along the valley and thus reaches areas near Rosh Pinah well over 60 km inland from the coast. Although no data on fog precipitation exist in the Sperrgebiet, in the central Namib the fog belt extends approximately 30 km inland and on average brings about 64 mm of moisture per annum at the coast decreasing to about 35 mm at the eastern edge of the fog belt (Hachfeld & Jürgens 2000). At the coast, fog precipitation therefore well exceeds rainfall.

Apart from aridity, the most critical climatic factor affecting life in this area is wind. Strong, southerly coastal winds prevail throughout the year, abating slightly as one moves eastwards. Constant daily winds at Pomona, for example, range between 30 and 50 km/hr in summer (Pallet et al. 1995), but often reach 100 km/hr. In winter, easterly "berg" winds related to high pressure cells over the southern African interior can occasionally generate equally high wind speeds and, in addition, impose hot, desiccating conditions on biota.

Temperature regimes in the study area are comparatively moderate. Although daily means are expected to only range between 14° and 18° C at the coast (e.g. Lüderitz) and from 10° to 24° C further inland (e.g. Aus) (Pallet et al. 1995), maximum temperatures of 40° C have been reported in both areas. Frosts are frequent in winter in the Aus area, but the remaining area at lower altitudes experiences frost only very rarely.

Land use

Mining and prospecting are at present the only significant land uses in this area. While diamond mining is restricted to the coast and terraces along the Orange River, a new zinc mine has been established in the eastern Sperrgebiet some 20 km outside of Rosh Pinah. Prospecting activities are taking place in the remaining Sperrgebiet. At present there is also one small tourism concession operating in the Pomona–Bogenfels area. The eastern part of the Sperrgebiet was used periodically for emergency grazing until the 1980s.

Biomes and vegetation

Although there is some debate regarding the exact boundaries of the biomes in this area (Irish 1994, Rutherford 1997), there is consensus that the Succulent Karoo, Desert, and Nama Karoo biomes all influence the Sperrgebiet. This means that low leaf-succulents, ephemeral grasses and dwarf shrubs form the main components of the vegetation. On a national scale, the vegetation had been classified as desert and succulent steppe (Gliess 1971), and more recently plain dwarf-shrubland, mountain dwarf-shrubland, mountain succulent dwarf-shrubland, sand plain dwarf-shrubland and sand plain succulent dwarf-shrubland (Burke et al. 2002).
Figure 2: Landmarks and localities in the Sperrgebiet
APPROACH AND METHODS

Vegetation mapping

The vegetation map of the Sperrgebiet is based on a stratification of land classes for this area which formed the backdrop for management zoning during the Sperrgebiet Conservation Planning Study (Burke 2002). At that point, 17 land classes were defined. These comprised major landforms such as drainage basins, inselbergs, semi-stabilised dunes, mobile dunes, and gravel and sand plains. A Landsat Thematic Mapping satellite image of 1995 was used to derive these main land classes which were verified and amended with input by Sperrgebiet specialists.

Field observations on vegetation collected since 1996 during systematic, annual plant-collecting trips, as part of botanical specialist studies for environmental impact assessments and, finally, during a dedicated field trip in 2003 to fill in the remaining gaps, were processed. Data points of vegetation types and vegetation boundaries were plotted on the satellite image within the established land classes. The stratification of land classes was verified, amended and further refined during the field work and by using the plotted vegetation types. In addition to the field observations, other sources reviewed to delineate vegetation boundaries were eight-year averages for Green Vegetation Biomass (from Mendelsohn et al. 2002, based on du Plessis 1999) and a preliminary geological map of the Sperrgebiet (Geological Survey 2000). In order to accomplish the task within the available time, and constrained by the resolution of the satellite image, the mapping was undertaken at a scale of approximately 1:500,000. Hence, for the purpose of this study, the map generated vegetation types rather than plant communities. Each resulting vegetation type provides a landscape-level mapping unit with various plant communities contained in that mapping unit. This approach is similar to that of Cowling and colleagues for Broad Habitat Units which they successfully used to broadly classify the vegetation of the Cape region (Cowling & Heijn 2001).

Information analysis

The vegetation types were named after the main descriptors of the vegetation, usually the dominant plant and one other characteristic plant species. To make it more accessible to non-specialists, descriptive names were derived for the mapping units. In order to provide information useful for management, the vegetation types have been further described in the form of "fact sheets". These have been presented by the descriptive name of the vegetation type and include a small map indicating the position of the vegetation type in the study area, as well as a photograph where available. Additional aspects to characterise the vegetation type, such as geographic extent, the main structural components (dwarf shrubs, grasses, etc.) and attributes related to conservation importance and resource use have been included (Table 1).

In order to derive estimates of plant diversity in each mapping unit, data from the Herbarium Specimens Database of the National Botanical Research Institute of Namibia and the author's own observations were compiled in species lists for each quarter-degree square. Although the quarter-degree square data were not congruent with the mapped vegetation types, knowledge of the particular vegetation type and its general diversity facilitated an evaluation of the species lists in terms of representation in the described vegetation type. Where data coverage was poor, plant diversity was estimated on the basis of habitat ("expected" denotes such estimates).

Species of conservation importance were determined based on these quarter-degree species lists and defined as species:
1) protected under Forestry and Nature Conservation legislation,
2) endemic to Namibia (Craven 1999, 2002),
3) listed on Cites (International Convention on Trade in Endangered Species) and
4) red-listed as near-threatened or higher
Figure 3: Landforms
Table 1: Aspects included in the descriptions of each vegetation type (pages 30–95)

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptive name of vegetation type</td>
<td>Based on common name of plant species and/or geographic landmark</td>
</tr>
<tr>
<td>Scientific name</td>
<td>Latin names of name-giving, characteristic plant species</td>
</tr>
<tr>
<td>Locality</td>
<td>Geographical position</td>
</tr>
<tr>
<td>Geographic unit</td>
<td>Based on land-class mapping (Burke 2002)</td>
</tr>
<tr>
<td>Vegetation sub-units</td>
<td>Potential sub-units within vegetation type</td>
</tr>
<tr>
<td>Habitat and environmental parameters</td>
<td>Geology, landform, substrate, climate and other main physical environmental parameters</td>
</tr>
<tr>
<td>Description</td>
<td>Growth forms and vegetation cover</td>
</tr>
<tr>
<td>Key species</td>
<td>List of characteristic species</td>
</tr>
<tr>
<td>Extent</td>
<td>Surface area covered by vegetation type within the Sperrgebiet</td>
</tr>
<tr>
<td>Plant diversity</td>
<td>Based on the lists of plant species by quarter-degree square, an estimate of plant diversity for the mapping unit was derived.</td>
</tr>
<tr>
<td>Conservation importance</td>
<td>Estimate of conservation importance is given, as well as important plant species (protected, endemic, Cites and/or red-listed)</td>
</tr>
<tr>
<td>Alien plant species</td>
<td>Invasive alien plant species recorded</td>
</tr>
<tr>
<td>Resource use</td>
<td>Importance of vegetation type as grazing and for other uses, as well as other interesting information related to this mapping unit</td>
</tr>
<tr>
<td>Threats</td>
<td>Imminent and possible threats</td>
</tr>
<tr>
<td>Recovery potential</td>
<td>Expert assessment (see description below)</td>
</tr>
<tr>
<td>Management</td>
<td>Management guidelines, including proposed zoning category</td>
</tr>
<tr>
<td>Research needs</td>
<td>Needs regarding biological data in general and particularly with regard to plant species and vegetation</td>
</tr>
<tr>
<td>Other mapping</td>
<td>Links to other land and vegetation classifications</td>
</tr>
</tbody>
</table>

Overall "conservation importance" was defined on the basis of the number of plant species of conservation importance (either endemic, protected, red-listed or Cites).

<table>
<thead>
<tr>
<th>Conservation Importance</th>
<th>Species Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>VERY HIGH</td>
<td>&gt;30 species</td>
</tr>
<tr>
<td>HIGH</td>
<td>20–30 species</td>
</tr>
<tr>
<td>MEDIUM</td>
<td>2–19 species</td>
</tr>
<tr>
<td>LOW</td>
<td>0–1 species</td>
</tr>
</tbody>
</table>

Recovery potential is an expert-based assessment using a three-point scale of low, medium and high. Recovery potential takes the longevity of the plants, the ability of individual plant species to establish from seeds or vegetative material and the dynamics of the habitat into account. A high recovery potential means the affected vegetation type can recover within one to two growing seasons after the disturbance (if rains fail, a growing season may not necessarily happen annually). Medium recovery potential has been defined as those requiring between 5 and 10 years; low recovery potential as those requiring more than 10 years.

Research needs were derived from the consultative process linked to the Sperrgebiet Conservation Planning Study (Burke 2002) and, for botanical aspects, further refined during the compilation of this map. These research needs include reference to groups of biota hitherto not well-collected within the described vegetation type, needs for further plant collecting and more detailed vegetation maps, as well as recommendations for priority areas that require red-list assessments for plants and taxonomic revisions. The majority of the derived vegetation types were backed by field observations. However, some areas were not accessible on the ground and a planned helicopter survey of these areas did not materialise due to technical problems. Where no field observations exist, this has been indicated in the description of research needs.

Existing land classifications and vegetation maps were reviewed and their linkages with the derived vegetation types listed. These comprised mostly broader-scale mapping, and in very few instances, local vegetation maps (e.g. Fanroth 1991, Burke 1997, 2000).
A SUMMARY OF THE FINDINGS

Vegetation types

At a 1:500,000 scale of mapping, 56 vegetation types were determined. These are adequate to give a broad overview of the main vegetation types and habitats for planning purposes, but they are not adequate for areas where developments are proposed. Hence, for developments, environmental impact assessments are required with more detailed vegetation assessments. This is particularly true for those vegetation types that were not verified by field observations or that occur in environmentally sensitive areas.

The most frequent plant species, which occur in several vegetation types, are the common brownanthus (*Brownanthus arenosus*), Marloth’s brownanthus (*Brownanthus marlothii*), gum milk-bush (*Euphorbia gymnifera*), *Euphorbia cibdeia* and the Namib bonsai (*Othonna furcata*).

Landforms and habitats

The mapping exercise identified 16 landforms (Figure 3), most of which support a number of different vegetation types. These landforms are largely determined by topography, substrate and associated geomorphological processes, climate variables and small-scale topography. In general, the "inselbergs" landform contains the largest number of vegetation types (16), followed by the "northern gravel and sand plains" landform (7 vegetation types). In some instances, one vegetation type may occur in a different landforms (e.g. gum milk-bush shrubland occurs on outwash plains and on the northern gravel and sand plains).

Plant diversity and extent of vegetation types

The most diverse vegetation types are associated with rocky outcrops, inselbergs and mountain areas. Here, plant diversity can range from 50 to over 300 species in diversity hotspots such as the Klingshardt and Aurus mountains. Plant diversity on plains and in dune habitats can range between 10 (e.g. northern barchans) and 150 species (e.g. Lüderitz plains).

The largest area is occupied by northern barchan grassland (9.97%), followed by northern gravel and sand plain grassland (9.60%), euphorbia shrubland (9.01%), southern plain dwarf-succulent shrubland (6.25%) and southern *Othonna* dwarf-shrubland (6.15%). All other vegetation types each contribute less than 5% to the area covered (Table 2). Many of the plant diversity hotspots, e.g. Aurus Mountains, Kowisberge, and the Skorpion and Tsaukeib inselbergs, each cover less than 1% of the area (Table 2).

Hiding most of its body underground, the window plant, *Fenestraria rhopalophylla*, is well-adapted to windy and arid conditions; it is endemic to the area and one of the flagship plants of the Sperrgebiet.

Inconspicuous for most of the year, the endemic dwarf succulent *Namibia cinerea* is restricted to outcrops in the Grillental and Pomona areas.
Table 2: Vegetation types and the land area they cover

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Area (km²)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agub–Letterkuppe inselberg shrubland</td>
<td>245.1</td>
<td>1.13</td>
</tr>
<tr>
<td>Aurus–Heioab grassland</td>
<td>177.8</td>
<td>0.82</td>
</tr>
<tr>
<td>Aurus Mountain succulent shrubland</td>
<td>148.9</td>
<td>0.69</td>
</tr>
<tr>
<td>Aurus sand plain grassland</td>
<td>138.9</td>
<td>0.64</td>
</tr>
<tr>
<td>Baker’s Bay coastal dwarf-shrubland</td>
<td>161.1</td>
<td>0.75</td>
</tr>
<tr>
<td>Baker’s Bay corridor dwarf-shrubland</td>
<td>162.5</td>
<td>0.75</td>
</tr>
<tr>
<td>Boegoeberg dwarf-shrubland</td>
<td>45.6</td>
<td>0.21</td>
</tr>
<tr>
<td>Bushman candle plain dwarf-shrubland</td>
<td>255.8</td>
<td>1.18</td>
</tr>
<tr>
<td>Central dune stem-succulent shrubland</td>
<td>1,018.7</td>
<td>4.71</td>
</tr>
<tr>
<td>Channel drainage dwarf-shrubland</td>
<td>46.8</td>
<td>0.22</td>
</tr>
<tr>
<td>Channelis dwarf-shrubland</td>
<td>157.9</td>
<td>0.73</td>
</tr>
<tr>
<td>Charmanib dune grassland</td>
<td>94.6</td>
<td>0.44</td>
</tr>
<tr>
<td>Charmanib shrubland</td>
<td>11.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Coastal pelargonium dwarf-shrubland</td>
<td>122.5</td>
<td>0.57</td>
</tr>
<tr>
<td>Eastern sand plain grassland</td>
<td>664.4</td>
<td>3.07</td>
</tr>
<tr>
<td>Euphorbia shrubland</td>
<td>1,946.9</td>
<td>9.01</td>
</tr>
<tr>
<td>Grillental corridor shrubland</td>
<td>973.2</td>
<td>4.50</td>
</tr>
<tr>
<td>Heioab shrubland</td>
<td>96.9</td>
<td>0.45</td>
</tr>
<tr>
<td>Hotenrot’s Bay salt flats</td>
<td>120.8</td>
<td>0.56</td>
</tr>
<tr>
<td>Kaukausib drainage dwarf-shrubland</td>
<td>241.8</td>
<td>1.12</td>
</tr>
<tr>
<td>Klinghardt succulent shrubland</td>
<td>609.5</td>
<td>2.82</td>
</tr>
<tr>
<td>Kovisberge dwarf-shrubland</td>
<td>110.8</td>
<td>0.51</td>
</tr>
<tr>
<td>Lüderitz Peninsula dwarf-shrubland</td>
<td>93.2</td>
<td>0.43</td>
</tr>
<tr>
<td>Lüderitz plain dwarf-shrubland</td>
<td>287.9</td>
<td>1.33</td>
</tr>
<tr>
<td>Namitis shrubland</td>
<td>14.3</td>
<td>0.07</td>
</tr>
<tr>
<td>Northern barchan grassland</td>
<td>2,155.8</td>
<td>9.97</td>
</tr>
<tr>
<td>Northern gravel and sand plain grassland</td>
<td>2,118.8</td>
<td>9.80</td>
</tr>
<tr>
<td>Obib Mountain succulent-shrubland</td>
<td>312.2</td>
<td>1.44</td>
</tr>
<tr>
<td>Orange River Valley shrubland</td>
<td>108.9</td>
<td>0.50</td>
</tr>
<tr>
<td>Orange River woodland and floodplain</td>
<td>58.3</td>
<td>0.27</td>
</tr>
<tr>
<td>Orthornia dwarf-shrubland</td>
<td>783.8</td>
<td>3.63</td>
</tr>
<tr>
<td>Pockenbank shrubland</td>
<td>11.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Rekwake shrubland</td>
<td>32.0</td>
<td>0.15</td>
</tr>
<tr>
<td>Rocky coast dwarf-shrubland</td>
<td>46.8</td>
<td>0.22</td>
</tr>
<tr>
<td>Rooiberg shrubland</td>
<td>22.3</td>
<td>0.10</td>
</tr>
<tr>
<td>Roolpel dwarf-shrubland</td>
<td>88.6</td>
<td>0.41</td>
</tr>
<tr>
<td>Salsola dwarf-shrubland</td>
<td>83.5</td>
<td>0.39</td>
</tr>
<tr>
<td>Salsola hummocks</td>
<td>28.4</td>
<td>0.13</td>
</tr>
<tr>
<td>Schakalsberge dwarf-shrubland</td>
<td>631.6</td>
<td>2.92</td>
</tr>
<tr>
<td>Schakalsberge plain dwarf-shrubland</td>
<td>207.2</td>
<td>0.96</td>
</tr>
<tr>
<td>Skorpion inselberg shrubland</td>
<td>126.2</td>
<td>0.58</td>
</tr>
<tr>
<td>Skorpion sand plain grassland</td>
<td>38.5</td>
<td>0.18</td>
</tr>
<tr>
<td>Southern Boegoeberg plain dwarf-shrubland</td>
<td>277.6</td>
<td>1.28</td>
</tr>
<tr>
<td>Southern dune dwarf-shrubland</td>
<td>589.8</td>
<td>2.73</td>
</tr>
<tr>
<td>Southern dune grassland</td>
<td>780.7</td>
<td>3.61</td>
</tr>
<tr>
<td>Southern dwarf-succulent shrubland</td>
<td>847.9</td>
<td>3.92</td>
</tr>
<tr>
<td>Southern euphorbia shrubland</td>
<td>38.9</td>
<td>0.18</td>
</tr>
<tr>
<td>Southern Orthornia dwarf-shrubland</td>
<td>1,329.8</td>
<td>6.15</td>
</tr>
<tr>
<td>Southern plain dwarf-succulent shrubland</td>
<td>1,350.5</td>
<td>6.25</td>
</tr>
<tr>
<td>Succulent grassland</td>
<td>170.9</td>
<td>0.79</td>
</tr>
<tr>
<td>Swartkloofberg shrubland</td>
<td>125.3</td>
<td>0.58</td>
</tr>
<tr>
<td>Tsaukhub dwarf-shrubland</td>
<td>195.3</td>
<td>0.90</td>
</tr>
<tr>
<td>Tsaus dune grassland</td>
<td>57.4</td>
<td>0.27</td>
</tr>
<tr>
<td>Tsaus dwarf-shrubland</td>
<td>106.6</td>
<td>0.49</td>
</tr>
<tr>
<td>Tsaus pan grassland</td>
<td>273.5</td>
<td>1.27</td>
</tr>
<tr>
<td>Western Klinghardt-plain shrubland</td>
<td>671.6</td>
<td>3.11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21,617.2</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

Dark shaded vegetation types = covering >5% of Sperrgebiet
Light shaded vegetation types = biodiversity hotspot covering <1% of Sperrgebiet
Conservation importance

Based on numbers of endemic, red-listed and/or protected plant species, vegetation types were assigned a rating of conservation importance. Rated as being of "very high" conservation importance are a number of vegetation types in the Lüderitz area, such as Lüderitz Peninsula dwarf-shrubland, Kowisberge and Tsaukhaib dwarf-shrublands and Grillental corridor shrubland. In addition, the inselberg and mountain shrublands (Klinghardt, Heioab, Boegoeberg, Roodberg, and the Aurus and Obib mountains and Schakalsberge) are also rated to be of "very high" conservation importance. Others that are of "very high" conservation importance include the Orange River Valley shrubland and southern Boegoeberg plain dwarf-shrubland, as well as the plains in the eastern Sperrgebiet such as the Skorpion sand plain grassland and Euphorbia shrubland on the Rosh Pinah plains (Figure 4).

Centres of plant endemism

Based on data at quarter-degree resolution, the following areas within the Sperrgebiet were identified as areas of greatest importance for plant endemism (Burke 2004):
- Lüderitz-Kowisberge
- Klinghardt Mountains
- Aurus-Heioab mountains
- Skorpion
- Obib-Schakalsberg
- Grillental
- the central coastal area (Baker's Bay to Pomona).

These areas of plant endemism largely overlap with those already identified as being of high conservation importance (Figure 4).

Invasive alien plant species

The majority of the Sperrgebiet is characterised by vegetation types free of invasive alien species. This is an extremely important aspect which augments the conservation value of the vegetation in this area. To date, invasive alien plant species have only been recorded in the vicinity of settlements (Lüderitz, Rosh Pinah and Oranjemund) and particularly along the Orange River. Drainage lines originating in the commercial farmland to the east of the Sperrgebiet, e.g. Anib, Rekviakte and Uguchab also provide corridors for alien plants into the Sperrgebiet. Although few plants have to date reached the Sperrgebiet along these river courses, these areas require regular monitoring and control measures should be introduced if necessary. Most vulnerable to invasion by alien plants is the Skorpion area due to human activities in the area. The Aurus Mountains are also vulnerable as they provide comparatively mesic conditions (higher moisture supply, greater soil depth) for a wide range of species.

Resource use

All vegetation types provide forage for wildlife, ranging from insects and small mammals to large herds of antelope. The importance of vegetation types as forage depends on their species composition and availability. Perennial plants such as the leaf-succulent dwarf shrubs, provide forage all year round, while short-lived plants such as grasses and herbs are important for migrating animals that follow the rains to find these green pastures.

The as yet untapped potential of plants in this area for medicinal, horticultural and industrial products that could be developed for commercial purposes is unknown for all vegetation types. However, plants that do occur in the Sperrgebiet that are known to have potential commercial value include Crassula, Hoodia, Lithops and Conophytum species.

Threats

Applicable to all vegetation types is the impending threat of climate change, as the Succulent Karoo is expected to be the most severely affected biome by changes in global climate patterns in southern Africa (Midgley et al. 2001). Declining populations of key species, such as the stem-succulent Aloe dichotoma, are convincing indications of these impacts (Midgley et al. 2005).

Another serious concern is the impact of illegal plant-collecting. These activities target the rarest and hence most vulnerable species which are usually found in the biodiversity hotspots within the area. Entire populations of Lithops, and probably other sought-after species such as Conophytum and Crassula, have already been removed by unscrupulous collectors where they are accessible (A. Burke & C. Mannheimer, pers. obs.).

Mining, quarrying and prospecting activities target specific habitats such as diamond-bearing gravel deposits along the Orange River and
along the coast, as well as potential ore bodies in the inland areas. Although prospecting activities in most cases do not result in the development of new mines, the extensive nature of prospecting activities can nevertheless affect large areas by developing networks of access roads, tracks and drill lines. Strict adherence to environmental guidelines can, however, largely mitigate these impacts.

Other threats are more localised. In the vicinity of settlements and human activities, off-road driving, collecting of wood for fuel and the spread of invasive alien plants, and habitat destruction associated with infrastructure developments are the most serious concerns.

Figure 4: Centres of plant endemism and the conservation importance of vegetation types
Recovery potential

As no quantitative information exists on the recovery time of vegetation in this area, it needs to be stressed that the assessment is general and largely based on the nature of the habitats (Burke 2005a). At the scale of this mapping exercise, there is only one vegetation type in the Sperrgebiet that is expected to show a quick recovery (i.e. within one season after the disturbance) – the northern barchan grassland. Although this may also be the case for a few localised plant communities, such as the semi-aquatic plant communities associated with the Orange River, these are treated with other plant communities in the broader vegetation type that are slower to recover, thus reducing the overall recovery potential.

Very few vegetation types are expected to have a medium-length recovery period. Such vegetation types are expected to be associated with habitats that experience natural disturbances, such as mobile and semi-stabilised dunes and some sand plain habitats where short-lived plants are dominant (e.g. northern gravel and sand plain habitats).

The remaining vegetation types are all expected to show slow recovery, i.e. take more than ten years to re-establish plant cover and composition similar to that prior the disturbance. Depending on the type and severity of the disturbance some may never recover at all (e.g. on old land surfaces where the topsoil has been stripped or the substrate has been chemically or physically altered).

Implications for conservation and land-use planning

Based on the derived vegetation types, various levels of information necessary for planning are provided. Vegetation types of conservation importance (Figure 4), as well as the identified centres of plant endemism, depict "biodiversity hotspots" in the area and are designed to guide the use of these areas. For example, those areas of "very high" conservation importance require the restriction of access or should only allow access under strictly controlled conditions. This applies equally to tourism, mining, exploration and research activities.

The rating of conservation importance of the broadly identified vegetation types further guides development projects, for example, by defining the level of detail required in environmental impact assessments.

Research needs

The research needs outlined in individual fact sheets have been included in the biodiversity gap analysis (see page 20).

Linkages with other vegetation classifications

Broader landform-based classifications, such as the agro-ecological zoning by de Pauw & Coetzee (1999) and the national vegetation map (Burke et al. 2002), coincide well with the mapped vegetation types and provide a coarser level of stratification. The altitude-based floristic zones (Williamson 1997) overlap only marginally (for some mountain areas) with the vegetation types described here.
Biodiversity Gap Analysis

Background

The Global Conservation Fund’s (GCF) pre-feasibility study for the Sperrgebiet included a research-needs assessment (Burke 2002). An updated and summarised version of this assessment is included here. This analysis of the gaps in our knowledge of the Sperrgebiet's biodiversity purposely takes a broad view to emphasise the link between biodiversity information and its application in management.

Approach

To guide the information gathering process a questionnaire was distributed to animal biologists asking questions about the relationships between information on animal groups and the proposed habitat mapping. Further, individual consultations with specialists, discussions at workshops and a review of the literature and on-going projects in the Sperrgebiet served as background information. This information was reviewed and updated in 2005 with input from relevant experts (listed on page 97).

A research framework was developed with the following question in mind:

What are the most important aspects that need to be known to manage a conservation area in a sustainable manner?

Typically, a vision for park management includes conservation of biodiversity, preservation of wilderness quality, maintenance of ecological processes and derivation of human benefits. To derive human benefits requires using resources and often inflicts pressures on natural ecosystems. The objectives and resulting activities of park management can be separated into baseline studies, monitoring programmes and management practices.

The following headings have been used to structure this study:

- Biodiversity inventory and evolutionary processes
- Environmental baselines
- Economic value of resources
- Monitoring resource use and pressures
- Climate change
- Information management, ecological assessment and indicators
- Environmental awareness and training

Topics for research are tabulated under each of these headings, followed by an explanation of the current status of knowledge and giving reference to more detail where applicable.

Finally, the proposed activities have been prioritised to facilitate a phased approach in the section, “The way forward” (page 26).
A research framework for the Sperrgebiet

Biodiversity inventory and evolutionary processes

<table>
<thead>
<tr>
<th>Subject</th>
<th>Research needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiversity inventory</td>
<td>- areas and habitats where data coverage is classified as “none” or “poor”</td>
</tr>
<tr>
<td></td>
<td>- groups of taxa requiring particular attention (insects)</td>
</tr>
<tr>
<td></td>
<td>- bird “atlassing” at finer scale</td>
</tr>
<tr>
<td></td>
<td>- red-list assessments</td>
</tr>
<tr>
<td></td>
<td>- information at a plant-community level in important areas</td>
</tr>
<tr>
<td>Evolutionary processes</td>
<td>- determination of areas or habitats of biogeographic importance (e.g. centres of endemism for insects)</td>
</tr>
</tbody>
</table>

A gap analysis based on a systematic scoring procedure was undertaken with relevant specialists, using the landforms as planning units. Invertebrates emerged as one of the most poorly studied groups. Areas for which little biodiversity information is available overall include the dune and coastal areas in the southwest (mostly high-security diamond area), largely inaccessible areas in the central south and several inselbergs, such as those in the Agub–Letterkuppe area in the northeast (Figure 5). Areas that are reasonably well covered for most taxa include Lüderitz and surrounding area, and the Orange River Valley.

Adequate coverage and subsequent taxonomic analysis of key groups of taxa would enable centres of endemism for certain groups to be determined and so highlight areas and habitats of particular conservation importance (Burke 2004, 2005b). For example, geomorphological processes driving sand transport in this wind-swept area are believed to be of extreme importance to the development of the highly specialised Namib dune insect fauna (J. Irish, pers. comm.).

On the botanical side, systematic plant collecting in the Sperrgebiet over the past decade has resulted in a reasonable general coverage of most areas. Nevertheless, the biodiversity hotspots, in particular, still generate new plant records on every collecting trip. There are also some areas in the central south of the Sperrgebiet that have not yet been accessed at all. Because of inter-annual variation in rainfall, the collecting of bulbs requires more attention. Future botanical work will particularly need to focus on field-based red-list assessments and the monitoring of critical plant populations. This is essential, if a gradual opening up of the area is foreseen in the future.

There are some groups of plants that urgently require taxonomic revision. Several tribes and subtribes in the Mesembryanthemaceae have not been studied at all in Namibia and taxonomic groups endemic to the Sperrgebiet, in particular, need attention. The genus *Salsola*, with supposedly over 30 species endemic to the Sperrgebiet, requires urgent taxonomic revision.
Figure 5: Research coverage
## Environmental baselines

<table>
<thead>
<tr>
<th>Subject</th>
<th>Research needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate data</td>
<td>- better utilisation of existing weather stations</td>
</tr>
<tr>
<td></td>
<td>- coast–inland gradient</td>
</tr>
<tr>
<td></td>
<td>- altitude gradients</td>
</tr>
<tr>
<td></td>
<td>- fog precipitation and frequency</td>
</tr>
<tr>
<td>Environmental baselines</td>
<td>- soil</td>
</tr>
<tr>
<td></td>
<td>- vegetation / habitats (see biodiversity inventory, above)</td>
</tr>
<tr>
<td></td>
<td>- marine intertidal habitats</td>
</tr>
<tr>
<td></td>
<td>- special habitats (e.g. springs and pans, archaeological sites) and</td>
</tr>
<tr>
<td></td>
<td>associated biota</td>
</tr>
<tr>
<td></td>
<td>- existing tracks</td>
</tr>
<tr>
<td></td>
<td>- alien invasive biota</td>
</tr>
<tr>
<td>Ecological processes</td>
<td>- restoration / recovery potential of habitats</td>
</tr>
<tr>
<td></td>
<td>- physical, chemical and biological processes of soil</td>
</tr>
<tr>
<td></td>
<td>- population structure and succession of vegetation</td>
</tr>
<tr>
<td></td>
<td>- flow of water and nutrients</td>
</tr>
<tr>
<td></td>
<td>- seed dispersal and seed-bank dynamics</td>
</tr>
<tr>
<td></td>
<td>- pollination biology</td>
</tr>
</tbody>
</table>

At present only one of the two official weather stations in the area (Lüderitz and Oranjemund) provides regular records. Oranjemund should be reconsidered as a first-order weather station to obtain regular records from the southwestern-most area of the Sperrgebiet. Presently, fog is not measured at any station. Considering that this is one of the most important sources of moisture, some form of measurement should be attempted. Access to data recorded at the automatic weather station at Skorpion Mine should be negotiated, as this provides an important data point in the eastern part of the area. A central point where climate data are maintained, regularly updated and made accessible is crucial.

Detailed vegetation maps at the plant community level are presently lacking. The vegetation types presented here provide good information for planning purposes, but do not replace detailed vegetation maps which are required for (1) all biodiversity hotspots and (2) areas where developments are proposed. Ideally, vegetation and soil should be mapped in conjunction with each other.

Research topics contributing to an understanding of ecological processes require longer-term observations and a large sampling effort. Some of these topics are suited for post-graduate work.

## Economic value of resources

<table>
<thead>
<tr>
<th>Subject</th>
<th>Research needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource economics</td>
<td>- monetary value of selected key natural resources (e.g. plant collectors’ items)</td>
</tr>
<tr>
<td></td>
<td>- development of objective methods to assess intangible values of biodiversity</td>
</tr>
</tbody>
</table>

Obtaining a monetary value for tangible (e.g. wildlife and plant collectors’ items) and intangible values of biodiversity are crucial to demonstrate the value of biodiversity conservation in this area. While resource economic studies evaluating different land uses that use tangible resources are feasible, the intangible value of biodiversity has not yet been adequately assessed. Pilot studies in this area may contribute to the development of an objective method of evaluation.
Monitoring resource use and pressures

<table>
<thead>
<tr>
<th>Subject</th>
<th>Research needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>• water use and recharge</td>
</tr>
<tr>
<td>Wildlife</td>
<td>• population status and movement of large mammals and ostrich</td>
</tr>
<tr>
<td></td>
<td>• population status and movement of key species of conservation importance (e.g.</td>
</tr>
<tr>
<td></td>
<td>brown hyena, Damara tern, gemsbok) in main ecological zones (e.g. coast, dunes,</td>
</tr>
<tr>
<td></td>
<td>sand plain)</td>
</tr>
<tr>
<td></td>
<td>• bird, seal and cetacean breeding areas</td>
</tr>
<tr>
<td>Grazing</td>
<td>• veld condition</td>
</tr>
<tr>
<td>Soil</td>
<td>• erosion hazard</td>
</tr>
<tr>
<td>Pressures</td>
<td>• prospecting and mining</td>
</tr>
<tr>
<td></td>
<td>• tourism impact (number of vehicles, visitors, volume of waste) at sites of</td>
</tr>
<tr>
<td></td>
<td>tourism activities</td>
</tr>
<tr>
<td></td>
<td>• habitat change</td>
</tr>
<tr>
<td></td>
<td>• invasive species</td>
</tr>
<tr>
<td></td>
<td>• determination of “limits of acceptable change” and carrying capacity for each</td>
</tr>
<tr>
<td></td>
<td>habitat, ecosystem or management zone</td>
</tr>
<tr>
<td>Monitoring</td>
<td>• impacts of human activities (mining and tourism) on species and habitats of</td>
</tr>
<tr>
<td>programmes</td>
<td>conservation concern</td>
</tr>
<tr>
<td></td>
<td>• recovery of habitats/ecosystems after mining and other environmental impacts</td>
</tr>
</tbody>
</table>

Conventional wildlife monitoring programmes are suitable to observe the impacts of human activities, provided that the impact is recorded (e.g. number of visitors, water use, etc.) and impact areas are compared to “control” areas with no impact. However, particular attention should be paid to species and habitats of conservation concern, such as fragile soil surfaces, easily disturbed flagship species (e.g. brown hyena) and bird breeding areas. All resources in short supply in this arid area, such as water and grazing, and fragile soils need to be monitored to determine carrying capacities for each ecosystem.

Recovery of habitats and ecosystems after mining is a critical question, since mining and prospecting are prominent land uses in this conservation area. At present, anecdotal evidence of recovery is only available for a few disturbed habitats. Yet environmental impact assessments for development projects need to take potential recovery of habitats into account to provide adequate management guidelines.

For management purposes, habitat change not covered in other monitoring programmes, such as road condition, pollution and disturbance to important sites, need to be monitored as these criteria are required to determine the “limits of acceptable change” and subsequent management actions.
Climate change

<table>
<thead>
<tr>
<th>Subject</th>
<th>Research needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td>consolidation and publication of available weather data</td>
</tr>
<tr>
<td></td>
<td>monitoring and evaluation of climate data</td>
</tr>
<tr>
<td></td>
<td>population status of taxa expected to respond first to climate change</td>
</tr>
</tbody>
</table>

An adequate network of weather stations is necessary to detect fine-scale changes in weather patterns. Available data not centralised at Namibia's weather bureau, such as rain-gauge records from the Sperrgebiet and Namib sand sea and weather data from Skorpion and Rosh Pinah, should be consolidated, analysed and published.

The population status of taxa expected to respond first to climate change, such as stem succulents, should be monitored.

Information management, ecological assessment and indicators

<table>
<thead>
<tr>
<th>Subject</th>
<th>Research needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database development</td>
<td>meta-database for biodiversity and environmental information</td>
</tr>
<tr>
<td>Method development</td>
<td>biological indicators (through phylogenetic analysis, for example)</td>
</tr>
<tr>
<td></td>
<td>indicators for effectiveness of conservation</td>
</tr>
<tr>
<td></td>
<td>standard methods for rapid biodiversity assessment</td>
</tr>
</tbody>
</table>

Environmental planning requires a solid well-maintained database that is regularly updated. Similar to obtaining weather data, environmental data for this area should be obtained from Namdeb, Skorpion and other potential data holders, and consolidated in a meta-database.

Data access agreements need to be developed for this purpose. The internet should be considered as an access point with the level of access defined for different user groups.

Biological indicators (perhaps through phylogenetic analysis) for monitoring potential disturbance, as well as indicators to monitor the effectiveness of conservation, need to be developed.

In order to maintain monitoring programmes for future needs, simple methods of rapid biodiversity assessment are crucial.

Environmental awareness and training

<table>
<thead>
<tr>
<th>Subject</th>
<th>Research needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental awareness and training</td>
<td>environmental guidelines</td>
</tr>
<tr>
<td></td>
<td>biodiversity field guides for different taxa</td>
</tr>
<tr>
<td></td>
<td>training of field biologists</td>
</tr>
</tbody>
</table>

The Sperrgebiet is a national asset of extremely high conservation value. Yet due to restricted access, few people have ever seen the area. Information is presently restricted to only a few widely available sources.

To sustain monitoring programmes into the future requires a solid, dedicated force of local field biologists. An extensive training programme, in support of those presently underway at the University of Namibia, the Polytechnic and the Desert Research Foundation of Namibia, is critical.
The way forward

Considering the comprehensive research and monitoring requirements for this area, some prioritisation is essential. Ideally, complete environmental baselines are desirable for any further planning, but not obtainable in the short-term. The four most pressing needs include:

- Environmental baseline development,
- Monitoring resource use and pressures,
- Raising environmental awareness and developing training, and
- Managing the existing and new information.

Environmental baselines

Environmental maps and biodiversity inventories need to be first completed for areas where impacts are currently happening or expected, and where developments are planned. Development needs to be subject to the completion of all relevant baselines, and if undertaken as part of an environmental impact assessment, appropriate experts must be involved. Some inventory work requiring substantial manpower, e.g. field-based red-list assessments, could possibly be done by less experienced biologists, and could involve students of tertiary training institutions and volunteers.

To ensure that field surveys contribute to filling the identified data gaps, a research co-ordination unit would be required. Such a unit – for example, based at the MET or within an environmental NGO – would be tasked to develop and advertise projects, provide logistic support (e.g. organising restricted area access) and ensure that the information gained from projects is interpreted for management purposes and incorporated into a central database.

Monitoring resource use and pressures

Where developments take place, monitoring of environmental impacts and, if necessary, adaptation of management practices is required.

Environmental awareness and training

The training of field biologists to gain a knowledge of the Succulent Karoo is crucial and should be prioritised.

Information management

Environmental planning requires a solid, well-maintained database which is regularly updated. In addition to weather data, environmental data for this area should be obtained from all data holders and consolidated in a meta-database.

The internet would provide a convenient access point, where different levels of access can be defined for different groups of users.

CONCLUSION

Restricted access, the absence of land-use activities with wide-ranging impacts, such as livestock farming, as well as its position in a global biodiversity hotspot, have made the Sperrgebiet a unique asset for Namibia. Vegetation types in this area are largely free of alien plant intruders; most are presently undisturbed. However, due to the aridity of the area, many vegetation types are expected to recover very slowly after disturbance, if at all. Based on high plant diversity and concentrations of species with restricted ranges, several vegetation types of "very high" conservation importance (i.e. biodiversity hotspots) were identified. These included most vegetation types on inselbergs and mountain areas, the Lüderitz Peninsula and the majority of the coastal area.

Sound management of a biodiversity hotspot of international importance requires good baseline information, as well as sound monitoring programmes. There are still many gaps that need to be filled in the long-term and these should be addressed systematically in a well-designed research programme. In the meantime, management will need to be guided by sound environmental data gained through research. To this end the following aspects need to be prioritised:

- Completion of environmental baselines in areas of very high conservation value and areas where developments are planned,
- Monitoring of resource use and environmental impacts in development areas,
- Training of field biologists with emphasis on the Succulent Karoo, and
- Development of an environmental meta-database.
THE VEGETATION TYPES

The following section provides a description of the vegetation types presented according to thematic groups and in alphabetic order of their common name.
Figure 6: Vegetation types
Vegetation types

Coastal dwarf-shrubland
1. Baker's Bay coastal dwarf-shrubland
2. Baker's Bay corridor dwarf-shrubland
3. Channel drainage dwarf-shrubland
4. Coastal polygonum dwarf-shrubland
5. Lüderitz Peninsula dwarf-shrubland
6. Lüderitz plain dwarf-shrubland
7. Ot_MENUONI dwarf-shrubland
8. Rocky coast dwarf-shrubland

Inland dwarf-shrubland
9. Bushman candle plain dwarf-shrubland
10. Kaukasib drainage dwarf-shrubland
11. Rooiplas dwarf-shrubland
12. Schakalsberg plain dwarf-shrubland
13. Southern Ot_MENUONI dwarf-shrubland

Inselberg dwarf-shrubland
14. Boegoeberg dwarf-shrubland
15. Knobberge dwarf-shrubland
16. Schakalsberg dwarf-shrubland
17. Tsoukraib dwarf-shrubland
18. Teus dwarf-shrubland

Transitional dwarf-shrubland
19. Channel dwarf-shrubland
20. Salsole dwarf-shrubland
21. Southern Boegoeberg plain dwarf-shrubland
22. Southern dune dwarf-shrubland

Dwarf succulent shrubland
23. Southern dwarf succulent shrubland
24. Southern plain dwarf succulent shrubland

Inselberg shrubland
25. Aqu-Reiterkopf inselberg shrubland
26. AURUS Mountain succulent shrubland
27. Chamraub shrubland
28. Heiaub shrubland
29. K Billing succulent-shrubland
30. Namibia shrubland
31. Obib Mountain succulent-shrubland
32. Pockenbank shrubland
33. Rosberg shrubland
34. Skorpion inselberg shrubland
35. Swartbooisberg shrubland

Shrubland
36. Central dune stem succulent shrubland
37. Euphorbia shrubland
38. Grevillea corridor shrubland
39. Orange River Valley shrubland
40. Southern euphorbia shrubland
41. Western Kleinharts-plain shrubland

Grassland
42. AURUS sand plain grassland
43. AURUS-Heiaub grassland
44. Eastern sand plain grassland
45. Northern gravel and sand plain grassland
46. Rehylake grassland
47. Skorpion sand plain grassland
48. Succulent grassland
49. Taus pan grassland

Dune grassland
50. Chamraub dune grassland
51. Northern baobab grassland
52. Southern dune grassland
53. Taus dune grassland

Hummocks
54. Salsole hummocks

Salt flats
55. Hottentots Bay salt flats

Woodland
56. Orange River woodland and floorplan

29
Baker's Bay coastal dwarf-shrubland

Scientific name
*Brownanthus marlothii* – *Lycium tetrandrum*
dwarf shrubland

Locality The coastal strip north of Baker's Bay comprises this vegetation type.

Geographic unit
Baker's Bay hummocks

Vegetation sub-units
Associated with different landforms, there are several vegetation sub-units. *Brownanthus marlothii*, *Cladoraphis cyperoides* and *Othonna furcata* dominate in dune areas, while *Amphibilia rupis-arculatae* and *Eberlanzia sedoides* are dominant on sand plains. *Lycium tetrandrum*, *Eremothamnus marlothianus*, *Othonna furcata* and *Zygophyllum clavatum* are prominent in rocky habitats. Large stands of *Salsola nolothenis* hummocks frame some of the beaches.

Habitat and environmental parameters
Coastal dunes, gravel and sand plains, salt pans and valleys provide the main landforms. There are also some small outcrops and ridges. Sand-blasting and windy conditions, mainly from the south, occur almost constantly. Rainfall is low – on average estimated to be below 50 mm per annum (there are no weather records available to confirm this) – and fog occurs frequently. The rock outcrops are composed of dolomite, quartzite and phyllite of the Gariep Complex.

Description
The vegetation is patchy and often confined to particular habitats. Dwarf stem- and leaf-succulent shrubs comprise the bulk of the vegetation. Very few plants grow taller than 30 cm. Plant cover is patchy and there are areas with no vegetation, such as salt pans and sand-blasted valleys. Overall, perennial plant cover hardly reaches 5%, but in sheltered places, for example in the lee of rock outcrops, it can reach 15–20%.

Key species
*Brownanthus marlothii* and *Lycium tetrandrum* have been selected as the species after which this unit is named because of their presence almost everywhere, but various other species are equally abundant. *Amphibilia rupis-arculatae*, *Drosanthemum paxianum* and *Eberlanzia sedoides* are dominant on sand plains, and *Othonna furcata* occurs on rocky ridges and in dune areas. *Salsola* species and *Limonium dyeri* occur on gravel plains and near salt pans. *Cladoraphis cyperoides* and *Salsola nolothenis* are the main species associated with coastal dunes. *Lycium tetrandrum* and *Zygophyllum clavatum* are prominent on rock outcrops.

Extent 161.1 km² (0.75% of the Sperrgebiet)

Plant diversity
Some 50 species are expected to occur in this mapping unit.

Conservation importance: VERY HIGH
Many species associated with rocky and sand plain habitats in this mapping unit are of conservation importance. There are protected species, such as *Adromischus*, *Amphibilia*, *Cephalophyllum*, *Conophytum*, *Crassula*, *Eberlanzia*, *Fenestraria*, *Juttadinteria*, *Lithops*, *Psammoporia*, *Ruschia*, *Stoeberia* and *Tylecodon* species. Southern Namib endemics include *Brownanthus arenosus*, *Brownanthus namibensis*, *Euphoria verruculosa*, *Jamesbrutia merxmuelleri*, *Limonium dyeri*, *Marlothiella gummifera*, *Pelargonium cortusifolium*, *Pelargonium sibthorpiifolium* and *Pleronia pomonae*. Several southern Namib coastal endemics, such as *Eremothamnus marlothianus*, *Brownanthus namibensis*, *Limonium dyeri*, *Pleronia spinulosa* and *Marlothiella gummifera* occur.

Alien plant species
None recorded

Resource use
Many plants provide food and moisture for wildlife. Salt pans in this coastal area provide breeding areas for Damara terns and salt licks for wildlife.

Threats
- Infrastructure developments
- Illegal plant collecting
- Quarrying, mining and prospecting
Recovery potential  Low

**Management**
- Recommended management zoning: IUCN 1b (wilderness)
- Monitoring of critical plant populations
- Spot-check people at exit points from the Sperrgebiet
- Involve botanical specialist in infrastructure planning
- Rehabilitate borrow-pits
- Avoid rocky outcrops
- Prohibit off-road driving
- Monitor occurrence of invasive alien plant species around potential tourism and mining developments

**Research needs** Animal records for this mapping unit are poor. Red Data assessments of range-restricted species are important.


**Baker’s Bay corridor dwarf-shrubland**

**Scientific name**
*Brownanthus arenosus* dwarf shrubland

**Locality** This mapping unit comprises the valley, slopes and plains north of Baker’s Bay.

**Geographic unit** Baker’s Bay corridor

**Vegetation sub-units** Associated with different landforms, there are several vegetation sub-units. *Cladoraphis cyperoides* and *Othonna furcata* dominate in dune areas, while *Amphibolia rupis-arcuatae* and *Eberlanzia sedoides* are prominent on sand plains.

**Habitat and environmental parameters** The landforms are largely plains and valleys. There are also some small outcrops and ridges. The valleys are either sand-filled or gravelly. Sandblasting and windy conditions occur frequently. Rainfall is low, on average estimated to be below 50 mm per annum and fog is frequent.

**Description** Dwarf stem- and leaf-succulent shrubs comprise the bulk of the vegetation. Very few plants grow taller than 30 cm. Plant cover is patchy and there are areas with no vegetation cover. Overall, perennial plant cover hardly reaches 5%.

**Key species** *Brownanthus arenosus* is the most frequently seen plant. *Amphibolia rupis-arcuatae* and *Eberlanzia sedoides* are dominant on sand plains, and *Othonna furcata* occurs on rocky ridges and in dune areas. *Salsola* species and *Sarcocaulon patersonii* occur largely on gravel plains.

**Extent** 162.5 km² (0.75% of the Sperrgebiet)

**Plant diversity** Some 50 species are expected to occur in this mapping unit.

**Conservation importance:** HIGH These valleys and associated slopes are of conservation importance. A great number of protected species occur, such as *Adromischus*, *Amphibolia*, *Cephalophyllum*, *Conophytum*, *Crassula*, *Eberlanzia*, *Fenestra*, *Jutta* *Lithops, Psammophora, Ruschia, Stoeberia* and *Tylecodon* species. Southern Namib endemics include *Brownanthus arenosus, Brownanthus namibensis*, *Euphorbia verruculosa*, *Jamesbrinsteinia menzmuelleri*, *Limonium dyeri*, *Marlothiella gummifer*, *Pelargonium cortusifolium*, *Pelargonium sibthorpiifolium* and *Pteronia pomonae*. 
Alien plant species None recorded

Resource use Many plants provide food and moisture for wildlife.

Threats
- Infrastructure developments
- Illegal plant collecting
- Quarrying and prospecting

Recovery potential Low

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Monitoring of critical plant populations
- Spot-check people at exit points from the Sperrgebiet
- Involve botanical specialist in infrastructure planning
- Rehabilitate borrow-pits

Research needs Animal records for this mapping unit are poor. Red Data assessments of range-restricted species are urgently required.


### Chameis drainage dwarf-shrubland

**Scientific name** *Pelargonium cortusifolium* dwarf shrubland (mapped as "vegetation very sparse")

**Locality** Positioned west of Boegeoisberg, this drainage area provides a corridor to the coast at Chameis Bay.

**Geographic unit** Chameis drainage

**Vegetation sub-units** None

**Habitat and environmental parameters** Drainage channels and a wide open drainage basin interspersed with eroded outcrops provide the backdrop to this mapping unit. The area is extremely arid and run-off probably only occurs in intervals of decades. Metalla, agglomerate, tuff, quartzite, phyllite and dolomite of the Gariep formation are the main rock types. No weather records are available for this area.

**Description** This drainage area is largely free of perennial vegetation and longer-lived plants only grow on the slopes of the surrounding outcrops. Carpets of *Mesembryanthemum* species appear after good rains.

**Key species** *Pelargonium cortusifolium* occurs on slopes adjoining the drainage area.

**Extent** 46.8 km² (0.22% of the Sperrgebiet)

**Plant diversity** Extremely low (1–10 species)

**Conservation importance:** MEDIUM The slopes and outcrops in this drainage area provide a home for protected species such *Conophyllum*, *Lithops* and *Tylecodon* species.

**Alien plant species** None recorded

**Resource use** The drainage area is an important corridor and habitat for wildlife, while the spring at the northern bank of the drainage is an important freshwater source.

**Threats** None at present

**Recovery potential** Low

**Management**
- Recommended management zoning: IUCN 1b (wilderness)
- Prohibit off-road driving
- Monitor emergence of invasive alien plant species, particularly near spring and Chameis Gate – remove, if emerging.

Research needs: Animal records are poor for this area.

Other mapping: AEZ: NAM4; Giess (1971); desert and succulent steppe; Williamson (1997); coastal zone; Jürgens et al. (1997): temperate zone of Namib plains; Burke et al. (2002): plain dwarf shrubland.

Coastal pelargonium dwarf-shrubland

Scientific name: *Pelargonium cortusifolium* dwarf shrubland

Locality: This mapping unit comprises the coastal stretch from approximately Possession Island to Black Point.

Geographic unit: Grilliental outcrops

Vegetation sub-units: The outcrops along this stretch of coastline are diverse. Although *Pelargonium cortusifolium* has been selected as the main descriptor, there are many other species locally dominant on different outcrops. These include *Fremothamnus marlothianus*, *Lycium tetrandrum* and *Othonna furcata*. Sandy areas support small *Cladoraphis cypereoides* hummocks, and occasional pockets of *Salsola nollothensis* hummocks frame some of the larger sandy beaches.

Habitat and environmental parameters: Metasedimentary rocks of the Namaqua Metamorphic Complex form these coastal outcrops. Rock types include different forms of gneiss and amphibolite. Constant southerly winds, regular fog and low rainfall shape the landforms and biotic communities in this mapping unit.

Description: Dwarf shrubs and grasses are the main components of the vegetation. Plant cover is low, usually less than 5%. Plant height, except for the large *Salsola* hummocks, is restricted to approximately 30 cm.

Key species: In addition to *Pelargonium cortusifolium*, *Brownanthus marlothii*, *Cladoraphis cypereoides*, *Eremothamnus marlothianus*, *Lycium tetrandrum*, *Othonna furcata* and *Zygophyllum ovatum* are other common species.

Extent: 122.5 km² (0.57% of the Sperrgebiet)

Plant diversity: Plant diversity is estimated to be medium, ranging between 20 and 50 species.

Conservation importance: MEDIUM. These coastal outcrops are important as they support many plant species of conservation importance. They include *Cephalophyllum*, *Conophyllum*, *Crassula*, *Juttaadinteria* and *Lavrania* species. There are several Namib endemic species, such as *Brownanthus namibensis*, *Crotalaria colorata*, *Eremothamnus marlothianus*, *Euphorbia verruculosa*, *Frankenia pomonensis* and *Limonium dyeri*.

Alien plant species: None recorded

Resource use: Some of the dwarf shrubs are good forage for wildlife in this area.

Threats: Mining and prospecting

Recovery potential: Low

Management:
- Recommended management zoning: IUCN 1b (wilderness)
- Control off-road driving
- Avoid rock outcrops for placing infrastructure
- Seek botanical specialist advice during land-based infrastructure developments, prospecting and mining

Research needs: Red Data assessments of range-restricted plant species are required. Most animal groups have not been collected and even plants are poorly collected in this mapping unit.

Other mapping: AEZ: NAM4; Giess (1971); desert and succulent steppe; Williamson (1997);
coastal zone 0–150 m; Jürgens et al. (1997); coastal zone, Burke et al. (2002): plain dwarf shrubland

**Lüderitz Peninsula dwarf-shrubland**

**Scientific name**
Brownanthus marlothii
- Lebeckia multiflora
dwarf shrubland

**Locality**
This mapping unit is associated with the peninsula and rocky areas to the south and east of Lüderitz.

**Geographic units**
Lüderitz Peninsula,
Lüderitz outcrops

**Description**
Leaf-succulent dwarf shrubs and evergreen shrubs are the most prominent plant growth forms in this mapping unit. The vegetation usually reaches no more than 30 cm in height, suppressed by the constant, strong winds. Only at sheltered places plants grow into sizeable shrubs, reaching 1.5 m. Plant cover usually ranges from 5% to 15%.

**Key species**
Brownanthus marlothii and Lebeckia multiflora have been selected as the main descriptors of this vegetation type because of their overall presence. Also characteristic are Asparagus capensis, Augea capensis, Ectadion latifolium, Euphorbia obdea, Euphorbia verruculosa, Galenia fruticososa, Gazania furlinefolia, Hypertelis angrae-pequenae, Limonium dyeri, Lycium tetrandrum, Pelargonium cortusifolium, Salsola zeyheri and Zygothyphum clavatum. A high diversity of lichens has been recorded on the peninsula.

**Extent**
93.2 km² (0.43% of the Spergebiet)

**Plant diversity**
Some 330 species have been recorded in the quarter-degree square associated with this mapping unit, making it one of the most diverse areas in the Spergebiet.

**Conservation importance: VERY HIGH**
There is a large number of protected species, many with a restricted range and high economic potential for the horticultural trade. These include Conophyton, Crassula, Lavrania, Lithops and Ruschia species. The Lüderitz area has been identified as a centre of endemism (Burke 2004), and hence a large number of endemics are present. A minimum of 40 recorded plant species are Namibian endemics, some restricted to the Lüderitz area. The lichen fields on the peninsula are of high conservation importance.

**Alien plant species**
*Nicotiana glauca* has been recorded in Lüderitz townlands. There are likely to be other alien species associated with the town.

**Resource use**
The diverse succulent cover provides important forage for wildlife in this area.

**Threats**
- Damage to plants through off-road vehicles, particularly on the Lüderitz Peninsula
- Illegal plant collecting

**Vegetation sub-units**
The vegetation is very diverse and many localised plant communities are associated with rocky ridges of different rock types and the habitats in between these rocky outcrops. Fanroth (1991) delineated four main communities within this mapping unit: the *Limonium dyeri, Lebeckia multiflora, Salsola zeyheri* – *Euphorbia verruculosa* and *Augea capensis* communities.

**Habitat and environmental parameters**
The terrain is largely rocky and formed by Pre-Cambrian schist and gneiss. In between the rocky outcrops, gypsum plains, salt pans, plains and sand-filled valleys are found. Fog occurs regularly, but rainfall is extremely low, averaging in the long term 17 mm per year at Lüderitz. Windy conditions, mostly from the south and southwest, prevail throughout the year. Soil types are as diverse as the landforms and range from saline, gypsum-rich and sandy soils to soils derived from schist and gneiss. However, most soils are poorly developed.
- Invasive alien plants
- Infrastructure developments
- Quarrying

Recovery potential Low

Management
- Recommended management zoning: IUCN 1a and b (strict reserve for area within Spergebiet, wilderness for public access area)
- Raise awareness of unique plant life of the Lüderitz Peninsula
- Restrictions should be accompanied by attractive, positively phrased information boards
- Prohibit off-road driving
- Minimise and clearly demarcate tracks to be used
- Demarcate lichen fields and declare out of bounds
- Undertake spot-checks of people leaving the peninsula with illegally collected plants
- Alert customs officials at airports
- Seek advice from botanical specialists for new infrastructure developments and quarrying activities
- Monitor and, if spreading, remove alien plant species
- Any large developments will require detailed environmental impact assessments (at a minimum these need to involve botanical specialists with appropriate knowledge)

Research needs Although plant species have been reasonably well collected, the reasons for the high levels of endemism as well as the factors driving the formation of unique plant communities have not yet been investigated in detail. Over 20 Salsola species are believed to be endemic to the Lüderitz area. This requires a field-based taxonomic study. Fanroth’s (1991) plant community survey needs to be transferred onto a map. Red Data assessments of all range-restricted plant species are required.


Lüderitz plain dwarf-shrubland

Scientific name
*Brownanthus marlothii* – *Ectadium latifolium* dwarf shrubland

Locality This mapping unit comprises plains and low outcrops adjoining the Lüderitz Peninsula to the east and south.

Geographic unit Lüderitz plains

Vegetation sub-units A variety of plant communities are associated with different substrates and landforms in this mapping unit. These include *Stipagrostis*-dominated grasslands on sandy plains, ridges supporting *Ectadium latifolium*, *Lycium tetrandrum*, *Pelargonium* spp. and *Zygophyllum clavatum* communities, as well as plains and valleys dominated by *Brownanthus* and *Psilocaulon* communities.

Habitat and environmental parameters This area is characterised by low, rocky outcrops, plains and sand intrusions to the east towards the sand corridor that feeds the large dune fields of the Namib. The main rock type is gneiss of the Namaqua Metamorphic Complex. Rainfall is low (mean annual average at Lüderitz is 17 mm), and fog becomes less frequent as ones moves away from the coast. Windy conditions, mostly from the south, prevail throughout the year, often transporting sand across these areas. Soil types are diverse and range from saline, gypsum-rich and sandy soils to poorly developed soils derived from gneiss.

Description Leaf-succulent dwarf shrubs, some evergreen shrubs as well as grasses are locally common. Vegetation cover is very sparse (often <1%) and mostly retracted to sheltered sites in valleys, shallow drainage lines and rocky ridges. In open areas, vegetation barely reaches 30 cm in height (except for *Ectadium latifolium*); in sheltered places vegetation can grow to 1.5 m high.

Key species In sandy areas *Cladoraphis cyperoides*, *Stipagrostis geminifolia* and *Stipagrostis lutescens* occur frequently. *Augea capensis*, *Brownanthus marlothii* and several *Salsola* species are characteristic on the plains. *Ectadium latifolium*, *Othonna furcata* and *Pelargonium* species are mainly associated with rocky outcrops.
Resource use The vegetation provides important forage for wildlife.

Threats
- Infrastructure development associated with mining and other activities
- Mining and quarrying
- Invasion of alien plant species

Recovery potential Low

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Prohibit off-road driving
- Demarcate lichen field and declare out of bounds
- Avoid rocky outcrops for positioning of infrastructure
- Involve botanical specialist when planning new infrastructure
- Monitor and, if spreading, remove alien plant species

Research needs This vegetation type has not been collected well for biota other than plants. Well over 20 Salsola species are believed to be endemic to the Lüderitz area. This requires a field-based taxonomic study. A detailed vegetation map is required. Red Data assessments of all range-restricted plant species are required.


Extent 287.9 km² (1.33% of the Spergebiet)

Plant diversity Although less diverse than the Lüderitz Peninsula to the west, well over 150 plant species are nevertheless expected to occur in this vegetation type. Plant diversity decreases away from the Lüderitz Peninsula.

Conservation importance: HIGH Amongst the many species of conservation importance, endemic to the Spergebiet are Ectadium latifolium, Euphorbia verruculosa, Juttadinteria deserticola, Marlothiella gymmifera and Synaptophyllum juttae. There are numerous protected plants, such as Cephalophyllum, Conophyllum, Eberlanzia, Fenestraria, Juttadinteria, Lithops, Psammophora and Ruschia species. All Euphorbia species that occur there are listed on Cites 2. There is a small lichen field on the main road to Elizabeth Bay Mine.

Alien plant species Nicotiana glauca grows near Kolmanskop, and possibly in the mining area.
**Othonna dwarf-shrubland**

**Scientific name**
*Othonna furcata* dwarf shrubland

**Locality**
This mapping unit contains the plains north of Boekeberg, the coastal strip between Uubvlei and Chameis along the southern Sperrgebiet coast and a small dune field to the east of Chammaub.

**Geographic units**
Boekeberg plains, Kerbehuk hummocks, Uub plains, Chammaub dunes

**Vegetation sub-units**
Associated with different landforms, there are several vegetation sub-units. *Cliadaphis cyperoides* and *Othonna furcata* dominate in dune areas, while *Amphibolia rupis-arcuatae, Brownanthus arenosus* and *Eberlanzia sedoides* are prominent on sand plains.

Associated with rock outcrops are sub-units dominated by *Cephalophyllum ebracteatum*, while gravel plains support *Salsola* species.

**Habitat and environmental parameters**
Plains of different substrates provide the majority of the landforms. Some small outcrops and ridges also occur. Sand plains are the main habitat, but there are areas where gravel plains occur locally. Sand-blasting and windy conditions, as elsewhere in the Sperrgebiet, are important environmental variables. Rainfall is low; the annual average is estimated to be below 50 mm (there are no weather records available to confirm this). Fog occurs occasionally, but it occurs less frequently in the eastern areas of this mapping unit.

**Description**
Dwarf stem- and leaf-succulent shrubs comprise the bulk of the vegetation. Very few plants grow taller than 30 cm. Plant cover is largely continuous and averages 10–15%.

**Key species**
*Othonna furcata* is the most common plant on these plains and is present in many vegetation units. *Othonna furcata* occurs on rocky ridges, as well as in dune areas. *Amphibolia rupis-arcuatae, Brownanthus arenosus* and *Eberlanzia sedoides* are dominant on sand plains. *Salsola* species and *Sarcocaulon patersonii* occur largely on gravel plains.

**Extent**
783.8 km² (3.63% of the Sperrgebiet)

**Plant diversity**
Some 90 species are expected to occur in this mapping unit.

**Conservation importance**
VERY HIGH
Plains north of Boekeberg are of very high conservation importance, while the Uubvlei and Kerbehuk hummocks are of high importance. A great number of protected species occur, such as *Adromischus, Ammobolus, Cephalophyllum, Conophyllum, Crassula, Dracophilius, Eberlanzia, Fenestraria, Juttadentia, Lithops, Psammophora, Ruschia, Sperosperma* and *Tylecodon* species. Southern Namib endemics include, amongst others, *Brownanthus arenosus, Brownanthus namibensis, Euphorbia verruculosa, Jamesbrowniella merxmuelleri, Limonium dyeri, Marlothiella gummifera, Pelargonium cortusifolium, Pelargonium sibthorpiifolium, Pteronia pomeranneae and Zygophyllum longicapsulare*.

**Alien plant species**
None recorded

**Resource use**
The continuous cover of the vegetation and prevalence of leaf-succulent shrubs make the vegetation an important food and moisture source for wildlife.

**Threats**
- Infrastructure developments
- Illegal plant collecting
- Quarrying, mining and prospecting

**Recovery potential**
Low to medium

**Management**
- Recommended management zoning: IUCN 1b (wilderness)
- Monitoring of critical plant populations
- Spot-check people at exit points from the Sperrgebiet
- Involve botanical specialist in infrastructure planning
- Rehabilitate borrow-pits

**Research needs**
Animal records for this mapping unit are poor. A more detailed vegetation map is required. Red Data
assessments of range-restricted plant species are very important. More plant collecting within the high security area is important.

Other mapping AEZ: NAM4; Geelss (1971): desert and succulent steppe; Williamson (1997):

Rocky coast dwarf-shrubland

Scientific name Brownanthus marlothii – Salsola nolothonensis dwarf shrubland

Locality This mapping unit comprises the vegetation along the coast between Große Bucht and Elizabeth Bay, i.e. the coastal strip north of Elizabeth Bay.

Geographic unit Elizabeth Bay coastline

Vegetation sub-units These coastal outcrops are diverse and locally dominant are Didelta carnosa var. tomentosa, Eremothamnus marlothianus, Othonna furcata and Zygophyllum clavatum.

Habitat and environmental parameters Largely rocky, gneiss and meta-gabbro are the main rock types. Sand-filled valleys, salt pans, gravel plains and drainage lines occur as well. Climatic conditions are similar to the Lüderitz Peninsula, with strong winds prevailing from the south and southwest, low rainfall and the frequent occurrence of fog. Soil types range from saline, gypsum-rich and sandy soils to poorly developed soils derived from gneiss and meta-gabbro.

Description Dwarf shrubs dominate the vegetation and are sparsely scattered on rocky ridges and plains, barely reaching 1% cover. Where drainage lines and deeper sand provide more favourable moisture conditions, as well as shelter from the wind, plant cover can reach up to 10%. Most plants reach no more than 30 cm in height.

Key species Brownanthus marlothii is prominent on plains in this vegetation type, Limonium dyeri near pans, and Eremothamnus marlothianus, Pelargonium species, Lycium decumbens and Othonna furcata grow largely on rock outcrops. Sandy areas support Cladoraphis cyparoides, Didelta carnosa var. tomentosa and occasionally Amphibolia rupestris-arctatae.

Extent 46.8 km² (0.22% of the Sperrgebiet)

Plant diversity Some 90 species have so far been recorded in the general area, and at least 60 are expected to be associated with this mapping unit.

Conservation importance: HIGH These coastal outcrops are of high conservation importance, as many protected species are associated with this vegetation type. Amphibolia, Cephalophyllum, Conophytum, Crassula, Eberlanzia, Fenestraaria, Juttadinteria, Lithops and Psammophora species are amongst those. There are also many Sperrgebiet endemics, such as Brownanthus namibensis, Ectadium latifolium, Eremothamnus marlothianus, Juttadinteria deserticola, Limonium dyeri and Marlothiella gummifera.

Alien plant species So far none has been recorded, but could be expected where there is frequent human activity.

Resource use The dwarf shrubs are important forage for wildlife.

Threats Mining and prospecting

Recovery potential Low

Management
- Recommended management zoning: IUCN 1b (wilderness area)
- Minimise off-road driving by demarcating and adhering to clearly marked tracks
• Rehabilitate tracks no longer required
• Avoid rocky outcrops and pans for positioning of infrastructure
• Involve botanical specialist during planning for new infrastructure and mining
• Monitor and, if necessary, remove alien invasive plant species

Research needs Animal collections are poor for this mapping unit. A detailed vegetation map for the entire mapping unit would facilitate better planning and management.

**Bushman candle plain dwarf-shrubland**

**Scientific name**
*Sarcocaulon patersonii*
dwarf shrubland

**Locality**
This vegetation type occupies the plains north of the central Kaukausib drainage.

**Geographic unit**
Eastern Lüderitz plains

**Vegetation sub-units**
Besides *Sarcocaulon patersonii*, there are areas dominated by *Stipagrostis ciliata* grassland and *Salsola* species.

**Habitat and environmental parameters**
Gravel plains and some low ridges support this vegetation type. Rainfall is low and patchy. Windy conditions, largely from the south, prevail throughout the year. Underlying the gravel and outcropping along ridges are meta-sediments of the Namaqua Complex.

**Description**
The low, deciduous *Sarcocaulon patersonii* is the main plant. Other than the mostly dry-looking gnarled stems of this shrub, few other shrubs and grasses (after rains) can be seen. The perennial vegetation is extremely sparse, hardly reaching 1% cover and normally does not exceed 30 cm height.

**Key species**
In addition to *Sarcocaulon patersonii*, several *Salsola* species and *Stipagrostis ciliata* occur.

**Extent**
255.8 km² (1.18% of the Sperrgebiet)

**Plant diversity**
Plant diversity in this mapping unit is low and expected to range between 10 and 30 species.

**Conservation importance:**
MEDIUM

Although plant diversity is low, several species of conservation concern occur in this mapping unit. These include Sperrgebiet endemics such as *Euphorbia namibensis*, *Polemanniopsis* sp. nov. and *Synaptophyllum juttae*. *Lavrana marlothii* and *Psammophora modesta* are protected species occurring in this mapping unit.

** Alien plant species**
None recorded

**Resource use**
The grasslands are important food sources for wildlife.

**Threats**
Off-road driving

**Recovery potential**
Low

**Management**
- Recommended management zoning: IUCN 1b (wilderness)
- Prohibit off-road driving

**Research needs**
Red Data assessments of species with limited distribution ranges are required. Most animal groups have been poorly collected. Reproductive material of *Polemanniopsis* sp. nov. is required to name this species.

**Other mapping**
Kaukausib drainage dwarf-shrubland

Scientific name
Salsola dwarf shrubland

Locality
The Kaukausib drainage area dissects the northwest corner of the Sperrgebiet in an east to west direction.

Geographic unit
Kaukausib drainage

Vegetation sub-units
The slopes of the drainage lines, as well as seepage areas support different vegetation. Sedges and grasses occur near water, Aridaria noctiflora and other leaf-succulent dwarf shrubs grow on the slopes.

Habitat and environmental parameters
This broad, shallow drainage area harbours a fountain and some temporal seepage areas. Sandy and gravel plains, as well as sandy and silty drainage lines occur. This area receives little rain. Fog is expected to only occur frequently to the west of the Zweikuppenberg.

Description
Extremely low plant cover; a few shrubs and grasses are present in sheltered places along the slopes of the drainage complex. The plains show patchy grass and annual succulent cover after rains; isolated dwarf shrubs are otherwise present. There are vast areas which are entirely free of perennial vegetation.

Key species
Euphorbia namibensis, Stipagrostis ciliata, as well as Salsola species occur. Ectadium latifolium is present in drainage lines, particularly beneath steep slopes.

Extent
241.8 km² (1.12% of the Sperrgebiet)

Plant diversity
As a result of the low cover, plant diversity is also low and estimated to range between 5 and 15 species.

Conservation importance: MEDIUM
Polennanopsis sp. nov. is endemic to the northern Sperrgebiet. Ectadium latifolium is a Sperrgebiet endemic, and Euphorbia namibensis is restricted to the northern and eastern Sperrgebiet and immediate surroundings.

Alien plant species
None recorded

Resource use
The spring, as well the temporary seeps, are important water sources for wildlife.

Threats
- Off-road driving
- Invasive alien plant species

Recovery potential
Low

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Prohibit off-road driving
- Monitor (particularly springs and temporary water sources) for alien plant species and remove when emerging

Research needs
Red Data assessments of range-restricted plant species are required.

Other mapping
Rooilepel dwarf-shrubland

Scientific name
Vegetation very sparse

Locality
This mapping unit is found west of the Schakalsberge.

Geographic unit
Rooilepel

Vegetation sub-units
Gravel plains support *Salsola*-dominated vegetation, while sandy areas are dominated by *Othonna cylindrica*.

Resource use
Rooilepel is of conservation importance because of significant fossil finds.

Threats
Illegal collecting of fossils

Recovery potential
Low

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Prohibit off-road driving

Research needs
Investigations during a very good season may reveal a few more plant records.

Habitat and environmental parameters
An extensive depression, bordered by calcrite outcropping to the south and surrounded by dunes in all other directions comprises this mapping unit.

Description
Plant cover is extremely sparse.

Key species
A few *Salsola* shrubs occur in this largely barren depression, while plains on higher ground support *Salsola* species, *Stipagrostis gaminifolia* and *Othonna cylindrica* dominated dwarf shrubland.

Extent
88.6 km² (0.41% of the Sperrgebiet)

Plant diversity
Low, expected to support 10–30 species.

Conservation importance: LOW
Extremely sparse plant cover and few plant species characterise this mapping unit.

Alien plant species
None recorded

Schakalsberge plain dwarf-shrubland

Scientific name
*Salsola* – *Stoeberia frutescens* dwarf shrubland

Locality
The plains west of Schakalsberge comprise this mapping unit.

Geographic unit
Schakalsberge plains

Vegetation sub-units
Calcrete and sand plains form a mosaic of various vegetation types. Closer to the mountains, more succulent dwarf shrubs, such as *Eberlanzia*, *Euphorbia* and *Stoeberia* species are prevalent. Where dunes intrude from the west, *Othonna cylindrica* is dominant, whereas calcrite plains support a sparse cover of *Salsola* species.

Habitat and environmental parameters
Bordered by the Schakalsberge to the east, sand piled up against the mountain forms an elevated plain dissected by various shallow drainage lines. Like in the Schakalsberge, strong, southerly
winds, regular fog and low rainfall are the main climatic factors.

**Description** Perennial plant cover comprises mainly low succulent shrubs, averaging 30 cm in height.

**Key species** Salsola sp. is prominent on plains in the south and also expected to occur elsewhere in this mapping unit. Stoeberia frutescens is prominent near the mountains, accompanied by Eberlanzia and Euphorbia species, which extend their ranges westwards from the mountain into this mapping unit. Stipagrostis geminifolia is locally dominant on calcrite plains. Sandy areas are dominated by Othonna cylindrica.

**Extent** 207.2 km² (0.96% of the Sperrgebiet)

**Plant diversity** This mapping unit probably supports medium plant diversity and about 20–30 species are expected to occur.

**Conservation importance: MEDIUM** There are some protected species, such as Dracophyllum and Eberlanzia, as well as Cites 2-listed Euphorbia species.

**Alien plant species** None recorded

**Resource use** Plant resources in this mapping unit provide forage for wildlife.

**Threats** None

**Recovery potential** Medium in dune areas, low on calcrite plains

**Management** Recommended management zoning: IUCN 1b (wilderness area)

**Research needs** Limited vegetation data and no plant collecting data exist for this mapping unit. Animal data are also poor.

**Other mapping** AEZ: NAM5; Gless (1971): desert and succulent steppe; Williamson (1997): coastal zone 0–150 m; Jürgens et al. (1997): temperate zone of Namib plains; Burke et al. (2002): plain dwarf shrubland

---

**Southern Othonna dwarf-shrubland**

**Scientific name** Brownanthus arenosus, Brownanthus marlothii, Salsola and Zygophyllum species dominate.

**Habitat and environmental parameters** A mosaic of large sections of sand, gravel and calcrite plains is expected to intermingle in this mapping unit. There are also localised sections with mobile dunes. No weather records exist for this mapping unit, but the general conditions are expected to be similar to those in the southern section of the Sperrgebiet. The mean annual rainfall of 54 mm at Oranjemund is probably not reached here, and fog events are less frequent than along the coast. Strong southerly winds blowing sand off the Hohenfels dunefields into this mapping unit is probably one of the most significant environmental factors shaping landforms and the vegetation.

**Description** A combination of low stem succulents, leaf succulents hardly reaching 30 cm height and patches of grasses intermingle
in this mapping unit. Plant cover is patchy throughout the overall unit, although continuous cover is expected in some of the more vegetated areas, such as on sand plains. Overall, perennial plant cover is low and estimated to range between 1% and 10%. Plant height averages at 30 cm.

**Key species.** *Brownanthus arenosus* is common throughout this unit. Other species expected to be locally dominant are *Othonna furcata*, *Othonna cylindrica*, *Brownanthus marlothii*, *Salisola* and *Zygophyllum* species.

**Extent** 1,329.8 km² (6.15% of the Sperrgebiet)

**Plant diversity** Scanty field data exist for this mapping unit, but plant diversity is expected to be low.

**Conservation importance:** MEDIUM The Sperrgebiet endemic *Brownanthus arenosus*, endemic *Zygophyllum* and also *Dracophilus* species occur in this mapping unit.

**Alien plant species** None recorded

**Resource use** Grass-dominated areas as well as leaf and stem succulents provide forage for a variety of animals.

**Threats** None at present

**Recovery potential** High to medium (high in sandy areas, medium on gravel plains)

**Management** Recommended management zoning: IUCN 1b (wilderness area)

**Research needs** As there are no established access routes through the majority of this mapping unit, field data for all biota (plants and animals) are scanty. Although expected to be overall of low diversity, field data should be gathered to back this up.

Boegoeberg dwarf-shrubland

Scientific name: *Pleronia glabrata* - *Zygophyllum clavatum* dwarf shrubland

**Locality:** This inselberg is positioned approximately 25 km east of Chameis Bay.

**Geographic unit:** Boegoeberg

**Vegetation sub-units:** Different plant species are dominant on different parts of this inselberg and associated outcrops. Slope aspect and altitude are believed to influence this. For example, *Othonna cylindrica* is prevalent on sandy footslopes, *Antimima buchbergensis* and *Pleronia glabrata* are more dominant higher up the slopes.

**Habitat and environmental parameters:** Slopes of this inselberg, as well as its surrounding plains and associated outcrops, comprise this mapping unit. The inselberg is composed of schist and quartzite. The highest point is approximately 200 m higher than the surrounding plains. Rainfall is low, but fog occurs frequently and often clothes this mountain in a seemingly impenetrable cover. Strong winds are observed near the top of the highest peaks. Southerly and southwesterly winds occur all year round.

**Description:** Dwarf succulent shrubs are the main plants on this mountain. Plant height varies from 0.2 to 1.0 m, depending on the plant's position in relation to the prevailing winds. Stunted growth is shown by many plants growing in exposed positions because of wind impact. Taller, upright forms of the same species can be observed in sheltered places. Plant cover is very patchy and ranges between 1% and 10%.

**Key species:** In addition to the main descriptors of this mapping unit, *Othonna cylindrica* is prevalent on sandy footslopes, while *Antimima buchbergensis* and *Aridaria nodiflora* are prevalent near the main peak. On other parts of the mountain *Didelella carnosa* var. *tomentosa* and *Eberlanzia clausa* are locally dominant.

**Plant diversity:** Some 153 species have been recorded on this inselberg and its immediate surroundings. This is a high diversity of plants considering the very arid and windy conditions, although they are moderated by the influence of fog.

**Conservation importance:** VERY HIGH The list of protected species comprises some 24 species so far, and includes species of the genera *Antimima*, *Amphibolia*, *Cephalophyllum*, *Conophyllum*, *Crassula*, *Eberlanzia*, *Euphorbia*, *Lachenalia*, *Stoeberia*, *Tylecodon* and *Tridentea*. Equally numerous are Namib endemics, including *Brownanthus arenosus*, *Bulbine namaensis*, *Eremothamnus marlothianus*, *Eriosperrnum buchbergense*, *Lachenalia buchbergensis*, *Mesembryanthemum barklyi* and *Pelargonium cortusifolium*.

**Alien plant species:** None recorded

**Resource use** Particularly the sand plains surrounding the mountain provide important forage for wildlife.

**Threats**
- Illegal plant collecting
- Infrastructure development

**Recovery potential:** Low

**Management**
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Prohibit unguided access
- Seek botanical specialist advice during planning of infrastructure

**Extent:** 45.6 km² (0.21% of the Sperrgebiet)
Research needs There is a need for better animal data for this inselberg. More collecting of bulbs is important.

Other mapping AEZ: R; Giess (1971); desert and succulent steppe; Williamson (1997); coastal

Kowisberge dwarf-shrubland

Scientific name
Euphorbia cibdelta – Zygophyllum clavatum dwarf shrubland

Locality These inselbergs east of Luderitz are the Kowisberge and Klammerberg and associated outcrops.

Geographic unit Luderitz inselbergs

Vegetation sub-units Different species are dominant on the inselbergs contained in this mapping unit, including small outcrops north of the Kowisberge. Salsola species are dominant on some. Euphorbia cibdelta and Euphorbia gummifera on others, while Zygophyllum clavatum occurs on most.

Habitat and environmental parameters Metamorphic rocks such as gneiss and schist make up the bulk of the substrate of the Kowisberge. Positioned in one of the main sand corridors, some 20 km east of the coastline, extremely windy and often sand-blasting conditions prevail on top of these inselbergs. Fog is an important moisture source, but occurs less frequently than near the coast. Rainfall is extremely low, often with several years between events.

Description A mixture of dwarf leaf-succulent and low deciduous shrubs comprises the dominant vegetation. Perennial vegetation cover is low and hardly reaches 5%. Most plants show a stunted growth due to the windy conditions, and only in sheltered places plants can reach 0.5–1 m in height.

Key species Besides Euphorbia cibdelta and Zygophyllum clavatum, which have been selected as the main descriptors because of their wide occurrence, other Zygophyllum species (e.g. Zygophyllum cordifolium, Zygophyllum hirticaule and Zygophyllum prismaticarpum) occur, as well as Euphorbia gummifera, Lycium decumbens, Pelargonium cortusfolium and Sarcocaulon patersonii.

Extent 110.8 km² (0.51% of the Sperrgebiet)

Plant diversity Considering the extreme climatic conditions, plant diversity is remarkably high. Some 220 species have been recorded in the Kowisberge and associated outcrops.

Conservation importance: VERY HIGH The Kowisberge are of extremely high conservation importance, while outcrops to the north are of medium importance. There is at least one species endemic to the Kowisberge, Julladinteria kowismontana. Over 40 endemic species have been recorded in total. Sperrgebiet endemics are, for example, Brownanthus arenosus, Berkheya schinzii, Ectadium latifolium, Psammophora modesta and Zygophyllum hirticaule. There is also a high number of protected plants, including Adromischus, Crassula, Hoodia, Julladinteria, Lithops, Namibia, Ozoroa, Psammophora, Stapelia and Tylecodon species, as well as Aloe dichotoma. The Kowisberge have been identified as one of the most important centres of endemism in the Sperrgebiet (Burke 2004).
Alien plant species  None recorded

Resource use  This area provides habitat and food sources for small mammals and invertebrates.

Threats
  • Illegal plant collecting
  • Quarrying, prospecting and mining

Recovery potential  Low

Management
  • Recommended management zoning: IUCN 1a (strict nature reserve)
  • Avoid positioning infrastructure on these inselbergs
  • Spot-check people for illegally lifted plants

• Seek botanical specialist advice for any mining, prospecting, quarrying or infrastructure developments

Research needs  There is a possibility that more endemic species in the Mesembryanthemaceae subtribe of Dracophilinae occur in these mountains. Red Data assessments of all protected and range-restricted species on these mountains need to be undertaken. All animal groups are poorly recorded.

Other mapping  AEZ: R; Giess (1971); desert and succulent steppe; Williamson (1997); coastal zone; Jürgens et al. (1997); temperate Namib mountains; Burke et al. (2002); plain dwarf shrubland

Schakalsberge dwarf-shrubland

Scientific name
  Euphorbia chersina – Stoebertia frutescens
dwarf shrubland

Locality  This mountain range runs in a northwest to southeast direction and is positioned west of the Obib dunes in the southern part of the Sperrgebiet.

Geographic unit  Schakalsberge

Vegetation sub-units  This mountain range supports diverse plant communities, the composition of which is largely determined by distance from the Orange River, aspect, slope and elevation.

Habitat and environmental parameters  The low mountain range is composed of different rock types, largely schist, dolomite, breccia and greywacke. The highest peaks rise about 150 m above the surrounding plains. Climatic conditions are similar to those for the Obib area. Fog, moving northeasterwards through the Orange River Valley, often reaches these mountains. Apart from mountain slopes, drainage lines, and gravel and sand plains adjoining the mountains are also included in this mapping unit.

Description  Succulent dwarf shrubs and shrubs are the main components of the vegetation. Plant cover is variable and patchy on the mountain slopes. Perennial plant cover varies between 5% and 15%. Plant heights on the mountain are variable and largely determined by the level of exposure. On the wind-swept tops, plant height barely reach 20 cm, while sheltered slopes support taller shrubs and occasionally trees up to 4 m in height.

Key species  Euphorbia chersina is frequent on the slopes and the plains in the immediate vicinity of the mountains. Stoebertia frutescens is largely restricted to the mountain slopes. Locally, a variety of other species are dominant, such as Astridia velutina, Cerveria fruticulosa, various Ebertanzia species and Pteronia giabrata.
Extent 631.6 km² (2.92% of the Sperrgebiet)

**Plant diversity** Considering the aridity and exposed nature of this mountain range, plant diversity is high. Approximately 110 species were recorded on the northern-most extension of the mountain, many more can be added that occur on the southern part in the vicinity of the Orange River only.

**Conservation importance:** VERY HIGH A great number of species of conservation importance is present on the Schakalsberge. This includes several protected species of the genera *Aloe*, *Amphibolia*, *Anacamptos*, *Antimima*, *Aridaria*, *Astridia*, *Bulbine*, *Cephalophyllum*, *Cheiridopsis*, *Conophytum*, *Crassula*, *Eberlanzia*, *Festucastraria*, *Juttafruticosa*, *Lavrania*, *Psammophora* and *Ruschia*. A variety of CITES 2-listed *Euphorbia* species also occur. In addition, there are also many endemic species, such as *Brownanthus arenosus*, *Mesembrianthemum kellitum* and several *Zygophyllum* species.

**Alien plant species** In the vicinity of the Orange River, several alien species, such as *Argemone ochroleuca* and *Nicotiana glauca*, have been reported.

**Resource use** These diverse dwarf shrublands are an important habitat and food source for wildlife.

**Threats** Illegal plant collecting

**Recovery potential** Low

**Management**
- Recommended management zoning: IUCN 1b (wilderness area)
- Prohibit unguided access
- Control track development

**Research needs** A detailed vegetation map of this mountain range and adjacent plains would facilitate the development of more detailed management guidelines. Animal records for this mountain are poor and red-list assessments of critical species are needed.


---

**Tsaukhaib dwarf-shrubland**

**Scientific name**
- *Euphorbia cibdela* — *Euphorbia gummifera* shrubland

**Locality**
The Tsaukhaib, Haalenberg and associated inselbergs in the north of the Sperrgebiet comprise this mapping unit.

**Geographic unit**
Lüderitz inselbergs

**Vegetation sub-units** Different landforms contained in this mapping unit support different vegetation types. These include grass-dominated plains surrounding the inselbergs, stands of *Euphorbia gummifera* on the plains and diverse shrub vegetation on the mountain slopes.

**Habitat and environmental parameters**
Granodiorite gneiss and gneissic granite comprise the underlying substrate. These inselbergs are at the eastern margin of the wind corridor along the Sperrgebiet coast. Hence southerly winds are expected to have an influence on the vegetation. Rainfall is low and as likely to fall in winter as in the summer months. Fog may occasionally reach these mountains.

**Description** An almost equal mixture of deciduous and succulent shrubs forms the vegetation on these inselbergs. Perennial plant cover is patchy and ranges 1–15%. Shelter from the prevailing wind probably influences plant height as well as plant cover. Most plants hardly reach 30 cm in height, but in sheltered positions and in drainage lines taller shrubs averaging 1 m can be found.

**Key species** *Euphorbia gummifera* is omnipresent in this mapping unit, accompanied by a variety of dwarf-succulent and shrub species. *Euphorbia cibdela* has been selected as the main species characterising the mountain vegetation, but many others are equally abundant. These include *Diospyros ramulosa*, *Eberlanzia claussa*, *Euphorbia lignosa*, *Othonna graveolens* and *Zygophyllum prismatocarpum*.

**Extent** 195.3 km² (0.90% of the Sperrgebiet)
Plant diversity  Plant life is diverse, totalling approximately 160 species.

Conservation importance: VERY HIGH  A range of species of conservation importance occurs in this mapping unit. These include the more widely distributed protected species, such as Aloe dichotoma, Boscia albitrunca and Ozoroa crassinervia, as well as a variety of range-restricted species of various genera, such as Amphibolia, Crassula, Dracophilus, Eberlanzia, Ebracteola, Hereroa, Juttadinteria and Ruschia. The southern Namib endemics Brownanthus arenosus and Euphorbia namibensis also occur in this mapping unit. Of particular concern are species largely restricted to these inselbergs such as Conophytum halenbergense, Eriospermum halenbergense and Juttadinteria simpsonii.

Alien plant species  None recorded

Resource use  The perennial plant cover of these inselbergs is an important habitat, and food and moisture source for a variety of animals.

Threats  
- Quarrying and prospecting
- Illegal plant collecting
- Off-road driving

Recovery potential  Low

Management  
- Recommended management zoning: IUCN 1a (strict reserve)
- Avoid positioning infrastructure on these inselbergs
- Spot-check visitors for illegally lifted plants
- Seek botanical specialist advice for any mining, prospecting, quarrying or infrastructure developments
- Access to Haalenberg from main road needs to be restricted

Research needs  Red Data assessments of all range-restricted plant species are urgently required.

Other mapping  AEZ. R; Giess (1971): desert and succulent steppe; Williamson (1997): coastal zone 0–150 m; Jürgens et al. (1997): temperate Namib mountains; Burke et al. (2002): mountain dwarf shrubland

Tsaus dwarf-shrubland

Scientific name  
Euphorbia cebela – Zygophyllum decumbens dwarf shrubland

Locality  The Tsaus Mountain is positioned in the northeast of the Sperrgebiet.

Geographic unit  Tsaus

Vegetation sub-units  The top, slopes, drainage channels and base of the mountain support different vegetation units.

Habitat and environmental parameters  This large mountain is a sedimentary massif of dark limestone and shale of the Nama Group. The highest peak rises nearly 400 m above the surrounding plains and the flat-top mountain slopes in steps towards the southwest. On the southwestern side, two deep valleys have broken up the once massive hump of rock. Deeply incised slopes exist all around the mountain. There are no long-term weather records for this area, but it is expected to receive summer and winter rainfall. Fog influence is rare, but southerly and southwesterly winds are still important forces as elsewhere in the Sperrgebiet. Easterly berg winds during the winter months bring abrasive dust storms to this mountain. Temperatures can fall below freezing at times.
Description  Low succulent and deciduous shrubs are the main form of vegetation on this mountain. Grasses are more dominant than they are on other Sperrgebiet mountains to the south and west. The shrubs are sparsely scattered on the top, with perennial plant cover hardly reaching 5%. Vegetation is denser on the slopes where plant cover averages around 15%. Plant heights vary as on most mountains. Mean height on top is approximately 30 cm, but 50 cm is reached by many plants on the slopes. The gullies often show higher plant cover and harbour even larger plants reaching 1 m in height.

Extent  106.6 km² (0.49% of the Sperrgebiet)

Plant diversity  Just over 100 species have so far been recorded on the mountain.

Conservation importance:  HIGH  The mountain is of high conservation importance as there are some protected Aloe, Crassula, Hoodia, Juttadinteria and Pelargonium species. There are also Namibian endemics such as Berkhaya schinzii, Encephalus giessii, Pteronia pomonae and Stipagrostis lamipes.

Alien plant species  None recorded at present

Resource use  Particularly the gullies with higher plant cover provide forage and shelter for wildlife.

Threats  None at present

Recovery potential  Low

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Track control

Research needs  Collecting during good rain years will produce a more comprehensive account of the flora. Animal records for this mountain are poor.


Key species  Euphorbia cibdela and Zygophyllum demimhens have been selected as the main descriptors of the vegetation. However, due to the overall low cover, many other species are similarly abundant. Didelma carnosa, Euphorbia gummifera, Montinia caryophyllacea, Pteronia glabrata, Pteronia lucilioides and Stipagrostis anomala are other characteristic species.
Chameis dwarf-shrubland

**Scientific name**
*Brownanthus arenosus*
- *Brownanthus mariothii* dwarf shrubland

**Locality**
This mapping unit is positioned to the west of Boegoeberg.

**Geographic units**
Chameis outcrops and Chameis plains

**Vegetation sub-units**
*Brownanthus arenosus* and *Brownanthus mariothii* alternate in their dominance. Locally, *Salsola* species and *Othonna furcata* are common.

**Habitat and environmental parameters**
The outcrops around Chameis, as well as the adjoining gravel and sand plains to the south are contained in this mapping unit. Shallow drainage lines are directed towards the Chameis basin; low rock outcrops add to the habitat diversity. The area is very dry, but expected to receive more fog as ones moves upwards to Boegoeberg.

**Description**
Dwarf succulent shrubs are the main component of the vegetation. Plant cover varies between being patchy and continuous. The outcrops around Chameis show extremely low perennial plant cover (below 0.5%), while the plains towards Boegoeberg reach 10–15% perennial plant cover.

**Key species**
*Brownanthus arenosus* and *Brownanthus mariothii* occur throughout this mapping unit, while rocky outcrops harbour *Pelargonium cortusifolium* and *Zygophyllum clavatum*. *Othonna furcata* and *Salsola* species are locally dominant.

**Extent**
157.9 km² (0.73% of the Sperrgebiet)

**Plant diversity**
The diversity of plants increases steeply from the species-poor Chameis drainage area towards Boegoeberg. Between 50 and 100 plant species are expected in this mapping unit.

**Conservation importance:**
HIGH This mapping unit is of conservation importance as a variety of protected species occur here. These are species of the genera *Amphibolia*,

**Cephalophyllum*, *Conophyllum*, *Crassula*,
*Dracophyllum*, *Eberlanzia*, *Fenestraria*,
*Juttadinteria*, *Lithops*, *Ruschia*, *Stoeberia* and
*Tylecodon*. Namib endemics include
*Brownanthus nambensis*, *Euphorbia verruculosa*, *Marlothiella gymnifera*,
*Pelargonium cortusifolium* and *Pteronia spinulosa*.

**Alien plant species**
None recorded

**Resource use**
The relatively high plant cover on the plains provides an important food source and habitat for wildlife.

**Threats**
- Infrastructure developments
- Quarrying

**Recovery potential**
Low

**Management**
- Recommended management zoning: IUCN 1b (wilderness).
- Prohibit off-road driving
- Involve plant specialist in the planning of infrastructure
- Rehabilitate borrow-pits

**Research needs**
Better plant and animal data are essential, as the area around Boegoeberg is expected to harbour a variety of range-restricted species. A more detailed vegetation map would help delineate important areas within this mapping unit.

[Salsola dwarf-shrubland]

Scientific name
Salsola dwarf shrubland

Locality This mapping unit intersects the Sarcocaulon patersonii (Bushman candle) plain dwarf-shrubland and is positioned north of the Kaukausib drainage.

Geographic unit Eastern Lüderitz plains

Vegetation sub-units One prominent inselberg to the west of the road, Zweikuppenberg, harbours more diverse and different vegetation. Euphorbia gummifera and Zygophyllum prismatocarpum are prominent here.

Habitat and environmental parameters Gravel plains support this vegetation type. Rainfall is low and patchy. Windy conditions, largely from the south, prevail throughout the year. Metasediments of the Namaqua Complex underlie the gravel. Soils are expected to be saline.

Description Wind- and sand-blasted dwarf shrubs characterise the vegetation. Perennial plant cover is low and ranges between 1% and 5%.

Key species Several Salsola species are believed to occur. Salsola albisepala, Salsola contrariifolia, Salsola namibica, Salsola nolothensis, Salsola schreiberei, Salsola tuberculata and Salsola zeyheri have been recorded in this quarter-degree square, and are probably associated with this vegetation type.

Extent 83.5 km² (0.39% of the Sperrgebiet)

Plant diversity Plant diversity on the plains is low and expected to range between 10 and 20 perennial species.

Conservation importance: MEDIUM Several of the Salsola species are endemic to the northwestern Sperrgebiet.

Alien plant species None recorded

Resource use The grasses as well as the sparse shrub cover provide habitat and food for animals.

Threats Off-road driving

Recovery potential Low

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Prohibit off-road driving

Research needs Well over 20 Salsola species are believed to be endemic to this area. This requires confirmation through a field-based taxonomic study.

Southern Boegoeberg plain dwarf-shrubland

Scientific name
*Zygophyllum clavatum* dwarf shrubland

Locality
This mapping unit comprises the plains to the south of Boegoeberg.

Geographic unit
Southern Boegoeberg plains

Vegetation sub-units
Several vegetation sub-units occur where different plant species are dominant. Sub-units with lichens (e.g., *Teloschistes capensis*) indicate regular fog influence. *Amphibolia ripis-arquatae* is prevalent on sand plains, *Stoeberia beetzii* dominates on gravel plains and *Othonna cylindrica* is present in dune areas.

Habitat and environmental parameters
The majority of this mapping unit covers level plains, but there are also some low outcrops, as well as a low rise in the western part of this mapping unit. Quartzite and schist are the main rock types underlying these plains. No long-term rainfall records exist for this area, but the annual mean is expected to range between 20 and 50 mm. Fog is an important moisture source in this mapping unit, and particularly ridges and gentle rises in the landscape appear to benefit from this regular moisture supply. Southerly and southwesterly winds occur throughout the year.

Description
Dwarf succulent shrubs of up to 30 cm in height dominate the vegetation. Perennial plant cover is largely continuous and varies between 10% and 20%.

Key species
Units with lichens (*Ramalina capensis* and *Teloschistes capensis*) indicate regular fog influence. In addition to *Zygophyllum clavatum*, also locally dominant are *Amphibolia ripis-arquatae, Othonna cylindrica* and *Stoeberia beetzii*.

Extent
277.6 km² (1.28% of the Sperrgebiet)

Plant diversity
The plant diversity on these fog-influenced plains is high. Well over a 100 plant species are expected to occur.

Conservation importance: VERY HIGH
Of extremely high conservation importance, within this mapping unit are pockets of vegetation with very high concentrations of protected species. Protected species in the genera *Amphibolia, Cephalophyllum, Crassula, Dracophyllum, Eberlanzia, Fenestrella* and *Stoeberia* are present. In addition, there are southern Namib endemics such as *Brownanthus arenosus, Eriocephalus kingesi, Mesembryanthemum barklyi, Pelargonium cortisolium* and *Psilocaulon dinteri*. Several Cites 2-listed *Euphorbia* species occur. The lichen fields within this mapping unit are of particular conservation importance.

Alien plant species
None recorded

Resource use
The dwarf succulent shrubs provide a reliable food and moisture source for wildlife.

Threats
- Infrastructure developments
- Illegal plant collecting
- Quarrying

Recovery potential
Low

Management
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Consult botanical specialist during the planning of infrastructure
- Undertake spot-checks for illegal collecting of protected plant species at Sperrgebiet exit points
- Demarcate lichen fields
- Rehabilitate borrow-pits

Research needs
The lichen fields in this mapping unit need urgent attention. These need to be mapped in detail and the boundaries demarcated. A detailed vegetation map would facilitate planning and management of this mapping unit. Animal data for this mapping unit are poor. Field-based red-list assessments are urgently needed for critical plant species.
Other mapping AEZ: NAM4; Giess (1971); desert and succulent steppe; Williamson (1997); coastal zone 0–150 m; Jürgens et al. (1997): temperate zone of Namib plains; Burke et al. (2002): plain dwarf shrubland

**Southern dune dwarf-shrubland**

**Scientific name** Othonna cylindrica dwarf shrubland

**Locality** This unit comprises the dunes north and west of Hohenfels towards Oranjemund. There are also two separate small dune fields associated with the outcrops Hoher Rücken and Chamnaub.

**Geographic units** Hohenfels dunes, Chamnaub dunes, Hoher Rücken

**Vegetation sub-units** Within the mapped area, other vegetation sub-units associated with this vegetation type are Othonna furcata and Amphibilia rupis-arcuatae dwarf shrubland on sand plains, as well as Salsola dwarf shrubland in areas with less sand cover, such as in the vicinity of depressions.

**Habitat and environmental parameters** This vegetation type is part of the large dune field that stretches from Oranjemund and Hohenfels northwards. Semi-stabilised dunes are the main habitat, with localised gravel and pan areas. Strong winds and sand-blasting conditions shape the vegetation. Long-term annual rainfall is approximately 50 mm and fog occurs regularly in this area. The soils are dune sands, probably of low nutrient status.

**Description** Low deciduous shrubs and grasses are the most conspicuous components of the vegetation. Average height of the vegetation is 30 cm, but Othonna furcata can grow up to 50 cm high. The shrubs are widely spaced and reach about 10% cover. Bulbs, herbs, grasses and other succulent dwarf shrubs are associated with this vegetation type.

**Key species** Always present in this vegetation type are two conspicuous, deciduous Othonna species, Othonna cylindrica and Othonna furcata.

**Extent** 589.8 km² (2.73% of the Sperrgebiet)

**Plant diversity** Plant diversity can vary from 5 to about 30 species depending on time of the year, and local environmental conditions. Particularly in the vicinity of outcrops in the southern section, more species are expected.

**Conservation importance:** MEDIUM Bulbs occurring in this vegetation type are likely to be of high conservation importance. A number of *Albuca, Bulbine* and *Trachyandra* species are expected to occur in these dune habitats. There is a potential that some southern Namib endemics could be amongst these bulbs. Presently no records are available to back this up.

**Alien plant species** None recorded at present

**Resource use** Forage for large game, desert snails and small mammals. Snail shells provide nesting places for wasps.

**Threats** Destruction of plants through off-road driving

**Recovery potential** Medium

**Management**
- Recommended management zoning: IUCN 2 (national park)
- Minimise disturbance of mature plants
- Minimise tracks, i.e. control recreational off-road driving

**Research needs** All short-lived (e.g. herbs) and short-time active (e.g. bulbs) components of this vegetation type are poorly known. Further plant collecting during good rain seasons is required.
Other mapping AEZ: NAM4; Giess (1971); desert and succulent steppe; Williamson (1997); coastal zone 0–150 m; Jürgens et al. (1997); temperate zone of Namib plains; Burke et al. (2002); plain dwarf shrubland
Southern dwarf-succulent shrubland

Scientific name
Brownanthus marlothii
- Stoeberia beetzii
dwarf shrubland

Locality Adjoining the coastal dwarf shrublands of Mining Area 1 to the east, this mapping unit extends up to the Boegoeberg plains in the north and is bordered by the Brownanthus arenosus - Othonna furcata (southern Othonna dwarf-shrubland) mapping unit to the east.

Geographic unit Southern sand plain

Vegetation sub-units These seemingly uniform sand plains support a variety of diverse vegetation sub-units. Areas where Stoeberia beetzii is dominant intermingle with stands of Amphibolia rupis-arcuatae and Othonna furca. Cladoraphis cyprioides dominates where mobile sand prevails. Brownanthus marlothii and Salsola species are more abundant on gravel areas.

Habitat and environmental parameters The topography of this mapping unit is largely flat, interrupted by some low ridges and intersected by shallow drainage lines and several depressions. The depth of sand cover varies throughout this mapping unit, and a mosaic of sand plain, quartz gravel and dunes provides the main landforms. Rainfall is expected to be similar as for Oranjemund, averaging 54 mm per annum, and fog occurs frequently. Soils are as variable as the landforms, but mostly sandy and often with high gypsum and salt content. Southerly winds blowing almost constantly throughout the year exert another pressure on plant life in this area.

Description A continuous plant cover characterises this mapping unit. Perennial cover ranges from 10% generally, to 25% locally, and shrub height averages 30 cm. Low leaf-succulent and stem-succulent shrubs are the main component of the vegetation, and are only locally replaced by grasses.

Key species Brownanthus arenosus is common throughout this mapping unit, but equally important are Amphibolia rupis-arcuatae, Othonna furcata, Stoeberia beetzii and Salsola species. The Salsola spp. prevail on more saline soils and gravel plains. Cladoraphis cyprioides occurs in mobile sand areas. The low ridges support species characteristic of coastal outcrops such as Pelargonium cultfolium.

Extent 847.9 km² (3.92% of the Sperrgebiet)

Plant diversity Plant diversity is expected to be medium, probably ranging between 50 and 100 species.

Conservation importance: MEDIUM This mapping unit harbours a number of species of conservation importance. These include the protected species Amphibolia rupis-arcuatae, Atriplex noctiflora, Cephalophyllum obracteatum, and Grassula, Conophyllum and Eberlanzia species, as well as Fenestra rhopalophylla and Stoeberia beetzii.

Alien plant species None recorded at present, but some horticultural plants have been introduced at Chameis Gate.

Resource use The permanent presence of a reasonable cover of succulent shrubs is an important food source for wildlife in this area, particularly during the dry season.

Threats Infrastructure developments for roads, power and telecommunications

Recovery potential Medium

Management
- Recommended management zoning: IUCN 1b (wilderness area)
- Close and rehabilitate all superfluous borrow-pits
Environmental assessments should be carried out for infrastructure developments, mining or prospecting in this mapping unit.

Research needs: Both, plant and animal collections are poor for this mapping unit.


**Southern plain dwarf-succulent shrubland**

**Scientific name** Brownanthus marlothii – *Salsola* dwarf shrubland

**Locality** Positioned in the western part of the study area, this mapping unit forms a transition between semi-stabilised dunes of the southern sand plain and the coastal plains.

**Geographic unit** Southern sand plain

**Vegetation sub-units** A mosaic of vegetation sub-units is included in this mapping unit. *Brownanthus marlothii* and *Salsola* species are abundant on gravel areas, but there are also vegetation units dominated by *Brownanthus arenosus* and *Euphorbia gummifera*.

**Habitat and environmental parameters** This mapping unit shows largely flat topography, interrupted by some low ridges and intersected by shallow drainage lines and depressions. The depth of sand cover varies throughout this mapping unit, and a mosaic of sand plain, quartz gravel and dunes provides the main landform. Rainfall is expected to be similar to Oranjemund, averaging 54 mm per annum; fog occurs frequently. Soils are mostly sandy and show high gypsum and salt content locally. Southerly winds blow almost constantly throughout the year.

**Description** A continuous plant cover characterises this mapping unit. Perennial cover ranges from 10% to 25% locally, and height averages 30 cm. Low leaf-succulent and stem-succulent shrubs are the main component of the vegetation.

**Key species** *Brownanthus marlothii* is common throughout this mapping unit, as are *Salsola* species.

**Extent** 1,350.5 km² (6.25% of the Sperrgebiet)

**Plant diversity** Plant diversity is expected to be medium, probably ranging between 30 and 100 species.

**Conservation importance:** MEDIUM Some protected species, such as *Dracophilus*, occur, as well as Cites 2-listed *Euphorbia* species.

**Alien plant species** None recorded at present.

**Resource use** A reasonable cover of succulent shrubs throughout the year is an important food source for wildlife in this area.

**Threats** Infrastructure developments (powerlines)

**Recovery potential** Low

**Management**
- Recommended management zoning: IUCN 1b (wilderness area)
- Environmental assessments should be carried out for infrastructure developments, mining or prospecting in this mapping unit.

**Research needs** More intensive plant collecting throughout this mapping unit, particularly targeting short-lived components, such as bulbs and herbs, is important. Animal records are poor for this mapping unit.

**Other mapping** AEZ: NAM4; Giess (1971): desert and succulent steppe; Williamson (1997): coastal zone 0–150 m; Jürgens et al. (1997): temperate zone of Namib plains; Burke et al. (2002): plain dwarf shrubland
Agub–Letterkuppe inselberg shrubland

Scientific name  
*Brownanthus ciliatus*  
dwarf shrubland

Locality  
This mapping unit combines the inselbergs in the northeast corner of the Sperrgebiet.

Geographic units  
Inselbergs: Aus, Letterkuppe, Agub, Giams, Kuckaus

Vegetation sub-units  
Although a common denominator has been selected for the inselbergs combined in this mapping unit, there are differences in vegetation composition depending on position of the inselberg, elevation, slope and aspect.

Habitat and environmental parameters  
Substrates derived from gneiss, schist, quartzite, amphibolite and marble in the Letterkuppe area, and from Augengneiss at Agub, provide a variety of soils as a backdrop. Equally important is the position of individual inselbergs in the landscape, particularly regarding their distance to other mountainous areas, their elevation and whether they fall in the path of rain cloud movement. The highest peaks rise about 400–500 m above the surrounding plains. Local environmental conditions are hence expected to be important in shaping plant communities. Although no long-term weather records are accessible, the northeast corner of the Sperrgebiet receives both winter and summer rain, and often probably no rain at all. Fog influence is negligible and the southerly winds impacting on the coastal and southern area of the Sperrgebiet are less severe here. Easterly berg winds in winter are common.

Description  
Low, leaf- and stem-succulent shrubs and deciduous shrubs are important components of the flora of these inselbergs. Plant cover is patchy and expected to range between 10% and 20%. Plant height varies according to position of the mountain; while overall, no more than an average height of 30 cm is expected on most slopes, in sheltered positions plants up to 1 m high are common.

Key species  
*Brownanthus ciliatus* has been selected as the main descriptor of the vegetation because of its frequent occurrence. Associated species are, amongst others, *Augea capensis* and *Salsofa* species.

Extent  
245.1 km² (1.13% of the Sperrgebiet)

Plant diversity  
Scanty field and collecting data exist for these inselbergs and it is thus not possible to estimate overall diversity.

Conservation importance: HIGH  
Amongst the available records are a number of species of conservation importance. They include protected species such as *Acacia erioloba*, *Aloe dichotoma*, *Boscia albitrunca*, *Crassula* and *Eberlanzia* species, *Hoodia gordonii*, *Maerua schinzii*, *Ozoroa crassivina* and *Ruschia spinosa*. Cites Appendix 2 species like *Euphorbia cibdela* and *Euphorbia gymnifera* also occur.

Alien plant species  
None recorded

Resource use  
As elsewhere in arid areas, the inselbergs with their higher and more persistent plant cover are expected to provide an important food source during the dry season to most animals.

Threats  
None at present

Recovery potential  
Low

Management  
- Recommended management zoning:  
  IUCN 1b (wilderness area)
- Avoid infrastructure developments on these inselbergs

Research needs  
No detailed field data for vegetation or for most animal groups are available. Hence these inselbergs deserve more thorough collecting.
Other mapping  AEZ: R; Giess (1971): desert
and succulent steppe; Williamson (1997): highlands, Jürgens et al. (1997): temperate

Namib mountains, Burke et al. (2002), mountain
dwarf shrubland

Aurus Mountain succulent-shrubland

**Scientific name**  
*Ceraria fruticulosa* - *Euphorbia cibdela*  
shrubland

**Locality**  
The Aurus Mountains are positioned in the central-eastern Sperrgebiet. This vegetation type also includes inselbergs to the west and southwest of Aurus.

**Geographic units**  
Mountains: Aurus Mountains, Buschmannberg

**Vegetation sub-units**  
Many sub-units are contained in this vegetation type. The Aurus Mountains themselves support different vegetation in different sections of the mountain chain. Altitude and aspect, as well as steepness of the slope are likely factors determining the dominant plant species. Inselbergs included in this mapping unit to the west of the main mountain chain support their own unique plant assemblages.

**Habitat and environmental parameters**  
The mountain chain stretching northwest to southeast for some 20 km is the main landform in this mapping unit. The highest peak rises approximately 480 m above the surrounding area. Some inselbergs occur to the west of the mountains. Different forms of gneiss, granite and some quartz intrusions of the Gariep Complex make up the rock stratum. No long-term weather records are available for the mountain, but based on recent rain records, it is expected that annual mean rainfall is approximately 100 mm. Although fog is less frequent than at the coast, fog clouds are often trapped in the upper reaches of the steep southwest face of the mountain. Poorly developed regosols (weathered bedrock) prevail on most mountain slopes, except in the eastern parts. Here, in the lee of the southwest face of the mountain, the horseshoe-like arrangement of the mountain chain and gentle slopes, which favour the accumulation of sand, in combination with higher plant productivity, have resulted in the development of organically richer and deeper soils.

**Description**  
Dominant on these mountains are dwarf succulents and shrubs. However, every other growth form is also represented, including trees, herbs, grasses and bulbs. Average plant height is variable and depends on the dominant species in a particular locality, as well as soil depth and exposure to wind. Plant height averages 0.5 m, but several species can grow over 2 m tall. Vegetation cover is very variable and ranges from 15% to 50%. The highest plant cover is reported on the eastern, gentle slopes.

**Key species**  
Due to their ubiquity *Ceraria fruticulosa* and *Euphorbia cibdela* have been selected as the main descriptors of the vegetation. Other common perennial species are *Aloe erinacea*, *Aloe remosissima*, *Antimima aurasensis*, *Antimima quanzitica*, *Cotyledon orbiculata*, *Didelta spinosa*, *Euphorbia dregeana*, *Euphorbia mauritanica*, *Euryops nambensis*, *Pelargonium klinghardtense*, *Pelargonium spinosum*, *Rhus populinia*, *Sarcostemma vinnale* and *Zygophyllum prismatocarpum*.

**Extent**  
148.9 km² (0.69% of the Sperrgebiet)

**Plant diversity**  
Some 400 plant species are expected to occur in this vegetation type. The Aurus Mountains are therefore clearly the top "hotspot" of plant diversity in the Sperrgebiet.

**Conservation importance**  
VERY HIGH  
These mountains and associated inselbergs are of extremely high conservation importance. A minimum of 80 species are protected, listed on Cites 2 or red-listed. Namibian endemic plant species tally 45 to date, the majority are restricted to the southern Namib.

**Alien plant species**  
None recorded at present
Resource use. The rich and ever-present plant cover of these mountains is an extremely important food source for wildlife, particularly during the dry season.

Threats
- Illegal plant collecting
- Off-road driving
- Infrastructure development
- Invasion by alien plant species
- Prospecting
- Erosion

Recovery potential. Low

Management
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Prohibit unguided access
- Restrict access to one or two clearly marked footpaths only
- Check all visitors for illegally lifted plants
- Consult botanical specialist during the planning of any infrastructure development in this area
- Detailed environmental assessments involving a full range of biological specialists should be carried out for prospecting, tourism and mining activities in this area
- Monitor emergence of — and, if necessary, remove — invasive alien plants

Research needs. A detailed vegetation map in combination with a soil survey, as well as Red Data assessments of critical, range-restricted plant species are essential to guide further planning. Animals have not yet been as well collected as plants.


Chamnaub shrubland

Scientific name
*Cerana trivialis* - *Zygophyllum prismaticarpum*

Locality. Chamnaub is positioned in the central Sperrgebiet, halfway between Boegoeberg and the Aurus Mountains.

Geographic unit. Chamnaub

Vegetation sub-units. The vegetation changes with altitude and slope aspect, and hence different species are dominant in different localities on the mountain. For example, *Othonna sedifolia* is prominent on the tops of hills, *Lampranthus hoerleinianus* on midslopes and *Othonna cylindrica* on sandy footslopes.

Habitat and environmental parameters. One main inselberg and several smaller inselbergs to the northwest and southeast comprise the Chamnaub Group. It also contains the adjoining sand plains, dunes and gravel plain areas. The inselberg is exposed to drifting sand and large dune areas can be found to the south and east of the inselberg group. Quartzite of the Gariep formation is the dominant rock type. The two peaks of this inselberg rise 110 m and 160 m, respectively, from the surrounding plains. There are no weather records for this area, but strong southerly winds are undoubtedly shaping the landforms and plant life on this inselberg. Fog influence is prevalent, but less frequent than near the coast and on the neighbouring Boegoeberg to the west.

Description. Dwarf succulent shrubs and shrubs are the most important component of the vegetation on the inselberg. Perennial plant cover ranges between 10% and 20%. The height of plants varies, depending on where they grow; in exposed places they hardly reach 30 cm, while in sheltered places plants can grow to 1 m high.
Extent 11.2 km² (0.05% of the Sperrgebiet)

Key species Zygophyllum prismatocarpum and Ceraria fruticulosa occur across the entire mountain; other species are locally dominant depending on altitude and slope aspect.

Plant diversity Plant diversity is high; approximately 100 species have been recorded so far on the inselbergs and immediate surroundings.

Conservation importance: VERY HIGH
Protected plants include Aloe, Amphibia, Antimima, Cephalophyllum, Crassula, Dracophylist, Eberlanzia, Hoodia, Juttadinteria, Lachenalia, Ruschia, Ruschanthemen and Stoeberia species. There are also southern Namib endemics, such as Amphiglossa thuja, Brownanthus arenosus, Erioccephalus klinghardtensis, Manuela namibensis, Pelargonium cortusifolium and Senecio giesii.
There are also eight Euphorbia species which are listed in Cites Appendix 2.

Alien plant species None recorded

Resource use As this is the only mountain area in a wide radius, the plant life provides a sheltered habitat and food sources for animals.

Threats Prospecting

Recovery potential Low

Management
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Prohibit unguided access

Research needs Animal records for this inselberg are poor, as are records for bulb species.


Heloab shrubland

Scientific name Ceraria fruticulosa – Euphorbia dregeana shrubland

Locality The Heloab range of mountains forms the link between the Klinghardt and Auras Mountains and is positioned in the central Sperrgebiet.

Geographic unit Heloab

Vegetation sub-units Besides a separation according to main landforms (plains, inselberg, drainage line), the influence of altitude and slope aspect results in different vegetation sub-units.

Habitat and environmental parameters
Several inselbergs and associated gravel and sand plains comprise this mapping unit. The Heloab and associated inselbergs run in a northwest to southeasterly direction and are composed of quartzite, phyllite and conglomerate of the Gariep Complex. The highest peak of the Heloab rises over 500 m above the surrounding plains. No local weather records are available, but rainfall conditions are believed to be similar to the Klinghardt Mountains and are speculated to be on average about 50 mm per annum.

Description Leaf-succulent dwarf shrubs and deciduous shrubs form the main vegetation on the inselbergs. Grasses and dwarf shrubs are prominent on plains. Perennial plant cover is variable and ranges 5–20%. Plant height on plains averages 30 cm, but different plant heights are prevalent on the inselbergs. An average height of 1.5 m has been observed on some slopes, but in exposed places a mean height of 30 cm is more common.

Key species Ceraria fruticulosa and Euphorbia dregeana have been selected as the main descriptors of this unit because of their presence on most inselbergs. On calcrete plains Salsola and Zygophyllum species are dominant, while Brownanthus arenosus, Phyllobolus melanaspemus, Stipagrostis ciliata and Stipagrostis geminifolia prevail in more sandy areas.

Extent 96.9 km² (0.45% of the Sperrgebiet)

Plant diversity Although plant diversity is not believed to quite reach the high diversity recorded for the Klinghardt Mountains, between 200 and 300 species can nevertheless be expected in this mapping unit. These include
many species in the genera Adromischus, Aloe, Amphibolia, Cephalophyllum, Conophytum, Crassula, Dracophyllum, Eberlanzia, Ebracteola, Fenestraria, Hoodia, Juttiadium, Lavania, Psammophora, Ruschia, Stapelea, Stoeberia and Tylecodon. Many southern Namib endemics occur, such as Bulbine namaensis, Brownanthus arenosus, Cyrtanchum meyeri, Neopatersonia falcata, Pelargonium klinghardtense and Tylecodon aridimontanus.

**Conservation importance:** VERY HIGH The inselbergs in this mapping unit are of very high conservation importance, since they harbour many of the same species of conservation importance that have been recorded for the Klinghardt Mountains.

**Alien plant species** None recorded

**Resource use** The shrubs are important forage for wildlife.

**Threats** Illegal plant collecting

**Recovery potential** Low

**Management**
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Prevent unguided access
- Control track development

**Research needs** The Heioab and associated inselbergs, particularly their higher reaches, deserve more thorough plant collecting. Animal data for this mapping unit are poor.


---

**Klinghardt succulent-shrubland**

**Scientific name** Zygophyllum prismaticarpum shrubland

**Locality** This mapping unit comprises the Klinghardt Mountains and surrounding lowlands.

**Geographic unit** Klinghardt

**Vegetation sub-units** A large number of vegetation sub-units occur in the Klinghardt Mountains, matching their geological complexity. The vegetation sub-units are linked to the main landforms, altitude, different rock strata, and the steepness and aspect of slope.

**Habitat and environmental parameters** The Klinghardt Mountains comprise several individual mountains forming a group in the central Sperrgebiet, approximately 35 km east of the coastline at their western margin. Mountain slopes of different aspect and steepness, sand and gravel plains, drainage lines, dunes and small rock outcrops provide the main habitats in this mapping unit. The higher peaks rise 250–500 m above the surrounding plains. Although no long-term rainfall data are available, recent rain recordings of several years indicate that the mountain complex receives more rain than the closest weather station at Lüderitz. It is estimated that an annual mean of approximately 50 mm can be expected. Fog occurs regularly in this mountain area, although at a lower frequency than at the coast. The geology is complex, and as a result a variety of very different rock types occur. The dark igneous phonolite caps about 50% of individual inselbergs. There are also quartzites, phyllite, dolomite and limestone of the Gariep Complex.

**Description** Dwarf shrubs, low shrubs and grasses comprise the majority of the vegetation. Grasses are prominent on sandy plains in between the mountains, while leaf-succulent dwarf shrubs and deciduous shrubs clothe the mountain slopes. Perennial plant cover is low and ranges between 10% and 20%. However, after rains, plains can show up to 40% grass and herb cover locally.
Key species  Due to its ubiquitous nature, Zygophyllum prismatocarpum has been selected at the main descriptor of the vegetation, however, many other species are equally abundant. The grasses Stipagrostis ciliata and Stipagrostis geminifolia are prominent on plains, while Stipagrostis lutescens occurs in the dunes. Other important species on plains are Brownanthus arenosus, Brownanthus ciliatus, Euphorbia gummifera and Pteronia pomonae. To do justice to the plant diversity on the mountain slopes is far beyond the scope of this description. Dominant species change according to rock type, altitude and slope aspect. Prominent in various places are Aloe ramosissima, Aridaria noctiflora, Astridia velutina, Ceraria fruticulosa, Euphorbia cibdela, Euphorbia dreggeana, Euphorbia gummifera and Stoeberia gigas.

Extent  609.5 km² (2.82% of the Spergebiet)

Plant diversity  Plant diversity is remarkably high considering the aridity of this area. Well over 350 plant species have been recorded in this mapping unit to date.

Conservation importance: VERY HIGH  The Klinghardt Mountains are of extremely high conservation importance. Some 65 protected plant species plus 10 species listed under Cites have so far been recorded. These include many species in the genera Adromischus, Aloe, Amphibolia, Antimima, Astridia, Cephalophyllum, Cheiridopsis, Conophytum, Crassula, Drecophillus, Eberlanzia, Ebracteola, Fenestria, Hoodia, Juttadinteria, Lavrania, Psammophora, Ruschia, Stapelia, Stoeberia, Tromotricha and Tylecodon. Equally long is the list of endemic species, including the southern Namib endemics Amphiglossa thuja, Balbine namaensis, Brownanthus arenosus, Cynanchum meyeri, Eriochephalus klinghardtii, Lachenalia klinghardtiana, Lessertia eremicola, Manulea namibensis, Othonna graveolens, Pelargonium cortsifolium, Pteronia pomonae and Zygophyllum longicapsulare.

Alien plant species  None recorded

Resource use  The vegetation of the mountains and surrounding plains are an extremely important food source for large game, such as gemsbok and springbok, as well as smaller animals.

Threats
- Off-road driving
- Prospecting
- Illegal plant collecting

Recovery potential  Low

Management
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Prohibit off-road driving
- Prohibit unguided access
- Regularly monitor critical plant populations
- Any tourism, infrastructure, prospecting or mining activities within this mapping unit require detailed environmental assessments, involving a full range of biological specialists

Research needs  A more detailed vegetation map, as well as Red Data assessments of range-restricted species are urgently required. Most animal groups have not been collected.

Namitsis shrubland

Scientific name
*Euphorbia cibdela* – Zygocephalum prismaticarum dwarf shrubland

Locality This inselberg is positioned south of the Klinghardt Mountains.

Geographic unit Namitsis

Vegetation sub-units The vegetation changes along an altitude gradient on this inselberg.

Habitat and environmental parameters
Isolated from the Klinghardt complex, this flat-top inselberg is composed of dark, igneous phonolite. It rises 190 m above the surrounding plains. Rainfall is likely to be similar to that of the Klinghardt Mountains, but due to its southerly position, it is expected to receive more fog moisture and probably also exposed to stronger winds.

Description Dwarf succulent shrubs, deciduous shrubs, as well as a variety of grasses, herbs and bulbs comprise the vegetation of this mountain. Perennial plant cover ranges between 10% and 20% and shrub height rarely exceeds 50 cm.

Key species While *Sarcocestma viminalis*, *Zygocephalum clavatum* and *Zygocephalum prismaticarum* occur largely on the slopes of this mountain, *Cephalophyllum ebracteatum*, *Euphorbia cibdela*, *Othonna sedifolia* and *Zygocephalum cordifolium* are prominent on the top.

Extent 14.3 km² (0.07% of the Sperrgebiet)

Plant diversity So far, 100 plant species have been recorded in this mapping unit.

Conservation importance: MEDIUM Endemic species include *Bulbine namaensis*, *Brownanthus arenosus*, *Cynanchum meyeri*, *Pteronia pomonae* and *Stipagrostis lanipes*, *Cephalophyllum ebracteatum*, *Crassula expansa*, *Crassula muscosa*, *Eberlanza sedoides*, *Juttadinteria species* and *Ruschia muelleri* are protected species associated with the vegetation of this inselberg.

Alien plant species None recorded

Resource use This vegetation type provides forage for wildlife, particularly the bulbs and plants with rhizomes.

Threats None at present

Recovery potential Low

Management
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Restrict off-road driving

Research needs Animal data are poor for this mapping unit.

Obib Mountain succulent-shrubland

Scientific name  
*Euphorbia cibdela* and *Euphorbia dregeana* have been selected as the main descriptors of the vegetation as these occur throughout the mapping unit. Many other species are locally dominant such as *Aloe ramosissima*, *Aloe pearsonii*, *Arideria noctiflora*, *Berkheya canescens*, *Ceraria fruticulosa*, *Drosanthemum paxianum*, *Lampranthus hoerleinianus*, *Othonna opima*, *Pelargonium spinosum* and *Ruschia muelleri*.

Locality  
This mapping unit contains the mountains in the southeast corner of the Sperrgebiet which includes the Obib Mountains and Gomtsawibberge.

Geographic unit  
Obib Mountain

Vegetation sub-units  
Mountain slopes of different altitude, steepness and aspect, as well as valleys and drainage lines, support different vegetation units. For example, *Euphorbia dregeana* forms sub-units in valleys and drainage lines; *Euphorbia cibdela* is prominent on many slopes. Footslopes support *Euphorbia gummifera* sub-units, and on gravel slopes sub-units are dominated by *Cephalophyllum*, *Dracophillus* and low-growing *Zygophyllum* species (for example, *Zygophyllum applanatum*, *Zygophyllum patenticaule* and *Zygophyllum pterocaule*). Also different parts of the mountain, depending on distance from the Orange River, harbour different vegetation.

Habitat and environmental parameters  
Mountains are the main landform in this mapping unit, but valleys and drainage lines are included, as well as the surrounding footslopes and plains near the mountains. In the northern section of the Obib Mountains, the highest peaks rise approximately 300 m above the surrounding plains. In the southern section, the Gomtsawibberge, the highest peak rises almost 500 m above the surrounding plains. Schist and quartzite of the Gariep Complex, interspersed by quartz veins, are the main rock types. Rainfall at nearby Rosh Pinah has been recorded to provide an average mean of 54 mm. Fog, moving up the Orange River, however, is an important additional moisture source. Windy conditions are expected all year round, but the broken-up nature of the mountains is expected to provide many sheltered places.

Description  
The vegetation consists largely of leaf succulents. Most show an average height of 30 cm, but in sheltered places and valleys, average plant height can reach 1.5 m. Plant cover is extremely variable and ranges from 1% on exposed, dry slopes to 20% in valleys and their sheltered places and those receiving run-off.

Conservation importance: VERY HIGH  
This mountain area is of extremely high conservation importance because of the presence of many range-restricted and protected species. Many species of the genera *Aloe*, *Amphibolia*, *Anacampseros*, *Antimima*, *Astridia*, *Cephalophyllum*, *Conophytum*, *Crassula*, *Eberlanzia*, *Hartmanthus*, *Hoodia*, *Juttadinteria*, *Lavrania*, *Psammophora*, *Ruschia*, *Stapelia*, *Stoebebra*, *Tromotricha* and *Tylecodon* occur which are all protected. In addition, there are also many southern Namib endemics, such as *Androcymbium exiguum*, *Arctotis frutescens*, *Berkheya schinzii*, *Brownanthus arenosus*, *Cynanchum meyeri*, *Eriocephalus klinghardtensis*, *Mesembryanthemum barklyi*, *Mesembryanthemum pellitum* and *Senecio giesii*.

Alien plant species  
*Nicotiana glauca* and *Ricinus communis* have been recorded in this area. These are intruding from the Orange River.

Resource use  
These mountains provide an important retreat and food source for wildlife. Obib Fountain is an important natural freshwater source for animals.

Extent  
312.2 km² (1.44% of the Sperrgebiet)

Plant diversity  
Over 450 species have been recorded in this area; the majority are expected to be associated with the mountains.
Threats
- Prospecting
- Illegal plant collecting
- Invasive alien plant species

Recovery potential  Low

Management
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Prohibit unguided access
- Control tracks
- Spot-check people for illegally lifted plants upon exit from this area (Sendelingsdrif Gate)
- Monitor and eradicate invasive alien plant species
- Monitor critical plant populations of conservation importance

- Tourism, prospecting and mining development require detailed environmental assessments involving a suitable suite of biological specialists.

Research needs A more detailed vegetation map would enable more accurate environmental guidelines for future activities in these mountains to be developed. Red Data assessments of range-restricted species are urgently required. Animal data are rather poor for most animal groups.


Pockenbank shrubland

Scientific name
Zygophyllum microcarpum, Zygophyllum rigidum and Zygophyllum simplex. Other important shrub species are Rhigozum trichotomum, Rhus populifolia, Sisyndite spartea and Tripteris karroica.

Locality Comprises the western-most section of the Pockenbank Mountains, which just protrudes into the Sperrgebiet.

Geographic unit Pockenbank

Vegetation sub-units Several sub-units are expected to be associated with different parts of the mountain.

Habitat and environmental parameters Black limestone of the Nama Group provides the underlying substrate. Climatic conditions are similar as for the Tsaus area.

Description Both, deciduous and succulent shrubs make up the majority of the mountain vegetation. Grasses and herbs are also important components of the vegetation. Perennial plant cover is patchy and overall ranges between 10% and 20%. Plant heights average at about 50 cm, but also show high variability depending on the plant’s position on the mountain. Depressions and gullies, for example, support taller plants.

Key species Zygophyllum appplanatum is prevalent, but so are many other Zygophyllum species, such as Zygophyllum longistipulatum,

Zygozum microcarpum, Zygophyllum rigidum and Zygophyllum simplex. Other important shrub species are Rhigozum trichotomum, Rhus populifolia, Sisyndite spartea and Tripteris karroica.

Extent 11.2 km² (0.05% of the Sperrgebiet)

Plant diversity Reasonable plant diversity is associated with these mountains. So far just over 100 plant species have been recorded.

Conservation importance: MEDIUM There are a number of species of conservation importance, such as protected Aloe, Anacampseros, Crassula, Hoodia and Ruscia species.

Namibian endemics include Zygophyllum applanatum and Zygophyllum segmentaceum.

Alien plant species None recorded
Resource use  Particularly during the dry season, the perennial plant cover on these mountains provides forage.

Threats  None

Recovery potential  Low

Management  Recommended management zoning IUCN 2 (national park)

Research needs  All biota need better collecting, particularly during a good rainy season.


---

**Rooiberg shrubland**

**Scientific name**  *Ceraria fruticulosa*

**Shrubland**

**Locality**  The Rooiberg is positioned in the eastern Sperrgebiet, directly east of the Auras Mountains.

**Geographic unit**  Rooiberg

**Vegetation sub-units**  Altitude and slope aspect result in different vegetation sub-units across the mountain.

**Habitat and environmental parameters**  This prominent inselberg is composed of granitic gneiss of the Gariep Complex. Rainfall is expected to be similar as for the Auras Mountains. Fog occurs rarely. Windy conditions are observed for most of the year, mainly from the south and southwest, but easterly *berg* winds occur during the winter months.

**Description**  Shrubs and dwarf succulent shrubs comprise the main component of the vegetation. Plant heights vary according to aspect and position to the prevailing winds. Mean heights of 30 cm are mostly recorded, but plants can also grow to 1.5 m high.

**Key species**  *Ceraria fruticulosa* is present on most parts of the mountain and has hence been selected as the main descriptor of the vegetation. Other characteristic species are *Cotyledon orbiculata, Didierea spinosa, Diospyros ramulosa, Euphorbia cibdela, Euphorbia dregeana, Lampranthus hoerleinianus, Pteronia divaricata, Rhus populifolia* and *Zygophyllum prismatocarpum.*

**Extent**  22.3 km² (0.10% of the Sperrgebiet)

**Plant diversity**  So far, 172 species have been recorded on this mountain.

**Conservation importance:**  VERY HIGH  Many protected species of the genera *Adromischus, Aloe, Amphibolla, Antimima, Astridia, Cephalophyllum, Conophytum, Crassula, Dracophyllum, Holothrix, Pelargonium, Ruschia* and *Stoeberia* occur. There are also many southern Namib endemics, such as *Cynanchum meyeri, Eriocaulus giebili, Lachenalia pearsonii, Monechma crassiusculum, Othonna graveolens, Pelargonium paniculatum* and *Pteronia poman."*

**Alien plant species**  None recorded at present

**Resource use**  The shrubs and dwarf shrubs on this mountain are an important habitat and food source for small animals.

**Threats**
- Illegal plant collecting
- Prospecting

**Recovery potential**  Low

**Management**
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Prevent unguided access and allow demarcated, guided trails only
- Prohibit off-road driving
Prospecting, tourism and any other activities affecting the mountain require detailed environmental assessments involving a range of appropriate biological specialists.

Research needs Animal data for this area are poor.


Skorpion inselberg shrubland

Scientific name
Aridaria noctiflora – Zygophyllum prismaticocarpum shrubland

Locality The inselbergs and foothills of the western escarpment surrounding the Skorpion plains, as well as those to the north towards the Auras Mountains, are included in this mapping unit (e.g. Skorpionkop).

Geographic unit Skorpion inselbergs

Vegetation sub-units The inselbergs in this mapping unit support very diverse vegetation. Depending on overall size of mountains, altitude, slope and aspect, different vegetation sub-units are found on individual mountains.

Habitat and environmental parameters The rocky habitat ranges from low outcrops and prominent inselbergs to undulating foothills of the escarpment. The complex geology in this area has exposed many different rock types. These include dolomite, quartzite, phyllite, schist, mittle and rhyolite interspersed by many quartz veins which are occasionally exposed as low outcrops. Prominent inselbergs rise approximately 100 m above the surrounding plains. Rainfall in this area shows an average annual mean of 54 mm at Rosh Pinah. Despite the distance from the coast being well over 60 km, fog reaches these inselbergs frequently. In this area fog migrates along the Orange River Valley, northeastwards, and then moves into the mountain areas. The southerly and southwesterly wind regime and the strong northeasterly berg winds in winter are other important environmental factors to be reckoned with. Sandstorms occur occasionally.

Description Succulent dwarf shrubs and shrubs are the main components of the vegetation on these inselbergs. Plant height and cover vary greatly depending on a plant’s position in relation to wind, fog and run-off. Most shrubs do not exceed 30 cm in height, but there are areas with taller shrubs growing 1–2 m high. Perennial plant cover ranges between 10% and, locally, 30%.

Key species Aridaria noctiflora and Zygophyllum prismaticocarpum are present on most inselbergs and have thus been selected as the main descriptors of this mapping unit. But there are many other species of equal or, locally, greater abundance on different mountains. These include Acanthopsis disperma, Berkhaya canescens, Didelta camosa, Diospyros ramulosa, Euphorbia cibdela, Othonna lasiocarpa, Pteronia paniculata, Tetragonia reduplicata, Tripteris karrolica and Zygophyllum clavatum.

Extent 126.2 km² (0.58% of the Sperrgebiet)

Plant diversity This mapping unit shows very high plant diversity. During the course of an environmental assessment associated with the Skorpion Mine, 180 plant species were recorded on the inselbergs immediately surrounding the mine. This figure could easily double in this mapping unit if plants on the remaining inselbergs are surveyed and added to the tally.

Conservation importance: VERY HIGH These inselbergs are of very high conservation importance as many protected and range-restricted species occur. Protected species include Adromischus, Aloe, Antimima, Cephalophyllum, Cheiridopsis, Conophytum, Cressula, Eberlanzia, Hoodia, Lavrania,
Psammophora, Ruschia, Stoeberia and Tylecodon species. Also the trees Boscolia albitrunca, Pappia capensis and Maenua schinzii are protected. In addition to these, southern Namib endemics are Gorteria diffusa, Mesembryanthemum barklyi, Mesembryanthemum pellitum, Monoricha crassissculum, Pelargonium paniculatum, Pteronia pumonae, Sarcocaulon inermis and Zygophyllum longicapsulare.

**Alien plant species** None recorded at present

**Resource use** The diverse shrublands of the Skorpion inselbergs provide an important habitat and food source for animals.

**Threats**
- Mining, quarrying and prospecting
- Infrastructure developments
- Illegal plant collecting

**Recovery potential** Low

**Management**
- Recommended management zoning: IUCN 1a (strict nature reserve)
- Avoid all inselbergs, outcrops and foothills of the escarpment for positioning of infrastructure
- Where these cannot be avoided, involve a botanical specialist during the planning
- All mining, quarrying and prospecting affecting outcrops will need a detailed environmental assessment involving a range of biological specialists
- Monitor and, if emerging, remove invasive alien plant species
- Undertake spot-checks for illegally protected plant species of people exiting through Skorpion Mine

**Research needs** A full account of the flora of all inselbergs contained in this mapping unit will be desirable. Red Data assessments of all critical plant species are necessary.


---

### Swartkloofberg shrubland

**Scientific name** Zygophyllum rigidum shrubland

**Locality** The western extension of the Swartkloofberg reaches into the Sperrgebiet to the east of Henties.

**Geographic unit** Swartkloofberg

**Vegetation sub-units** Different parts of this extensive northwest-southeast extending mountain range support different vegetation sub-units.

**Habitat and environmental parameters** Conspicuously stepped along its margins, black limestone of the Nama Group comprises this mountain range. Rainfall is low, fog is expected to be very rare and temperature ranges are expected to be larger than near the coast and in the south of the Sperrgebiet. Berg wind conditions in winter are probably frequent, but the southerly winds affecting the coastal and southern sections of the Sperrgebiet are expected to be weaker.

**Description** Similar to Pockenbank, deciduous and succulent shrubs comprise the majority of this mountain’s vegetation. There are also grasses, herbs and bulbs. Perennial plant cover is patchy and ranges between 10% and 20%, overall. Plant height averages at about 50 cm, but is variable depending on the plant’s position on the mountain. Depressions and gullies, for example, support taller plants.

**Key species** Zygophyllum rigidum is prevalent on the western section of this mountain range. Accompanying species are Euphorbia ciebdtia,
Euphorbia guerichiana, Kleinia longiflora, Lycium cinereum, Salsole species, Zygophyllum microcarpum and Zygophyllum prismatocarpum.

**Extent** 125.3 km² (0.58% of the Sperrgebiet)

**Plant diversity** Some 130 species have so far been recorded on this mountain range.

**Conservation importance: MEDIUM** There are a number of species of conservation importance, such as the protected Aloe, Crassula, Eberlanzia, Hoodia and Ruschia species. Acacia erioloba and Maerua schinzii trees are also protected, while all Euphorbia species are listed under Cites 2.

**Alien plant species** None recorded at present

**Resource use** The vegetation comprises important dry-season forage for wildlife.

**Threats** None

**Recovery potential** Low

**Management** Recommended management zoning IUCN 2 (national park)

**Research needs** Short-lived components of the vegetation need collecting, as do all animal groups.

Central dune stem-succulent shrubland

Scientific name  
Euphorbia gummifera –  
Othonna cylindrica  
shrubland

Locality  These mobile dunes occur on the southwestern side of the Klinghardt, Heioab and Aurus Mountain complex and are a northward extension of the Obib dunes.

Geographic units  Klinghardt dunes, Heioab dunes, Roter Kamm dunes

Vegetation sub-units  Stands of Euphorbia gummifera and Othonna cylindrica alternate throughout this mapping unit. Stipagrostis lutescens and occasionally Cladopharis spinosa are prevalent where sand movement is great.

Habitat and environmental parameters  A mobile, sandy substrate is the main characteristic of this mapping unit. Rainfall and fog precipitation is expected to be similar to that received at the Klinghardt Mountains.

Description  Stem succulents or grasses dominate the vegetation. Vegetation cover is very variable, ranging from 1% to 10%.

Key species  Euphorbia gummifera and Othonna cylindrica are the main species.

Extent  1,018.7 km² (4.71% of the Sperrgebiet)

Plant diversity  Approximately 10–30 species are expected to occur in these dunes.

Conservation importance: MEDIUM  
Euphorbia gummifera is a Cites 2 species. There is a possibility that bulbs associated with this vegetation type are Namib endemics, but no records exist at present.

Alien plant species  None recorded

Resource use  Large and small herbivores rely on plant resources in this mapping unit.

Threats  None at present

Recovery potential  Medium

Management
- Recommended management zoning: IUCN 1b (wilderness)
- No special guidelines

Research needs  Collection of bulbs and more data on the animals found in this area are required. No vegetation field data exist for the Heioab and Roter Kamm dunes.

Euphorbia shrubland

Scientific name
*Euphorbia gumsiferia*

Localities
The main mapping unit adjoins to the west and east of the Klinghardt Mountains. In addition, *Euphorbia gumsiferia* shrubland is also dominant in several separate mapping units.

These are – from north to south – the plains east of Tsaukhalb, Teufelskuppe, inselbergs to the southeast of the Klinghardt Mountains (Morgen and associated inselbergs) and plains west of the Aurus Mountains.

Geographic units
Klinghardt sand plain, Klinghardt west, Aurus plains, Morgen inselbergs, Teufelskuppe

Vegetation sub-units
Where sand cover is reduced, plant communities associated with calcrite and gravel plains occur, such as dwarf shrublands dominated by *Pteroaria pumona*, *Salsola* and *Zygophyllum* species. *Brownanthus arenosus* and *Phyllobolus melanospermus* are also locally dominant. Within the section west of Aurus, *Othonna cylindrica*, *Stipagrostis ciliata* and *Zygophyllum picrocaule* are locally dominant. The dolomite outcrops associated with the section around the Morgen inselbergs support stands of the rare *Euylea asperme*.

Habitat and environmental parameters
Sand-covered plains are the main habitat. Rainfall is low and probably similar to that measured at the Klinghardt Mountains (estimated at approximately 50 mm as annual mean). Fog occurs rarely, but strong southerly, southwesterly and, during the winter months, easterly winds prevail.

Description
Multi-stemmed succulents and leaf succulents characterise this mapping unit. Perennial plant cover is patchy and ranges between 5% and 15%. Plant height rarely exceeds 30 cm, except where stands of *Euphorbia gumsiferia* occur. These can grow up to 2 m high. A variety of herbs, grasses and bulbs grow after good rains.

Key species
*Euphorbia gumsiferia* (gum milk-bush) is the dominant plant. Locally common are *Salsola* and *Stipagrostis* species, *Brownanthus arenosus* and *Pteroaria pumona*.

Extent
1,946,9 km² (9.01% of the Sperrgebiet)

Plant diversity
These plains are reasonably diverse and, particularly after good rains, support a variety of colourful herbs and bulbs. Over 50 species are expected to occur in these mapping units, with probably a higher diversity in the vicinity of outcrops and other species-rich habitats.

Conservation importance: MEDIUM
So far five Namibian endemics and the Cites 2-listed *Euphorbia gumsiferia* have been recorded in this mapping unit. A variety of bulbs – which are also likely to be Sperrgebiet endemics – are expected to be associated with this mapping unit. No detailed data are available.

Alien plant species
None recorded

Resource use
The shrubs and grasses support a variety of wildlife, while the stands of *Euphorbia gumsiferia* are believed to provide an important food source for gemsbok during times of drought (W. Killian, pers. comm., 2002).

Threats
Prospecting

Recovery potential
Medium

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Control track development

Research needs
Some of these vegetation sub-units, such as the plains east of the Klinghardt Mountains, the Morgen inselbergs and Teufelskuppe lack field data. Bulbs associated with this mapping unit are poorly known. Most animal groups have not been well collected.

Other mapping
AEZ: NAM4 and NAM5; Giessen (1971): desert and succulent steppe; Williamson (1997): central and eastern sand plains; Jürgens
et al. (1997): temperate zone of Namib plains, eastern grassland and stem succulent shrubland zone; Burke et al. (2002): plain dwarf shrubland and sand plain dwarf shrubland

**Grillental corridor shrubland**

**Scientific name**
*Brownanthus arenosus* – *Euphorbia gummifera* dwarf shrubland

**Locality** This mapping unit stretches from the Kaukasib drainage south to the Bogenfels turn-off.

**Geographic unit** Grillental corridor

**Vegetation sub-units** Corresponding to the varied landforms, this large mapping unit combines several vegetation sub-units. Sandblasted, dolomite rock outcrops harbour vegetation dominated by *Ectadrum latifolium*, while other rock outcrops and inselbergs support a diverse dwarf succulent vegetation, such as populations of *Namibia cinerea*, and stands of *Euphorbia gummifera* are associated largely with sandy areas. *Brownanthus arenosus* prevails on many plains, and more localised vegetation types are associated with calcrite and quartz outcroppings and plains.

**Habitat and environmental parameters** A rugged landscape of eroded rock outcrops, sandscoured valleys and some prominent inselbergs provides the backdrop for plants to get a foothold. Dolomite, quartzite and limestone of the Gariep Complex form the rocky components in this area. Consistently strong southerly winds shape the landforms and associated vegetation. Rainfall is low and estimated to average 20 mm per annum. Fog occurs regularly, but becomes less frequent further eastwards. Several inselbergs, such as Dreizackberg, Drachenberg and Schwarzer Berg are included in this mapping unit.

**Description** Stem succulents, dwarf shrubs and leaf-succulents are the main growth forms supported by the various landforms. Vegetation cover is very patchy and many areas are entirely free of vegetation. Where there is plant cover, the cover of perennial plants ranges between 5% and 10%. Vegetation height is normally low, not exceeding 30 cm, but some large shrubs and stem succulents are present. These can grow up to 2 m high.

**Key species** Stands of *Euphorbia gummifera* occur, and *Brownanthus arenosus* is prevalent on plains throughout this mapping unit. In rocky areas *Ectadrum latifolium*, *Zygophyllum prismatocarpum* and many dwarf succulents are present.

**Extent** 973.2 km² (4.50% of the Sperrgebiet)

**Plant diversity** Considering the harsh environmental conditions, plant diversity throughout this mapping unit is remarkably high. Over 160 species have so far been recorded, the majority are associated with rock outcrops and inselbergs.

**Conservation importance:** VERY HIGH The outcrops and rocky areas in this mapping unit are of very high conservation importance. Limited distribution of species of conservation importance and threats by illegal collecting put these as high priorities for conservation action. These include populations of *Conophytum*, *Crassula*, *Dracophyllum*, *Fenestaria*, *Juttadiptera*, *Lithops* and *Namibia* species. There are also various other protected species, such as *Aloe dichotoma*, *Cephalophyllum ebrectatum*, *Psammophora modesta* and *Stoebe* rubescens. Endemics include *Ectadrum latifolium* and *Frankenia pometae*, while Cites-recognised species include *Euphorbia hamata*, *E. gummifera* and *E. verruculosa*.

**Alien plant species** None recorded

**Resource use** The perennial vegetation is a food source for wildlife and dwarf shrubs provide a habitat for small animals.
Threats
- Illegal plant collecting
- Quarrying and prospecting

Recovery potential Low

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Regular assessments of plant populations of high conservation concern
- Spot-checks of people exiting the Sperrgebiet for illegally lifted plants
- Rehabilitate borrow-pits

Research needs Detailed Red Data assessments of range-restricted plant species are urgently required. More detailed vegetation maps are necessary to guide environmental planning. Some of the inselbergs have not yet been surveyed. Most animal groups require more detailed collecting.


Orange River Valley shrubland

Scientific name
Stoeberia gigas dwarf shrubland

Locality This mapping unit covers the eastern, largely rocky section of the Orange River in the Sperrgebiet.

Geographic unit Orange River Valley

Vegetation sub-units Several vegetation types are combined in this mapping unit. There are Rhus pendulina - Tamarix usneoides woodlands along the banks of the Orange River, dwarf succulent shrublands with different species dominant on the slopes and in gullies adjoining the northern banks of the river, plains with Stipagrostis ciliata grassland or Brownanthus marlothii shrubland and gravel terraces with their own set of unique plant assemblages.

Habitat and environmental parameters This section of the Orange River comprises a varied and scenic landscape. River banks, drainage areas, gravel terraces, gravel and sand plains, as well as steep slopes and gullies provide an enormous palette of habitats. Complex geology provides a backdrop of a range of rock types including schist, dolomite and quartzite. Where two prominent north–south trending mountain chains, the Schaksalsberge and Gorrntswibberge (the southern extension of the Obib Mountains), meet the river, prominent rock outcrops, such as Skilpad, and steep slopes rise high above the river valley. Overall, rainfall and fog decrease in a west–east direction, but moisture supply to plants is largely determined by local topography. Slopes facing the Orange River, for example, receive regular fog precipitation. The Orange River Valley is characterised by great temperature extremes with very hot conditions during summer and when berg winds reign in winter. The cooling effect of southerly winds is deflected by the valley slopes and thus often blows upstream, but abates while doing so.

Description Dwarf succulent shrubs dominate on gravel terraces, rocky slopes and gravel plains, while sand plains support local patches of grasslands. The bank of the Orange River and associated drainage areas support large trees and tall shrubs. Plant height is, hence, variable; mean plant height ranges from 5 m along the river to 30 cm in shrublands and grasslands. Perennial plant cover is patchy and extremely variable. Sections of the river banks support dense vegetation reaching 50% cover, while plant cover on the plains and slopes varies between 1% and 10%. After rains, the grasslands on the plains can reach 30% cover.

Key species Because it is locally dominant, Stoeberia gigas is selected as the characteristic species of this mapping unit. Frequently occurring tree species in the riverine woodlands

74
are Acacia karroo, Euclea pseudobenus, Rhus pendulina, Salix mucronata and Tamarix usneoides. Drainage lines harbour tall shrubs such as Gomphocarpus filiformis, Sisydite spartea and Zygophyllum microcarpum. Stipagrostis ciliata is the dominant species on grassy plains, Brownanthus mariothii on gravel plains. The rocky slopes and gravel terraces are very diverse and support, amongst others, populations of Euphorbia cibdela, Hartmanthus pergamentaceus, Juttadinteria albata, Othonna opima and Rhusianthema gigas.

**Extent** 108.9 km² (0.50% of the Sperrgebiet)

**Plant diversity** It is estimated that over 200 species occur in this section of the Orange River Valley – 170 species have been recorded in one quarter-degree square overlapping with this mapping unit.

**Conservation importance:** VERY HIGH The Orange River Valley is of extremely high conservation importance as many species with a very restricted range occur here. These include species of the genera Aloe, Amphilobia, Anacampteros, Antimima, Aridaria, Aneitia, Cephalophyllum, Cheiridopsis, Conophytum, Crassula, Dracophyllum, Eberlanzia, Euphorbia, Fenestraria, Hartmanthus, Juttadinteria, Lavrania, Lithops, Portulacaria, Ruschia, Sarcocaulon, Stoeberia and Tylecodon. All these are also protected.

**Alien plant species** The Orange River is a conduit for alien invasive plant species. Almost all species occurring in southern African drylands have been observed. These include Argemone ochroleuca, Chenopodium species, Datura species, Nicotiana glauca, Nicotiana longiflora and Ricinus communis. Of greatest concern, however, are Prosopis species which are aggressive invaders in all Namibian semi-arid and arid perennial and ephemeral river systems.

**Resource use** The woodlands of the Orange River provide an important source of firewood and building material. The grasslands and, of course, the river itself, are extremely important food and water sources for large and small wildlife.

**Threats**
- Cutting trees and removal of firewood in the vicinity of settlements (Rosh Pinah)
- Illegal succulent collecting
- Prospecting, mining and quarrying

**Recovery potential** Low

**Management**
- Recommended management zoning: IUCN 1b (wilderness)
- Undertake environmental awareness campaigns
- Provide alternative fuel to townships and enforce regulations curbing the destruction of trees on river banks
- Undertake spot-checks for illegally collected succulents upon exit from the Sperrgebiet (Sendelingsdrif, Oppenheimer Bridge)
- Prohibit off-road driving
- Monitor succulent populations under threat
- Environmental assessments, involving a botanical specialst with appropriate experience, are required for all development activities

**Research needs** Red Data assessments of all range-restricted plant species are urgently needed.

Southern euphorbia shrubland

Scientific name
Euphorbia gummifera
shrubland

Locality
This mapping unit comprises plains to the west and south of Rosh Pinah and the foothills of the Kolimb Mountains.

Geographic units
Rosh Pinah plains,
Kolimb Mountains

Vegetation sub-units
Sand and gravel plains, as well as drainage lines, support different vegetation sub-units. Brownanthus arenosus is prevalent on sand plains, Euphorbia dregoana in drainage lines and Zygophyllum prismatocarpum on inselbergs. Localised patches of calcareous and gravel plains support a variety of Zygophyllum species.

Habitat and environmental parameters
A variety of landforms are included in this mapping unit. Schist, quartzite, felsite and tuff of the Gariep Complex provide the underlying geology. Many outcropping and eroded quartz veins form low ridges and supply material for quartz gravel plains. The area receives a mean of 54 mm of rain per annum and regular fog which snakes in along the Orange River. Southerly winds prevail most of the year and easterly berg winds during winter. The main wind directions are often deflected by the rugged, local topography.

Description
In accordance with the different landforms and vegetation units contained in this mapping unit, plant heights and cover are variable. A number of tall species grow in drainage lines and an average height of 1.5 m is reached in many places. The plants on plains usually average 30 cm, except where Euphorbia gummifera forms prominent stands. Here mean plant height reaches 1.5 m. Perennial plant cover is patchy, ranging between 5% and 15%.

Key species
Euphorbia gummifera was selected as the name-giving species as it is characteristic in this landscape. However, Brownanthus arenosus, Euphorbia dregoana, Zygophyllum appianatum, Zygophyllum patenticaule, Zygophyllum prismatocarpum and Zygophyllum segmentatum are locally abundant.

Extent
38.9 km² (0.18% of the Sperrgebiet)

Plant diversity
Plant diversity is estimated to be medium, ranging between 50 and 150 species.

Conservation importance: HIGH
This mapping unit is of high conservation importance because of the occurrence of many species with a very restricted distribution range. These include all low-growing Zygophyllum species (Zygophyllum appianatum, Zygophyllum patenticaule, Zygophyllum longistipulatum, Zygophyllum schreberianum and Zygophyllum segmentatum). There are also a variety of Cites 2 plants, such as Euphorbia cibdela, Euphorbia dregoana, Euphorbia ephedroides, Euphorbia gariepina and Euphorbia gummifera. Many tree species are protected, such as Aloe dichotoma, Aloe pilansii, Osoros crassirnervia and Parkinsonia africana.

Alien plant species
In the vicinity of the town Rosh Pinah, numerous exotic species occur. Of concern, as invasive in arid areas, are Argemone ochroleuca, Nicotiana glauca, Ricinus communis and Prosopis species.

Resource use
The plant resources contained in this mapping unit are important forage for wildlife and livestock. Although unsuitable, shrubs and stem succulents are presently heavily used for firewood in the vicinity of informal settlements.

Threats
- Uncontrolled expansion of settlements along the river and in the vicinity of town have resulted in increasing destruction of vegetation for firewood and building material
- Invasion by alien invasive plant species
- Off-road driving
- Mining
- Pollution associated with unplanned settlements and Rosh Pinah
- Illegal plant collecting

Recovery potential
Low
Management
- Recommended management zoning: IUCN 1b (wilderness)
- Institute an adequately staffed environmental office in Rosh Pinah in support of MET’s regional office
- Undertake an environmental awareness campaign, targeting all levels of the Rosh Pinah population
- Supply alternative fuel sources to townships
- Enforce regulations curbing the destruction of trees on river banks
- Prohibit off-road driving
- Eradicate and monitor alien invasive plants

- Detailed environmental assessments need to accompany all infrastructure and mining developments

Research needs
Red Data assessments of range-restricted species are extremely urgent. A detailed vegetation map will be needed to guide environmental planning.

Other mapping
AEZ: NAM5; Giess (1971); desert and succulent steppe; Williamson (1997); lower Orange River zone; Jürgens et al. (1997); eastern grassland and stem succulent shrubland; Burke et al. (2002); sand plain succulent dwarf shrubland

Western Klinghardt-plain shrubland

Scientific name
Euphorbia decussata
Euphorbia gymnifera
dwarf shrubland

Locality
This mapping unit comprises the western section of the plains leading towards the Klinghardt Mountains.

Geographic unit
Western Klinghardt plains

Vegetation sub-units
Several vegetation sub-units occur, largely associated with changes in the substrate. Euphorbia gymnifera dominates mainly on deeper sand, while several Eropechmus, Pteronia and Zygophyllum species form localised units where quartz gravel and calcrite prevail.

Habitat and environmental parameters
Quartz gravel and calcrite, as well as sand plains are the main habitats. There are also some low ridges. Underlying rock types are diverse and include dolomite, limestone, quartzite and conglomerate. Quartz veins provide outcroppings of quartz. Rainfall is low; fog occurs occasionally.

Description
Dwarf shrubs and shrubs comprise the main components of the vegetation. Perennial plant cover ranges between 10% and 20%, and most plants are less than 50 cm in height.

Key species
Euphorbia gymnifera dominates in deep sand. Euphorbia gymnifera characterises the dwarf shrublands on gravel and sand plains with the co-dominant Euphorbia decussata. Other frequently occurring species are Brownanthus arenosus, Eropechmus giesii, Pteronia pomonae and Sarcocaulon patersonii.

Extent 671.6 km² (3.11% of the Sperrgebiet)

Plant diversity
Plant diversity on these plains is medium and expected to range between 50 and 70 species.

Conservation Importance: HIGH
Protected plants include Cephalophyllum, Crassula, Dracophyllum, Eberianza, Fenestralia, Psammophora and Juttadinteria species. Brownanthus arenosus, Pteronia pomonae, Trachyandra glandulosa, Zygophyllum appianatum and Zygophyllum hirticaule are southern Namib endemics found here. Also a minimum of six CITES 2-listed Euphorbia species occur in this mapping unit.

Alien plant species
None recorded

Resource use
Providing comparatively high plant cover in this arid area, these shrublands are important food sources for wildlife.
Threats
- Off-road driving
- Illegal plant collecting

Recovery potential  Low

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Prohibit off-road driving

- Spot-check visitors exiting the Sperrgebiet for illegally lifted plants

Research needs Parts of this mapping unit are not well-collected for most biota.

Aurus sand plain grassland

Scientific name
Stipagrostis ciliata – Stipagrostis geminifolia

Conservation importance: MEDIUM Several of the bulb species growing here are southern Namib endemics, such as Bulbine namaensis and Eriocaphalus giassii.

Locality These sand plains adjoin to the east of the succulent (Brownanthus arenosus – Stipagrostis ciliata) grasslands of the Aurus Mountains and are confined to the northeast by the Ugachab drainage.

Alien plant species None recorded at present

Resource use These grasslands are extremely important grazing areas for the Sperrgebiet's gemsbok populations.

Threats None at present

Recovery potential Medium

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Control vehicle tracks

Geographic unit Aurus sand plain

Vegetation sub-units No sub-units are recorded.

Habitat and environmental parameters These sandy plains gently slope to the northeast towards the Ugachab drainage. Slightly more arid conditions and greater exposure to wind – as distance increases from the shelter of the mountain chain – are the main climatic characteristics of these sand plains.

Description Perennial and annual grasses dominate, but herbs and bulbs provide a colourful addition after good rains. Perennial plant cover varies between 1% and 30%, depending on rainfall; plant height averages 30 cm after a good season.

Key species Stipagrostis ciliata and Stipagrostis geminifolia are the most common plant species. Bulbs so far recorded include Bulbine, Eriospermum and Trachyandra species. Herbs include Arctotis fastuosa, Foveolina albida, Helichrysum obtusum, Hirpicium echinus, Oncosiphon grandiflorum and Ursinia speciosa.

Extent 138.9 km² (0.64% of the Sperrgebiet)

Plant diversity Full records are not available, but it is expected that 30–50 species occur in this mapping unit.

Research needs Many more bulb species are expected to occur in this mapping unit and bulbs have hitherto been poorly recorded. Animal records are poor.

Aurus–Heioab grassland

Scientific name
*Stipagrostis geminifolia* grassland

Locality These grassy plains are positioned to the west of the Heioab Mountains and to the southeast of the Aurus Mountains.

Geographic units Heioab and Aurus plains

Vegetation sub-units Sub-units with *Brownanthus arenosus*, *Zygophyllum applanatum*, *Zygophyllum patenticaula* and *Zygophyllum pteroicaule* occur locally.

Habitat and environmental parameters Level outwash plains, in the case of the Heioab plains, and sand plains near Aurus, characterise this mapping unit. Sand cover is variable and on the Heioab plains very patchy. Rainfall, wind and temperature are expected to be similar as for the Klinghardt and Aurus Mountains.

Description This unit is dominated by grass. Plant cover is directly dependent on rains and can reach 25% and more in good years.

Key species Although *Stipagrostis geminifolia* has been selected as the main descriptor, there are also patches of *Augea capensis*, while *Brownanthus arenosus* and *Stipagrostis ciliata* occur as co-dominant species in places.

Extent 177.8 km² (0.82% of the Sperrgebiet)

Plant diversity Plant diversity is expected to range between 10 and 30 species, but could well be higher in the vicinity of rock outcrops and drainage lines.

Conservation importance: MEDIUM Some bulb species of conservation importance may occur, but have not yet been documented.

Allen plant species None recorded

Resource use These grasslands are very important grazing resources for wildlife.

Threats None at present

Recovery potential Medium

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Control vehicle track development

Research needs Bulbs potentially associated with this vegetation type need attention.

Other mapping AEZ: NAM5; Giess (1971); desert and succulent steppe; Williamson (1997); eastern sand plains; Jürgens et al. (1997); temperate zone of Namib plains; Burke et al. (2002): sand plain dwarf shrubland

Eastern sand plain grassland

Scientific name
*Stipagrostis ciliata* grassland

Locality Two isolated sections of this mapping unit occur in the Sperrgebiet. The Ugachab drainage area is positioned just north of the Aurus Mountains, and a second unit comprises the plains north of Tsusus Mountain in the eastern Sperrgebiet.

Geographic units Ugachab drainage, Aus southern plains

Vegetation sub-units The Ugachab drainage harbours a stand of widely scattered *Acacia erioloba* and *Acacia karroo* trees. Isolated stands of *Euphorbia gummifera* occur in both sections of this mapping unit. *Salsola–Lycium* dwarf shrubland is prevalent mainly to the north of the Ugachab drainage, but also found on its southern banks.

Habitat and environmental parameters Run-off from the Swartkloofberg to the north and the Aurus Mountains to the south have shaped the wide, southeast to northwest, and then southwest curving Ugachab drainage. Although above-ground flow conditions have not been reported in the last few decades, it is likely that there are underground water sources which support stands of trees. In addition to the prevailing southerly and southwesterly winds, this area is also
exposed to easterly berg winds during the winter months. The northern mapping unit consists largely of gravel plains and a few drainage lines.

Conservation importance: MEDIUM. *Acacia erioloba* and *Euclea pseudebenus* are protected trees. *Euphorbia gummifera* is listed on Cites Appendix 2.

Alien plant species *Argemone ochroleuca* and *Nicotiana glauca* have been recorded in drainage lines associated with this vegetation type.

Resource use Although most of the mapping unit is bare of plant cover, except after rains, the sparse trees in this area provide an important shelter, resting place and food source for animals.

Threats Alien invasive plants

Recovery potential Low (for trees) to medium (for grasslands)

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Control vehicle tracks
- Monitor alien plant invasives and, if emerging, remove

Research needs Animals have not been well studied in this area.


Description Except for a few widely scattered trees, stands of widely spaced *Euphorbia gummifera* and some isolated dwarf shrubs, this mapping unit is largely bare of perennial vegetation. Annual grasses, however, can cover these vast plains after adequate rains.

Key species *Acacia erioloba* and *Euclea pseudebenus* are the main tree species in the Uguchab drainage channel, accompanied by *Rhigozum trichotomum* towards the east. *Stipagrostis ciliata* and probably other grass species, such as *Stipagrostis obtusa* and *Eragrostis nindensis* occur in the broader area after rains.

Extent 664.4 km² (3.07% of the Sperrgebiet)

Plant diversity This mapping unit is not very diverse in plant species and is expected to support 20 to 30 species.

### Northern gravel and sand plain grassland

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Vegetation sub-units</th>
</tr>
</thead>
</table>
| *Euphorbia gummifera* – *Stipagrostis ciliata* grassland | Low inselbergs and ridges, and sandy, gravel and calcere plains harbour distinct vegetation sub-units.

<table>
<thead>
<tr>
<th>Locality</th>
<th>Habitat and environmental parameters</th>
</tr>
</thead>
</table>
| Plains and low inselbergs to the north, south and east of the Kaukausib drainage form this extensive mapping unit. | Landforms contained in this unit comprise gravel, sand and calcere plains, several low inselbergs and small rock outcrops, as well as a network of channels draining into the Kaukausib drainage area. Aluminium-rich gneiss and schist are the main underlying rock types. Rainfall is low – on average, expected to be less than 20 mm per annum – and fog rarely occurs.

<table>
<thead>
<tr>
<th>Geographic units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Lüderitz plains, Letterkuppe plains</td>
<td>Low stem-succulent shrubs and grasses are the main components of the vegetation. On calcere plains and in rocky areas, more leaf-succulent shrubs and also other dwarf...</td>
</tr>
</tbody>
</table>
shrubs occur. Perennial vegetation cover is patchy and ranges from 0% to 15%. In most areas, shrubs reach no more than 30 cm in height. The stem-succulent *Euphorbia gummifera*, however, averages 1.5 m in height.

**Key species** Stands of *Euphorbia gummifera* are associated with sand cover. These are the most conspicuous components of the vegetation. On gravel plains *Augea capensis*, *Mesembryanthemum hypetropicum*, *Stipagrostis ciliata* and many herbs can provide a reasonable plant cover after rains. The dwarf shrubs of the calcrite plains include *Eriocaphalus scariosus*, *Pteronia pomenae*, *Zygophyllum applanatum* and *Zygophyllum hirticaule*. On rock outcrops, more diverse vegetation is present, including *Euphorbia cibdela*, *Pteronia glabrata* and *Zygophyllum prismatocarpum*.

**Extent** 2,118.8 km² (9.80% of the Sperregebiet)

**Plant diversity** Plant diversity in this mapping unit varies according to vegetation sub-unit. It can hence range from 10 species on plains to approximately 50 on rocky outcrops.

**Conservation importance:** MEDIUM The sandy, calcrite plains and rocky outcrops harbour the majority of species of conservation importance. Bulbs occur on gravel and sand plains, and possibly endemic bulb species may occur here. Some of the protected species so far recorded are *Aloe dichotoma*, *Eberlanzia sedoides* and *Juttadineria suavissima*. *Polemanniopsis* sp. nov. and *Euphorbia namibensis* are two species with a very limited distribution range that occur in this mapping unit. Cites 2 species include *Euphorbia cibdela* and *Euphorbia gummifera*, while endemics include *Brownanthus arenosus*, *Ectadium latifolium*, *Moncha desertorum*, *Pteronia pomenae* and *Zygophyllum hirticaule*.

**Alien plant species** None recorded

**Resource use** The grasslands are important grazing for wildlife.

**Threats** Off-road driving

**Recovery potential** Low to medium (medium on sand plains and where short-lived grasses prevail, low in shrublands and *Euphorbia gummifera* stands)

**Management**
- Recommended management zoning: IUCN 1b (wilderness)
- Avoid infrastructure development on sand, as well as calcrite plains, and particularly avoid rocky outcrops.

**Research needs** Plants on many rocky outcrops have not yet been surveyed; sandy areas and gravel plains deserve attention after good rains, particularly with regard to bulbs.

**Other mapping** AEZ: NAM8; Giess (1971): desert and succulent steppe; Williamson (1997): central sand plains; Jürgens et al. (1997): eastern grassland and stem succulent shrubland zone; Burke et al. (2002): sand plain dwarf shrubland

---

**Rekvlakte grassland**

**Scientific name**
*Euphorbia gummifera* – *Stipagrostis gymnifolia* grassland

**Locality** Encircled by the groups of Morgen inselbergs, which are the western extension of the Swartkloofberg, this mapping unit is positioned in the eastern Sperregebiet.

**Geographic unit** Rekvlakte (Anib)

**Vegetation sub-units** These grasslands with their stands of *Euphorbia gummifera* form a transition to the open plains and Tsaus pan grasslands to the north of this mapping unit.

**Habitat and environmental parameters** Gravel and sand plains, shallow drainage lines and a few low outcrops occur in this mapping unit. Although no long-term rainfall records exist for this area, climatic conditions are expected to be drier and show greater temperature fluctuations
than in other parts of the Sperrgebiet. Fog is not expected to occur frequently and rainfall is likely in winter or summer, and is often altogether absent in a year. Southerly winds are probably less important than in the western and southern areas of the Sperrgebiet, but easterly berg winds are expected to occur frequently during the winter months.

**Description** These mostly barren plains support ephemeral grasslands after good rains. Isolated stands of *Euphorbia gumifera* are almost the only perennial plant cover. Perennial plant cover is low, ranging from 1% to possibly 15% in a good season. Plant height for the grass-dominated areas is 30 cm, and 1 m in stands of *Euphorbia gumifera*.

**Key species** *Euphorbia gumifera* and *Stipagrostis* species, such as *Stipagrostis geminifolia*, and probably *Stipagrostis ciliata* and *Stipagrostis obtusa*, occur.

**Extent** 32.0 km² (0.15% of the Sperrgebiet)

**Plant diversity** The diversity of plants is expected to be low, although no detailed records exist for this mapping unit.

**Conservation importance:** MEDIUM

*Euphorbia gumifera* is a Cites 2 species. Short-lived components of the vegetation are unknown and could include southern Namib endemics.

**Alien plant species** No records

**Resource use** After good rains these grasslands are important grazing resources for wildlife.

**Threats** None at present

**Recovery potential** Medium

**Management**
- Recommended management zoning: IUCN 1b (wilderness area)
- Control vehicle track development

**Research needs** This mapping unit has been poorly collected for animals. Short-lived components of the vegetation (herbs, bulbs) deserve more thorough collecting.

**Other mapping** AEZ: NAM5; Giess (1971): desert and succulent steppe; Williamson (1997): eastern sand plains; Jürgens et al. (1997): eastern grassland and stern succulent shrubland zone; Burke et al. (2002): sand plain dwarf shrubland

---

### Skorpion sand plain grassland

**Scientific name**
- *Brownanthus arenosus - Stipagrostis ciliata* grassland

**Locality** This mapping unit comprises the Skorpion sand plains and those to the south towards the Oib Mountains in the eastern Sperrgebiet.

**Geographic unit**
- Spitzkop plains

**Vegetation sub-units** Within this mapping unit there are also gravel and calcrete plains which support different vegetation, such as a range of low-growing *Zygophyllum* species. Locally, *Othonna cylindrica* and *Stipagrostis geminifolia* form sub-units on sand plains.

**Habitat and environmental parameters** Sand cover of varying depth, locally exposed calcrete and gravel plains, as well as drainage lines are the main habitats. Overall, climatic conditions are similar to those described for the Skorpion inselbergs. A mean annual rainfall of 54 mm has been recorded at Rosh Pinah. Fog occurs frequently. Southwesterly winds and strong northeasterly berg winds in winter, bringing sandstorms, are other important environmental variables.

**Description** Dwarf succulent shrubs and grasses are the most abundant plant growth forms in this mapping unit. Grasses are prominent on most gravelly areas, while dwarf succulents, or equal portions of succulents and grasses prevail in areas with deeper sand cover. The sand plains provide a continuous and permanent plant cover. Plant height averages 30 cm, and plant cover is extremely variable depending on rainfall and local substrate conditions; it can range from 1% to over 30%.

**Key species** *Brownanthus arenosus* is ubiquitous throughout this mapping unit. *Stipagrostis ciliata* is the characteristic grass on the calcrete plains. On sand plains *Lebeckia*
Halenbergensis and Othonna cylindrica are also locally abundant. During the growing season a variety of herbs transform the sand plains into colourful carpets. Most prevalent are Arctolis fastuosa, Didelis carnosa, Foveolina albida, Oncosiphon grandiflorum and Ursinia speciosa. Accompanying grasses are Karroochoa schisoides, Stipagrostis obtusa and Stipagrostis geminifolia. On calcrite and gravel plains, in addition to Stipagrostis obtusa, Stipagrostis ciliata is an important grass component, while Augea capensis is locally abundant. In drainage lines additional species are Sisyndite spartea, Stipagrostis brevifolia and Zygophyllum microcarpum.

Extent 38.5 km² (0.18% of the Sperrgebiet)

Plant diversity Although not reaching the tally of rocky substrates, plant diversity on these plains is remarkably high. During the environmental assessment for the Skorpion Mine, 114 species were recorded, and many more have been added since.

Conservation importance The plains are of high conservation importance due to the presence of many range-restricted species. Some of the protected species with a southern Namib restricted range are Cheiridopsis, Dracophytilus, Eberlanzia and Ebracteola species. Other southern Namib endemics are Eriospermum and Lachenalia species, as well as Mesembryanthemum barikiyi and Mesembryanthemum pellitum. Euphorbia melanohydrata is a Cites 2 species occurring on these plains. Most low-growing Zygophyllum species are Sperrgebiet endemics. Bulbs in this mapping unit are poorly collected and many more southern Namib endemics are expected to be recorded in future.

Alien plant species None recorded at present.

Resource use The grasslands of this mapping unit are an extremely important grazing area for the Sperrgebiet’s gemsbok populations. Many other animal species are associated with these dwarf shrubs and grasses.

Threats
- Mining and prospecting
- Infrastructure
- Illegal plant collecting
- Alien invasive plant species

Recovery potential Low to medium (low on gravel and calcrite, medium on sand plains)

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Prohibit off-road driving
- Involve botanical specialist during the planning of infrastructure, prospecting and mining developments
- Monitor for emergence of alien invasive plant species and remove when recorded
- Undertake spot-checks for illegally collected plant species upon exit at Skorpion Mine
- Any prospecting, tourism and mining activities in this mapping unit require detailed environmental assessments involving appropriate biological specialists

Research needs Bulb species in this mapping unit deserve particular attention and require more thorough collecting.

Succulent grassland

Scientific name
*Brownanthus arenosus* – *Stipagrostis ciliata* grassland

Locality This mapping unit comprises isolated pockets of deeper sand cover associated with the Aurus and Rooi Berg mountains as well as the inselbergs around Skorpion.

These include the sand plains immediately adjoining the eastern slopes of the Aurus Mountains – some of which are enclosed by mountain ridges – and a patch of sand plain south of Rooi Berg. More sand plain areas are found east and west of the Skorpion inselbergs and in the south towards the Obiib Mountains.

Geographic units Aurus sand plain, Spitzkop plains, Skorpion sand plain

Vegetation sub-units There are pockets of calcrite and shallow sand cover which support *Zygophyllum* and *Salsola* species. Locally, *Othonna cylinardes* and *Stipagrostis geminifolia* form sub-units on sand plains.

Habitat and environmental parameters Deeper sand cover is the main characteristic of this landscape unit. The parts of this mapping unit near Aurus are in a relatively sheltered position since they are in the lee of the Aurus Mountains. Rainfall conditions are similar to those for the Aurus Mountains and estimated to reach an annual mean of around 50 mm. Fog occurs frequently. Southwesterly winds and strong northeasterly *berg* winds in winter bringing sandstorms are other important environmental factors.

Description An equal mix of grasses and dwarf succulents forms the main component of this vegetation. Grasses are dominant on most gravel areas, while dwarf succulents, or equal portions of succulents and grasses prevail in areas with deeper sand cover. The sand plains provide a continuous and permanent plant cover. Plant cover varies according to rainfall conditions, but ranges between 1% and 40%. Average plant height is 30 cm.

Key species *Brownanthus arenosus* and *Stipagrostis ciliata* have been named the descriptors of this mapping unit, but other grasses are equally common locally. These include *Stipagrostis geminifolia* and *Stipagrostis obtusa*. In places where sand cover is reduced and exposes underlying calcrite or gravel, *Salsola* and *Zygophyllum* species occur. On sand plains *Lebeckia halenbergenensis* and *Othonna cylindraca* are also locally abundant. During the growing season a variety of herbs transform the sand plains into colourful carpets. Most prevalent are *Arctotis fastuosas*, *Didelta carnosas*, *Foveolina dichotoma*, *Oncosiphon grandiflora* and *Ursinia speciosa*. Accompanying grasses are *Karroochoa schimoides*, *Stipagrostis obtusa* and *Stipagrostis geminifolia*. In drainage lines, additional species are *Sisyrdite spartea*, *Stipagrostis brevifolia* and *Zygophyllum microcarpum*.

Extent 170.9 km² (0.79% of the Sperrgebiet)

Plant diversity Although not reaching the tally of rocky substrates, plant diversity on these plains is remarkably high. During the environmental assessment for the Skorpion Mine, 114 species were recorded and many more are expected for the wider area.

Conservation importance: HIGH There are populations of protected *Cheiridopsis*, *Dracophilus*, *Eberlanzia*, *Juttadinteria* and *Ruschia* species. Southern Namib endemics are *Brownanthus arenosus*, and *Eriosepermum* and *Lachenalia* species, as well as *Mesembryanthemum barkyi* and *Mesembryanthemum pellitum*. *Euphorbia melanohydrata* is a Cites 2 species occurring on these plains. Most low-growing *Zygophyllum* species are Sperrgebiet endemics. Bulbs associated with these sand plains are likely to include many southern Namib endemics. At present there are few records to support this.

Alien plant species None recorded at present

Resource use The relatively high grass cover makes this mapping unit a very important grazing area for wildlife, particularly the Sperrgebiet’s gemsbok populations.
Threats
- Mining and prospecting
- Infrastructure
- Illegal plant collecting
- Invasion by alien plant species from neighbouring farmland
- Off-road driving

Recovery potential Low to medium (low on gravel patches, medium on sand plains)

Management
- Recommended management zoning: IUCN 1a and 1b (strict nature reserve near Auras, wilderness near Skorpion)
- Spot-check of all visitors to this area for illegally lifted plants
- Stringent vehicle track control
- Monitor critical range-restricted plant populations
- Monitor the emergence of and, if necessary, remove invasive alien plants
- Involve botanical specialist during the planning of infrastructure, prospecting and mining developments
- Any prospecting, tourism and mining activities in this mapping unit require detailed environmental assessments involving appropriate biological specialists

Research needs Bulb collection in this mapping unit deserves attention. A detailed vegetation map (as part of a vegetation map for the Auras Mountains) is required.


Tsax pan grassland

Scientific name
Salsola – Stipagrostis grassland

Locality The plains and pan south of Tsax are contained in this mapping unit.

Geographic unit
Arasab–Anib drainage

Vegetation sub-units Large parts of this mapping unit are free of perennial vegetation. In areas with sand accumulation, Salsola and Lycium species are prevalent. Parts of this mapping unit can bear grass cover after good rains. In the eastern section of this mapping unit (towards the Sperrgebiet fence) plant cover increases.

Habitat and environmental parameters This mapping unit delineates the western-most extension of the Arasab–Anib drainage area. These two, westward flowing, wide rivers converge here and form an extensive pan. Level gravel and sand plains surround the pan area. Climatic conditions are similar as for Tsax and characterised by low rainfall, probably an absence of fog and higher temperatures than near the coast.

Description This area is in many parts devoid of vegetation. Ephemeral grasslands occur patchily after rains, and perennial plant cover is restricted to some sandy patches and drainage lines. Low shrubs up to 50 cm in height, reaching no more than 1% cover, comprise the vegetated areas.

Key species Lycium and Salsola species, and some isolated patches of Euphorbia gummifera occur here.

Extent 273.5 km² (1.27% of the Sperrgebiet)

Plant diversity Very low diversity, which is expected to reach no more than 20 species, is characteristic of this area.

Conservation importance: MEDIUM Euphorbia gummifera is listed as a Cites 2 species.
Alien plant species  None recorded

Resource use  Although plant resources in this mapping unit hardly provide any sustenance to wildlife, the pan holds water after good rains and hence provides an important watering point.

Threats  None

Recovery potential  Medium

Management
- Recommended management zoning: IUCN 2 (national park reserve)
- Control vehicle track development

Research needs  Animals, particularly those associated with temporal pools, require sampling.

Chamaubu dune grassland

**Scientific name**  
*Othonna cylindrica* - *Stipagrostis lutescens* grassland

**Locality**  
These dunes are positioned to the south and east of the Chamaubu inselbergs.

**Geographic unit**  
Chamaubu dunes

**Vegetation sub-units**  
No vegetation sub-units are recorded.

**Habitat and environmental parameters**  
This mapping unit comprises mobile and semi-stabilised dunes. Strong winds and an unstable substrate are the main environmental characteristics.

**Description**  
Dwarf shrubs and grasses largely form the perennial plant cover which ranges between 10% and 20%. The average height of the vegetation is 30 cm. After rain, a variety of bulbs and herbs are present.

**Key species**  
In addition to *Othonna cylindrica*, localised *Brownanthus arenosus*, *Euphorbia nummifera*, *Othonna furcata* and *Stipagrostis lutescens* are present. Herb species include *Grietum humifusum*, *Helichrysum obtusum* and *Oncosiphon grandiflorum*, while bulbs include *Bulbinia* species. Other grasses include *Cladoraphis spinosa* and *Stipagrostis geminifolia*.

**Extent**  
94.6 km² (0.44% of the Sperrgebiet)

**Plant diversity**  
Although the diversity of perennial plants is low (a total of 5–10 species is estimated), many more short-lived plants occur. These have not yet been collected.

**Conservation importance**  
MEDIUM  
Endemic bulb species (e.g. *Bulbine*) occur in these dunes.

**Alien plant species**  
None presently recorded.

**Resource use**  
The dune fields are important forage areas for wildlife. The southern Namib endemic desert snail (*Trigonephrus* sp.) also lives in these dunes.

**Threats**  
None at present

**Recovery potential**  
Medium

**Management**  
Recommended management zoning: IUCN 1b (wilderness)

**Research needs**  
Bulbs associated with this dune field are likely to be of conservation importance and they deserve more thorough collecting.

**Other mapping**  
Northern barchan grassland

Scientific name
Cladoraphis cyperoides – Stipagrostis lutescens grassland

Locality
This northern sand corridor originates in Elizabeth Bay and extends northwards into the mobile dunes of the Namib sand sea.

Geographic unit
Northern barchans

Vegetation sub-units
Where sand movement is high, this mapping unit is free of vegetation. There are, however, pockets of dune grasses such as Cladoraphis cyperoides, Stipagrostis lutescens and Stipagrostis sabulicola.

Habitat and environmental parameters
This mapping unit comprises mobile sand in the form of small barchans. A mobile substrate, strong southerly winds and aridity are the main habitat characteristics.

Description
Large parts of the area are devoid of vegetation, but in valleys, depressions and on lower dune slopes some grasses have taken a foothold. Overall, perennial plant cover is less than 1%, but can reach 10% after rains and where a slightly more stable substrate prevails.

Key species
Cladoraphis cyperoides, Stipagrostis geminifolia, Stipagrostis lutescens and Stipagrostis sabulicola occur. After good rains, herbs such as Foveolina albida, Grielum humifusum and Monsonia ignorata as well as annual grasses, such as Stipagrostis ciliata, can also be present.

Extent
2,155.8 km² (9.97% of the Sperrgebiet)

Plant diversity
Plant diversity is expected to be low, ranging from 5 to approximately 20 species.

Conservation importance
LOW One endemic plant species has so far been recorded.

Alien plant species
None recorded

Resource use
The grasslands contained in this mapping unit are important food sources for large and small herbivores. They are also an important habitat for endemic Namib insects.

Threats
None at present

Recovery potential
High

Management
- Recommended management zoning: IUCN 1b (wilderness)
- Avoid large-scale blocking of sand transport through infrastructure developments

Research needs
Invertebrates are poorly known, and collecting of bulbs is important.

Other mapping
Southern dune grassland

Scientific name
Cladoraphis spinosa

Conservation importance: LOW Amongst bulb species, Namibian and probably Sperrgebiet endemics could be expected, but have so far not been recorded.

Locality The Obib dunes are sandwiched between the Schakalsberge and Obib Mountains.

Alien plant species None recorded at present.

Geographic units
Obib dunes,
Oranjemund dunes

Resource use Although the vegetation only provides low coverage, some of the perennial grasses are important food sources for wildlife in this area.

Vegetation sub-units Locally, pockets of Stipagrostis lutescens and Stipagrostis sabulicola are present.

Habitat and environmental parameters Mobile dunes are the landform of this mapping unit. Overall climatic conditions are expected to be similar to those experienced in the Obib area, with a mean annual rainfall of around 50 mm (54 mm has been measured at Rosh Pinah) and occasionally fog, particularly in the southern section of the dunes near the Orange River. The continuous southerly winds are probably transporting sand northwards.

Description Annual and perennial, largely tuft-forming grasses are the main components of the vegetation. Some low stem succulents and deciduous shrubs also occur, while bulbs and herbs emerge after good rains. Perennial plant cover is patchy and very low during the dry season, ranging 1–5%.

Threats None at present

Key species Cladoraphis spinosa is the most abundant plant, but the large tufts of Stipagrostis sabulicola are also characteristic.

Recovery potential High

Management Recommended management zoning: IUCN 1b (wilderness area)

Research needs Bulb species deserve more thorough collecting during a good season.

Other mapping AEZ: NAMS; Giess (1971): desert and succulent steppe; Williamson (1997): coastal zone 0–150 m; Jürgens et al. (1997): temperate zone of Namib plains; Burke et al. (2002): sand plain succulent dwarf shrubland

Extent 780.7 km² (3.61% of the Sperrgebiet)

Plant diversity Plant diversity is very low and not expected to exceed 30 species.
Tsous dune grassland

Scientific name
Cladoraphis spinosa grassland

Locality
These dunes adjoin the eastern section of the Tsous Mountain.

Geographic unit
Tsous dunes

Vegetation sub-units
No further sub-units are present.

Habitat and environmental parameters
Mobile and semi-stabilized sections alternate in these dunes. No long-term weather records are available for this area, but southerly and easterly winds are important environmental factors.

Description
Grasses form the main vegetation; perennial cover is patchy. Overall, approximately 10% perennial grass cover is present, but after rains this can increase to 30%. Mean plant height is approximately 50 cm. Several bulb species emerge during the growing season.

Key species
In addition to Cladoraphis spinosa, most Stipagrostis species in this area occur in these dunes. These include Stipagrostis ciliata, Stipagrostis lutescens and Stipagrostis sabulicola. Although only present for a short duration, bulbs such as Bulbine species and Hexacrytis dickiana, as well as the herb Grielum humifusum, can be abundant after good rains.

Extent
57.4 km² (0.27% of the Sperrgebiet)

Plant diversity
During the dry season plant diversity is low, ranging between 5 and 10 species. However, more species have been recorded after rains and many more are expected during a good season.

Conservation importance:
LOW This conservation rating is based on existing records. Should bulb species restricted to the southern Namib occur here, conservation importance would be rated higher. However, none have been recorded so far.

Alien plant species
None have been recorded to date

Resource use
The grasslands of these dunes are important grazing areas for wildlife.

Threats
None at present

Recovery potential
Medium

Management
Recommended management zoning: IUCN 2 (national park)

Research needs
The collection of bulbs requires attention.

Other mapping
**Salsola hummocks**

**Scientific name** *Salsola nolothensis*

**Locality** This mapping unit fringes Elizabeth Bay and extends south approximately to opposite Possession Island. *Salsola* hummocks extend all along the Sperrgebiet coastline. However, due to their localised extent, other areas have not been mapped and are included in other vegetation types.

**Geographic unit** Elizabeth Bay coastline

**Vegetation sub-units** In addition to *Salsola nolothensis* hummocks, rock outcrops support sparse, dwarf succulent vegetation.

**Habitat and environmental parameters** Framing the sandy beaches, these large hummocks are maintained by regular sand input. Low rainfall, almost constantly windy conditions and the occurrence of fog are the main climatic parameters.

**Description** Growing out of accumulating piles of sand, these hummocks can reach 3 m in height. Plant cover is patchy, as plants only grow in association with the *Salsola* hummocks.

**Overall perennial plant cover is low and ranges between 1% and 5%.

**Key species** Where *Salsola nolothensis* forms large hummocks along the beach, very few other species occur. On rock outcrops, particularly to the south, more species such as *Pelargonium cortusifolium*, *Lycium tetrandrum*, *Zygophyllum clavatum* and other *Salsola* species occur.

**Extent** 28.4 km² (0.13% of the Sperrgebiet)

**Plant diversity** Plant diversity in these hummocks is very low, usually ranging between 1–5 species. The rock outcrops are more diverse.

**Conservation importance:** MEDIUM The rock outcrops harbour plant species of conservation importance. These include *Conophyton*, *Crassula* and *Juttadinteria* species. The *Salsola* hummocks are important dune stabilisers.

**Alien plant species** None recorded

**Resource use** The *Salsola* hummocks provide shelter and a food source for range-restricted small reptiles and amphibians, such as the desert rain-frog (*Brevicopea macrops*) and Namib endemic insects.

**Threats** Mining

**Recovery potential** Low

**Management**
- Recommended management zoning: IUCN 1b (wilderness)
- Avoid rocky outcrops for infrastructure

**Research needs** The restoration of *Salsola* hummocks after mining will need to be investigated as natural recovery appears to be extremely slow.

Hottentot's Bay salt flats

Scientific name  
Hottentots' Bay salt flats

Locality  
These salt flats form the northwestern corner of the Sperrgebiet.

Geographic units  
Coastal outcrops and pans

Vegetation sub-units  
Present on dunes, sand plains and outcrops adjacent to the salt pan are vegetation sub-units dominated by Drosanthemum luederitzii, Limonium dyeri and Salsola nollothensis.

Habitat and environmental parameters  
Coastal fog provides most of the moisture, while rains are expected to provide, on average, less than 20 mm per annum. Constant southerly and southwesterly winds prevail. The salt pan substrate is highly saline and hence free of vegetation. Adjacent areas support salt-tolerant plants.

Description  
Although the majority of this mapping unit is vegetation free, areas adjacent to the salt pan are vegetated. Salsola nollothensis hummocks present an important component of the vegetation in dune areas adjacent to the beach, while a variety of succulents and dwarf shrubs grow on rocky outcrops along the coast. Even in these vegetated areas perennial plant cover is low, hardly reaching 5% in more favourable localities, such as in the lee of outcrops and in depressions. Hummock-forming plants can reach up to 3 m in height, while most other plants are low-growing, and are usually not more than 50 cm high.

Key species  
Salsola nollothensis is the most abundant species in this mapping unit. There are also isolated hummocks of Acanthosicyos horridus (nara), while Othonna furcata and Chrysanthenoides incana are prominent on some outcrops.

Extent  
120.8 km² (0.56% of the Sperrgebiet)

Plant diversity  
Plant diversity is fairly low and not expected to exceed 20 species in this mapping unit.

Conservation importance: MEDIUM  
Although plant diversity is low, the occurrence of Sperrgebiet endemics, such as Eremothammum marlothianus and Mariothelia gymnifera contribute to the conservation importance of this mapping unit.

Alien plant species  
None recorded

Resource use  
Animal activity in this area is relatively high, particularly in areas with some plant cover.

Threats  
Off-road driving

Recovery potential  
Low

Management  
- Recommended management zoning: IUCN 2 (national park)
- Prevent unguided access
- Control vehicle track development

Research needs  
Plant collections after a good rainy season are required to record the ephemeral component of the vegetation.

Other mapping  
Orange River woodland and floodplain

Scientific name  *Rhus pendulina* – *Tamarix usneoides* woodland

Locality  This mapping unit comprises the western-most section of the Orange River Valley, from west of Skilpad to the Orange River mouth.

Geographic unit  Orange River Valley (western section)

Vegetation sub-units  Due to the variety of landforms, many vegetation sub-units are included in this mapping unit. These are riverine woodlands on the bank of the river, adjoining shrublands in drainage areas towards the river, as well as floodplain grasslands with grasses and sedges on islands and on sediment accumulations near the river banks. There are also sections of dune fields, as well as the Swartkop rocky outcrops near Oranjemund.

Habitat and environmental parameters  Many different landforms, such as river banks, drainage areas and floodplains comprise this mapping unit. Hence, microclimatic conditions, substrate and level of inundation vary greatly. The vegetation types directly associated with the flowing river are dynamic and change with the water level. On landforms away from the river, more stable plant communities persist. Mean annual rainfall in Oranjemund is 54 mm and fog occurs regularly. Southerly winds prevail throughout the year.

Description  Plant cover, heights and species compositions are as variable as the landforms inhabited by the vegetation. The riverine woodlands have an overall mean height of approximately 5 m, but trees can reach up to 10 m in places. The riverine vegetation is dense, but patchy, and overall perennial plant cover averages at about 40%. The floodplain grasslands range from 20 cm to 2 m in height and reach up to 100% cover locally. The vegetation away from the river shows much lower plant height and cover with mean heights between 30 and 50 cm, and perennial plant cover 1–10%.

Key species  The trees *Rhus pendulina* and *Tamarix usneoides* are the most prominent components of the vegetation and have thus been selected as the name-giving species of this mapping unit. Many more species occur in these woodlands, such as *Acacia karroo*, *Diospyros lycoides*, *Euclea undulata* and *Salix mucronata*. In dune areas, *Othonna cylindrica*, and where the sands are very mobile, *Stipagrostis sabulicola*, are characteristic species. The rock outcrop at Swartkop is an important haven for range-restricted dwarf succulents. Islands and sand accumulations in the river support dense stands of *Phragmites australis*, sedges and the short grass, *Cynodon dactylon*.

Extent  58.3 km² (0.27% of the Sperrgebiet)

Plant diversity  Overall, plant diversity in this mapping unit is high, totalling well over 200 species in the Oranjemund area alone.

Conservation importance:  VERY HIGH  This mapping unit is of high conservation importance, as vegetation with important ecological functions pertaining to the maintenance of a healthy river ecosystem and vegetation types with many range-restricted species are found. The latter are associated with rocky outcrops along the river and include many species of the genera *Aloe*, *Amphibolia*, *Anacamptseros*, *Aridaria*, *Astridia*, *Cephalophyllum*, *Cheiridopsis*, *Conophytum*, *Crassula*, *Dracophyllum*, *Eberlanzia*, *Euphorbia*, *Fenestraria*, *Othonna*, *Psammophora*, *Stapelia*, *Stoeberia*, *Strumaria*, *Tridentea* and *Tylecodon*.

Alien plant species  A large number of invasive alien plants are associated with the Orange River. These include *Datura innoxia* and *Datura stramonium*, *Ricinus communis*, and the aggressive invader trees, *Prosopis* species. Many additional exotic species are planted in Oranjemund’s gardens. Amongst those, *Acacia*
**cyclops**, *Eucalyptus* species and *Lantana camara* may be of concern and could possibly spread into the riparian woodlands.

**Resource use** The dense vegetation along the river is an important habitat, food source and shelter for many animals.

**Threats**
- Off-road driving
- Recreational activities
- Illegal succulent collecting

**Recovery potential** Low to medium (low for dwarf shrublands and woodlands, medium for grasslands)

**Management**
- Recommended management zoning: IUCN 2 (national park)
- Undertake environmental awareness campaign, particularly targeting Oranjemund residents
- Undertake spot-checks for illegally collected succulents upon exit from the Sperrgebiet (Sendelingsdrif, Oppenheimer Bridge)
- Limit off-road driving to designated areas
- Monitor succulent populations under threat
- Environmental assessments, involving a botanical specialist with appropriate experience, are required for all developments in this area

**Research needs** Red Data assessments of range-restricted plant species are urgently required.

**Other mapping** AEZ: NAM4; Gless (1971); desert and succulent steppe; Williamson (1997); coastal zone 0–150 m; Jürgens et al. (1997); temperate zone of Namib plains; Burke et al. (2002): plain dwarf shrubland
REFERENCES


IUCN (1994) IUCN red list categories. Species Survival Commission, IUCN, Gland, Switzerland.


David Philip Publishers, Cape Town.


**Sperrgebiet Interest Group**

The following people comprised the Sperrgebiet Interest Group (2002):

- Phoebe Barnard (Biologist, National Biodiversity Programme)
- Antje Burke (Plant Ecologist, EnviroScience)
- Trygve Cooper (Chief Warden, MET)
- Patricia Craven (Botanist, NBRI)
- Mike Griffin (Mammal and Reptile Biologist, MET)
- John Irish (Entomologist, NBRI)
- Holger Kolberg (Ornithologist, MET)
- Patrick Lane (Chief Control Warden, MET)
- Gillian Maggs-Kölling (Botanist, NBRI)
- Coleen Mannheimer (Botanist, NBRI)
- Kevin Roberts (Freshwater Biologist, Department of Water Affairs)
- Tony Robertson (Ornithologist, Atlas of Namibia Project)
- Rob Simmons (Ornithologist, MET)

**Other contributing specialists**

Additional biodiversity specialists who provided input included:

- Werner Killian, Wildlife Biologist, Ministry of Environment and Tourism
- Eugene Marais, Entomologist, National Museum of Namibia
- Dieter Noli, Freelance Archaeologist
- Jean-Paul Roux, Mammal Biologist, Ministry of Fisheries and Marine Resources
- Ingrid Wiesel, Wildlife Biologist, Namib Desert Brown Hyena Project
**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>degrees Celsius</td>
</tr>
<tr>
<td>AEZ</td>
<td>Agro-ecological Zoning</td>
</tr>
<tr>
<td>cm</td>
<td>centimetre(s)</td>
</tr>
<tr>
<td>Cites</td>
<td>International Convention on Trade in Endangered Species</td>
</tr>
<tr>
<td>ESC6</td>
<td>AEZ classification: Escarpment, inselbergs and pediment plains with stony/sandy cover</td>
</tr>
<tr>
<td>GCF</td>
<td>Global Conservation Fund</td>
</tr>
<tr>
<td>IUCN</td>
<td>The World Conservation Union</td>
</tr>
<tr>
<td>km/hr</td>
<td>kilometre(s) per hour</td>
</tr>
<tr>
<td>m</td>
<td>metre(s)</td>
</tr>
<tr>
<td>mamsl</td>
<td>metres above mean sea level</td>
</tr>
<tr>
<td>MET</td>
<td>Ministry of Environment and Tourism</td>
</tr>
<tr>
<td>mm</td>
<td>millimetre(s)</td>
</tr>
<tr>
<td>NAM2</td>
<td>AEZ classification: Namib Sand Sea, low transversal dunes</td>
</tr>
<tr>
<td>NAM4</td>
<td>AEZ classification: Namib Desert Plains, sand drift and gravel pavement</td>
</tr>
<tr>
<td>NAM5</td>
<td>AEZ classification: Namib Desert Plains, sand sheets and low dune cover</td>
</tr>
<tr>
<td>NBRI</td>
<td>National Botanical Research Institute of Namibia</td>
</tr>
<tr>
<td>R</td>
<td>AEZ classification: Undifferentiated rocky hills and inselberg mountains</td>
</tr>
<tr>
<td>SKEP</td>
<td>Succulent Karoo Ecosystem Programme</td>
</tr>
<tr>
<td>sp. nov.</td>
<td><em>species novum</em>; new species</td>
</tr>
</tbody>
</table>
INDEX

A
agro-ecological zones........................................8
Agab–Letterkoppe inselberg shrubland..................58
Auras–Heteho grassland...................................30
Auras Mountain succulent-shrubland...................59
Auras sand plain grassland.................................79

B
Baker's Bay coastal dwarf-shrubland.....................30
Baker's Bay corridor dwarf-shrubland...................31
biodiversity hotspot.....................................8, 16, 17, 19, 21, 23, 26
Boegoeberg dwarf-shrubland..............................45
Broad Habitat Units........................................12
Bushman candle plain dwarf-shrubland..................40

C
Central dune stem-succulent shrubland.................71
Chameis drainage dwarf-shrubland.......................32
Chameis dwarf-shrubland................................51
Chamaebedeza succulent dwarf-shrubland..............88
Chamaebedeza shrubland................................60
Cites................................................................12, 14
Coastal dwarf-shrubland..................................30–39
Coastal pelargonium dwarf-shrubland....................33

D
Dune grassland..............................................86–91
Dwarf-succulent shrubland................................56–57

E
Eastern sand plain grassland..............................80
emergency grazing.........................................10
Euphorbia grazing...........................................72

F
fog..................................................................10, 23

G
Grassland.....................................................79–87
Grillental corridor shrubland..............................73

H
Heincab shrubland..........................................61
Hottentots' Bay salt flats................................93
Hummocks...................................................92

I
illegal plant-collecting..................................17, 23
Inland dwarf-shrubland..................................40–44

J
Inselberg dwarf-shrubland...............................45–50
Inselberg shrubland.......................................58–70
invasive alien plants.....................................14, 17, 18, 23, 24

K
Kaula-sim drainage dwarf-shrubland.....................41
Klinghardt succulent-shrubland.........................62
Kweisbode dwarf-shrubland...............................46

L
land classes...................................................8, 12, 14
land use......................................................10, 23, 24
Lüderitz Peninsula dwarf-shrubland......................34
Lüderitz plain dwarf-shrubland.........................35

N
Naminib shrubland..........................................64
National Botanical Research Institute of Namibia.....12
Northern barchan grassland..............................89
Northern gravel and sand plain grassland...............81

O
Oibib Mountain succulent-shrubland....................65
Orange River Valley shrubland..........................74
Orange River woodland and floodplain................94
Oibib drainage dwarf-shrubland.........................37

P
plant endemism............................................17, 18, 19
Pockenkloof shrubland....................................66
prospecting................................................10, 17, 18, 24

R
recovery potential........................................14, 19, 23, 24
red-listed..................................................12, 14, 17
Riekvlakte grassland...................................82
rock types.................................................9, 10
Rocky coast dwarf-shrubland............................38
Rooiberg shrubland.......................................67
Rooipel dwarf-shrubland................................42

S
Salsola dwarf-shrubland................................52
Salsola hummocks.........................................92
Salt flats..................................................93
Schakalsberge dwarf-shrubland.........................47
Schakalsberge plain dwarf-shrubland....................42
Shrubland................................................71–78
Skorpion inselberg shrubland............................68
Skorpion sand plain grassland .......................................................... 83
Southern Boegoeberg plain dwarf-shrubland .................................. 53
Southern dune dwarf-shrubland ...................................................... 54
Southern dune grassland ............................................................... 90
Southern dwarf-succulent shrubland .............................................. 56
Southern euphorbia shrubland ....................................................... 76
Southern *Hofmamia* dwarf-shrubland ......................................... 43
Southern plain dwarf-succulent shrubland ..................................... 57
Sporgebiet Conservation Planning Study ........................................ 12, 14
Succulent grassland .................................................................... 85
Succulent Karoo Bloms ................................................................. 8, 10
Succulent Karoo Ecosystem Plan ................................................... 8
summer rains ................................................................................. 10
Swartkloofberg shrubland ............................................................ 69

T

temperature ..................................................................................... 10
tourism ....................................................................................... 8, 10, 19, 24
Transitional dwarf-shrubland ....................................................... 51–55
Tsauxhale dwarf-shrubland ........................................................... 48

Tsaxus dune grassland ................................................................. 91
Tsaxus dwarf-shrubland ............................................................... 49
Tsaxus pan grassland ................................................................. 86

V

vegetation type ............................................................................. 15, 16, 27–95

W

Western Klinghardt-plain shrubland ............................................ 77
wind ............................................................................................. 9, 10, 21
winter rains .................................................................................. 10
Woodland .................................................................................... 94–95