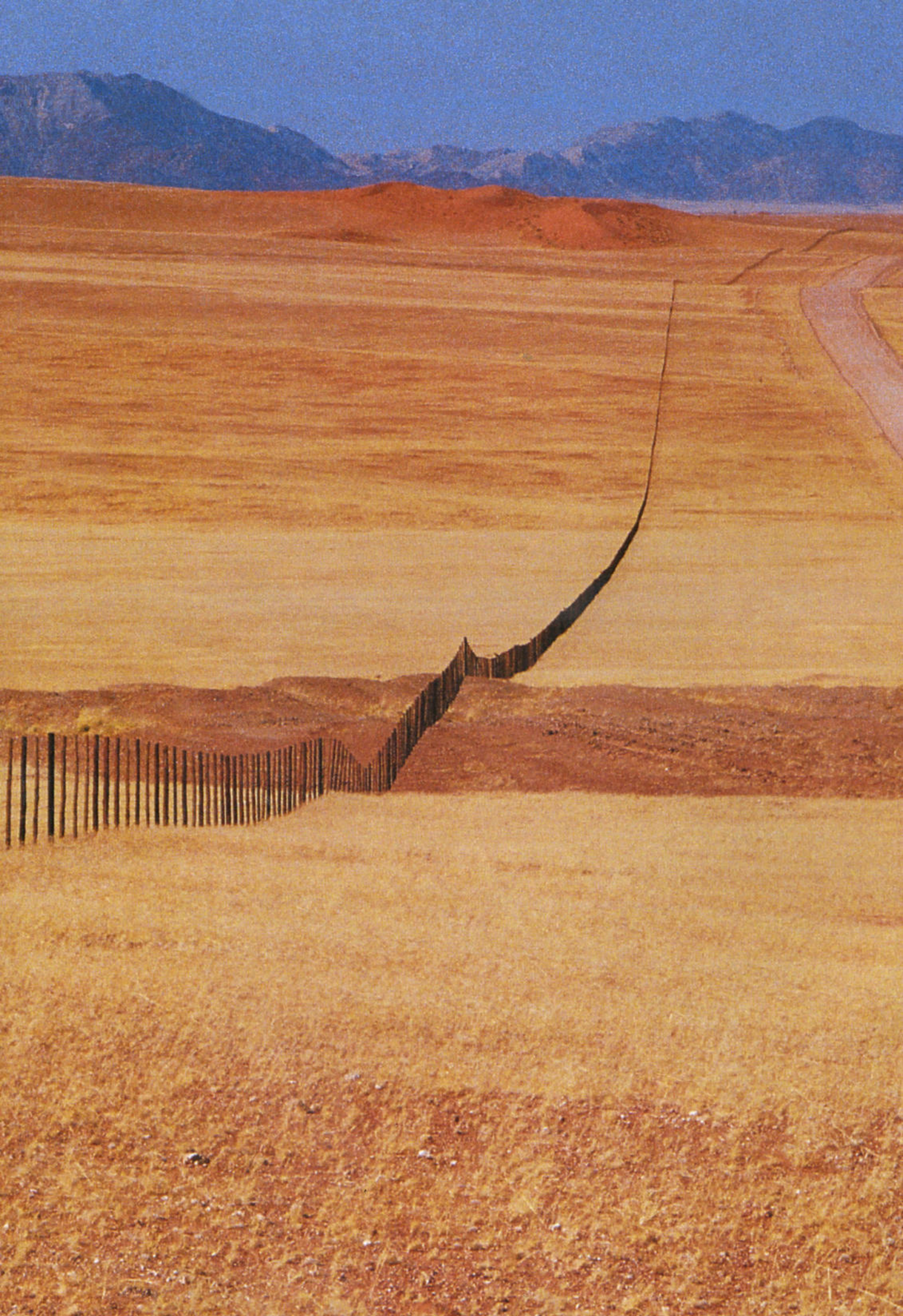
BIOLOGICAL DIVERSITY IN NAMIBIA

- a country study

PHOEBE BARNARD (editor)
and the Namibian National Biodiversity Task Force



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NAMIBIAN NATIONAL BIODIVERSITY TASK FORCE

in cooperation with

- *Ministry of Environment and Tourism, Namibia*
- *United Nations Environment Programme*
- *Global Environment Facility*
- *Namibia Nature Foundation*

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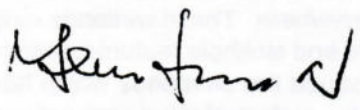
Foreword

The importance of biological diversity, or biodiversity, to Namibians of today and tomorrow cannot be overemphasised. For millennia, people have relied on ecosystems to meet their basic needs for food, water and other natural resources. Preserving these natural systems is thus so vital for our national development, our livelihoods, and indeed our very survival, that severe environmental degradation would be calamitous. So too would it be if we do not strike the right balance between our demands on the natural environment and the productive potential of this environment. Essentially, this means safeguarding our biological diversity, that is, the entire, complex, fascinating variety of the living world and its ecological 'life support systems.'

Namibia has, by ratifying the Convention on Biological Diversity and related environmental treaties such as the Ramsar Convention on Wetlands and the Convention on International Trade in Endangered Species (CITES), joined the international community of nations in acknowledging the need for urgent action to conserve species and ecosystems and prevent, as far as possible, the loss of biodiversity during human development. In Namibia we have a fairly long history of information to support this process. Since the eighteenth century, early explorers and subsequent colonial administrators in Namibia have fostered scientific enquiry, including biological research. The problem lay in that such enquiry was often unfocused, uncoordinated, and lacked clear priorities.

This book — and the publications for lay readers which will follow — represents something of a milestone in Namibia's history of biodiversity knowledge and management. For one, it is an important snapshot of what we know and where we are in terms of biological diversity as we turn the corner of the next millennium. Second, it is a significant achievement in terms of bringing together previously fragmented, uncomputerised, inaccessible and poorly-understood information held by numerous biologists, ecologists, and biosystematists. Thirdly, it sets these data in a socioeconomic perspective by incorporating important analyses of the economic values of biological diversity, biological resources, and ecosystem functions which are so crucial to Namibia, as well as the legal framework under which these values can be protected and realised. And finally, it sets out some important priorities for the next century. With these priorities, we can fill gaps in our knowledge and understanding, synthesise material to support human development and the environmental planning process, and select and train the cream of Namibia's upcoming scientists, economists and development workers to carry this process forward into the foreseeable future.



Philemon Malima
Minister of Environment and Tourism

Namibia is one of the world's driest countries, skirted by the Namib and Kalahari Deserts and desiccated by the interplay of winds off the cold Atlantic and the hot southern African basin. It is therefore a nation with unusual and impressive habitats and species, many of them unique to the country or to the southwestern African arid zone.

This book summarises what is currently known of the country's biological diversity at the habitat, species and genetic levels, and how this diversity can be effectively safe-guarded through economic valuation, legislative protection, and policy reform. It is a national assessment, funded by the United Nations Environment Programme and Global Environmental Facility in order to aid Namibia's process of implementing the Convention on Biological Diversity (CBD). Namibia signed the CBD at the U.N. Conference on Environment and Development in 1992, and ratified it in March 1997. By this latter date, progress towards a National Biodiversity Programme and a national strategy and action plan was already well advanced. Below are some of the key points made in the book.

The country's context and constraints

As one of the world's driest countries, Namibia faces significant fundamental environmental constraints which it cannot ignore. Its annual rainfall is modest and highly variable, the more so the further west one travels. This has not only shaped a range of extraordinary arid-adapted ecological communities, but has also powerfully shaped the human development options of the modern Namibia. **Chapter 1** is a brief portrayal of the country, its biophysical and socioeconomic environments, and its history of resource conflict and rise to political self-determination. All of these major themes influence in some way the challenges which we in Namibia face today in our efforts to safeguard the nation's biological diversity and environmental health for our children and grandchildren, while using our living resources sensibly to sustain human development.

Modest diversity, impressive endemism on land and in freshwater systems

Chapter 2 follows with a detailed account of the country's terrestrial and freshwater diversity at the habitat, species and genetic levels. While the country and its habitats are diverse, the species richness of many groups in these habitats is only modest compared to other countries. What is most distinctive about Namibian biodiversity is its high degree of *endemism*, or the extent to which its organisms are found here and only here. As a dry country, Namibia depends heavily on its few wetlands, and these — and the species which depend on them — are under threat virtually everywhere. These wetlands range from subtropical floodplains to saline desert springs and limestone cave and sinkhole features, many of which support their own unique fauna. Other habitats under threat include the savannas which have been heavily appropriated for agriculture, most of which remain outside the state protected area network. Poor land management on farmlands is almost certainly one of Namibia's greatest threats to its biodiversity.

Low diversity, abundant productivity in the marine environment

Namibia's ocean and coastal environments and their extraordinary productivity are legendary, and compare favourably to the most productive marine upwelling systems in the world. Like these other systems, Namibia's Benguela Current system is a highly dynamic, complex and powerful upwelling which supports lucrative fisheries. Again like these other systems, the productivity of the Benguela has been badly abused in the past and has in many ways not yet recovered. Circumspection and wisdom in fisheries management are essential to Namibia's future economic development, and this means significant

investment in understanding the natural complexity and dynamism of the ecosystem, in order to predict natural perturbations which reduce the available resource stocks. **Chapter 3** shows that this marine system features low species richness, but high abundance, in many taxa. It is still in a relatively pristine state, but faces potential and current threats through mining and fossil fuel exploration and development activities, as well as harvesting strategies which are mismatched to its natural variability.

Appropriate development strategies are illuminated by economic analysis

Working with, rather than against Namibia's fundamental environmental constraints is the only way to achieve sustained human development and economic growth. **Chapter 3** outlines imaginative strategies which can turn these constraints into significant assets for the country, particularly in the spheres of ecotourism and other forms of wildlife use. The vast majority of people in Namibia remain rural dwellers who depend directly on biological resources and a healthy environment for their survival. Enhancing opportunities for people to benefit from these resources in rural areas maximises their quality of life and minimises the risks of suffering from drought. It also keeps people productive and self-reliant on the land, rather than dependent and poverty-stricken in the demoralising and unhealthy urban squalour they may encounter as migrants to Namibia's rapidly growing towns. Policy and market failures which influence decisions about natural resource use, and the resulting success of biodiversity conservation, include excessive subsidies to the agricultural sector and overcentralised management structures.

Effective biodiversity conservation requires a progressive legal framework

Legal measures to protect biodiversity in Namibia are outdated, fragmented under the auspices of numerous controlling agencies, and often discriminatory to the majority of Namibians. **Chapter 5** outlines the development of a revised legislative framework to safeguard Namibia's environment, including its biological diversity. Aside from measures to secure the protection of species and habitats, which was the traditional core of nature conservation legislation, Namibia urgently needs mechanisms to realise profits from its genetic resources, traditional knowledge systems and biotechnologies. The rationalisation of Roman Dutch law, inherited from South Africa, and traditional common laws is also a priority for Namibia.

The way forward

Namibia's central gaps and priorities relating to biodiversity conservation have become clear in the preparation of this book. As **Chapter 6** concludes, these include the need for better (and more accessible) basic information on biological diversity; more focused analysis and prioritisation of conservation needs; more explicit data relating to the current harvesting levels of biological resources, and measures to put this harvesting on a sustainable footing; monitoring and evaluation of the biodiversity conservation implications of land use systems in Namibia, including those intended to further conservation aims; and focused research on key issues of conservation concern in terrestrial, freshwater and marine environments, such as the population fragmentation and viability of red data, endemic and indicator species and the safeguarding of genetic resources important in agriculture and other fields. To do all of these things, one of Namibia's overriding concerns is the development of a contingent of technically competent, dedicated and passionate young Namibian biodiversity specialists who will meet or exceed the standards of those active today.

Editor's preface

This book is the culmination of a two-year study of the biological diversity of Namibia, for Namibia, by Namibians. It was initiated after our President, Dr Sam Nujoma, signed the Convention on Biological Diversity (CBD) at Rio de Janeiro in 1992. With his signature, he led the way for our country to enter a new, more modern, and more comprehensive approach to the protection of its biodiversity, and the circumspect, sustainable use of its biological resources.

This is a 'semi-technical' study, something of a bet-hedging approach which we hope proves successful. On the one hand, it combines the analyses of professional ecologists, taxonomists, marine biologists, economists and lawyers to survey what we know of our biodiversity and the threats which it faces. We cast it as 'semi-technical' rather than 'semi-popular' to present much of the raw material from which upcoming summaries for decisionmakers, teachers and learners will be distilled. On the other hand, we have tried to make it a book to which the interested lay reader will refer and return. We have attempted to weed out as much of the irritating technical jargon as possible to make the book an absorbing, if perhaps not a lightweight, read. It may be unrealistic to process the work of 46 technical contributors — many of them iconoclastic, and some cranky — into a stylistically smooth and uniformly exciting book, but while attempting to cajole their submissions into a mutually compatible format, I trust they will ultimately forgive me for what they might currently see as ruthless homogenisation.

The structure and process underlying the book are relatively simple, and have so far served their purpose reasonably well. The Namibian National Biodiversity Programme (NNBP) was launched in 1994 and forms the overall structure under which several working groups, some of them relatively autonomous, operate. Through its National Biodiversity Task Force, the NNBP's central functions are to plan, coordinate, guide, and support research, management and policy actions related to biological diversity conservation in Namibia. It is housed in the Directorate of Environmental Affairs (DEA) of the Ministry of Environment and Tourism, with a base of expertise spread much more broadly through numerous ministries, institutes, non-government organisations and university departments. The Task Force and its associates (Appendix 1), who produced this book, reflect the range of this expertise. However, there are a few gaps in its composition which must be filled in the near future and are explored in Chapter 6.

Phase I 1994-1998	***Phase II*** 1995-1999	***Phase III*** 1999-2002
Secure funds and establish programme	Increase information accessibility and analysis	Evaluate and monitor key issues and programme activities
Establish multisectoral steering body (National Biodiversity Task Force)	Establish key working groups	Implement National Strategy/Action Plan
	Popularise Country Study	Adapt planning and implementation to lessons learned
Prepare and publish Country Study	Initiate targeted research to fill obvious gaps	
	Prepare National Strategy & Action Plan	

Many countries commit themselves to international conventions such as the CBD without being well prepared to tackle the commitments therein. Developing countries, for example, have often brought in foreign professional consultants to prepare biodiversity country studies. Our approach has been to make almost exclusive use of Namibian expertise in the preparation of this book: of the 46 text contributors, 44 are (or were until recently) Namibian citizens / residents working for Namibian institutions. We are pleased that a small and often overlooked country like Namibia has so much to offer in this respect, and we value highly the work of all our contributors and referees. We are also working to ensure that more young Namibians will enter this field, so that our busy programme ahead can also be handled 'in-house.'

— Phoebe Barnard

Acknowledgements

A multi-authored book such as this is always a complex and exhausting team effort. An editor's role is inevitably a prominent one, but this book represents the collective experience and insight of nearly 50 specialists, 70 reviewers and several dozen photographers, some of whom have been active on the Namibian biodiversity scene for many decades. I thank the members of the Biodiversity Task Force and other contributors for their much-valued input and skills, their patience, their tireless checking and proofreading. While each person's role has been invaluable, the stamina of Shirley Bethune, Barbara Curtis, Herta Kolberg, Carole Roberts, Sem Shikongo and Rob Simmons in the book's late stages deserves special mention. I particularly thank Rob, Catherine and Julia Simmons for immense patience and support during the long weeks of burning too much editorial midnight oil.

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Individual appendices: Shirley Bethune, Charles Breen, Barbara Curtis, Michelle Hamer, Joh Henschel, Eugene Marais, JF Mettler, Nancy Rainer, Kevin Roberts, Mark Robertson, Maitland Seaman

AIDS	Acquired Immune Deficiency Syndrome
c.	circa
CBD	Convention on Biological Diversity
CBPP	Contagious bovine pleuropneumonia (lungsickness)
DEA	Directorate of Environmental Affairs, MET
DERU	Desert Ecological Research Unit of the DRFN
DF	Directorate of Forestry, MET
DRFN	Desert Research Foundation of Namibia
DRM	Directorate of Resource Management, MET
DSSS	Division of Specialist Support Services, MET
DWA	Department of Water Affairs, MAWRD
EA	Environmental assessment
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot-and-mouth disease
GEF	Global Environment Facility
HDS	Half-degree square
IBPGR	International Board for Plant Genetic Resources
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
MAWRD	Ministry of Agriculture, Water & Rural Development
MET	Ministry of Environment & Tourism
MFMR	Ministry of Fisheries & Marine Resources
MLRR	Ministry of Lands, Resettlement & Rehabilitation
NAMDEB	Namibia-De Beers Diamond Corporation Ltd (previously Consolidated Diamond Mines)
NAPCOD	Namibia's Programme to Combat Desertification
NatMIRC	National Marine Information & Research Centre, MFMR
NBDTF	National Biodiversity Task Force
NNBP	Namibian National Biodiversity Programme
NBRI	National Botanical Research Institute, MAWRD
NDTC	Namibian Drought Tolerant Composite
NGO	Non-government organisation
nm	nautical mile
NOLIDEP	Northern Livestock Development Programme, MAWRD
NORAD	Norwegian Agency for International Development
PTS	Performance Testing Scheme (livestock)
PPRI	Plant Protection Research Institute, Agricultural Research Council, South Africa
QDS	Quarter-degree square
SADC	Southern African Development Community
SARDEP	Sustainable Animal and Range Development Programme, MAWRD
sp.	species (singular)
SPGRC	SADC Plant Genetic Resources Centre
spp.	species (plural)
TACs	total allowable catches
TASA	Tourism and Safari Association of Namibia
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

Tables, graphs, maps and appendices

Tables

Tables

Graphs

Maps

Text boxes

Appendices

1 Overview of Namibia and its biological diversity

Phoebe Barnard with contributors

Courtesy LC Weaver

1.1 Geographical features

Namibia's landscape is a stark, vividly coloured and remarkably varied one. It stretches from cold and desolate coasts through gravel plains, "dune seas" and rugged inselbergs to the scrublands, thorn savannas, ephemeral pans and rocky hills of the interior. Contrasting softly with these forbidding lands, the moist woodlands and tropical floodplains of the northeast help make Namibia one of the most fascinatingly varied countries of its size on earth. Its rapidly expanding tourism industry attests to the geographic variety of the country, with its unusual habitats and invigorating wilderness that people pay considerable money to experience.

Namibia is undoubtedly scenically diverse. But to what extent does this geographic diversity contribute to biological diversity? Because the country is so arid overall, one would think perhaps rather little. Compared to South America's or Australasia's tropical moist forests, or South Africa's Cape floral kingdom, Namibia does not have huge numbers of species. This reflects not only its aridity, but also its past ecological and climatic history. However, we have a high proportion of biota which are unique to the Southwestern Arid Zone, with many unusual restricted-range species. This first chapter sets the scene for a portrayal of this unusual and impressive biodiversity.

Box 1.1 Namibia at a glance

Land area	*823,988 km^2*
Population	*1.61 million (1995 estimate)*
Population growth	*3.1% per year*
Population density	*1.7 persons / km^2*
Mean fertility	*6.1 children / woman*
Urban population	*28% of total*
Life expectancy	*Men 59.1 years Women 62.8 years*
Per capita income	*US$1610 / year*
Economic growth	*Real GDP growth: 2.9% (see Box 1.2)*
Climate	*Hyper-arid (west) to dry subhumid (east)*
Rainfall	*Mostly summer rain, increasingly variable towards west coast*
Biomes	*Desert, savanna, broadleaf woodland*
Main languages	*English (official), Oshiwambo, Otjiherero, Nama-Damara, Afrikaans, Rukavango*

Updated from: NPC;[1] EIU[2]

Climate and palaeoclimate

The overwhelming two features of Namibia's climate are the scarcity and unpredictability of rainfall. Within Africa, our climate is second in aridity only to the Sahara. Rainfall everywhere in the country is lower and more variable than in the eastern subcontinent, and lower and more variable the further west one travels. Steep gradients thus characterise the country's rainfall (map 1.1), from tropical semi-humid in the northeast (3% of land area) to hyper-arid in the west (12%). The country-wide average rainfall of under 250 mm per year is coupled with annual mean evaporation of up to 3700 mm (map 1.2).[3] Overall, 69% of the country is regarded as semi-arid, with the remaining 16% as arid.[4] What little rain reaches the hard-baked soil is mostly lost again to the clouds. It is estimated that about 83% of rainfall evaporates, and a further 14% is transpired by plants. This leaves 2% to enter drainage systems, where some is retained in dams, and only 1% to recharge the land's severely stressed groundwater tables.[5]

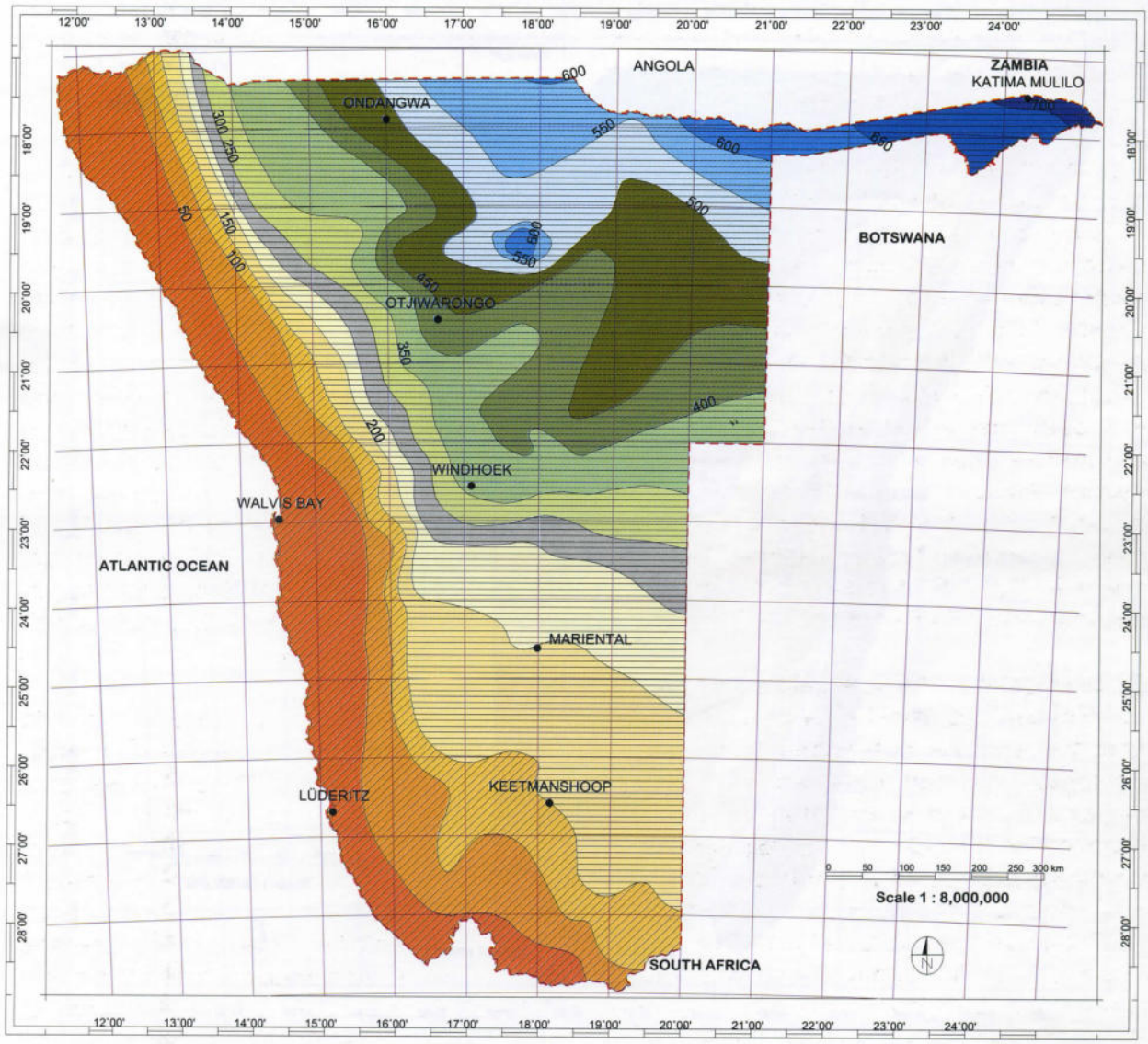
By themselves, the low rainfall and high evaporation over most of Namibia strongly limit the species composition of natural ecological communities, as well as the options for human development. The combination of a cold, subantarctic upwelling on the Atlantic coast and a hot subtropical interior have led to hyper-arid, bleak coastal conditions in the Namib Desert, similar to those of Chile's Atacama Desert and of Baja California, México. The effect of the Benguela Current on climate of the Namib is pervasive. Not only has the cold, nutrient-rich, north-flowing upwelling fostered one of the most productive marine ecosystems in the world, but it has also created a dramatic clash of sea and land, fog and dust, with implications for the southern African region as a whole. However, the obvious zone of transition between cold sea and hot desert is narrow. A thin strip of coastal fog, seldom reaching more than 30 km inland, frequently blows over the hyper-arid coast and sustains life there in the absence of rainfall[6] (map 1.2).

Most of Namibia's rain falls in summer, from November to April. There is extraordinary variation between years, with the driest areas having the least predictable rainfall. However, southwestern Namibia lies in the winter rainfall zone, which characterises Africa's entire southwest corner. In this zone, a diverse succulent flora has proliferated.

Temperatures in Namibia can also be extremely variable and challenging to plant and animal life, with temperatures well over 50°C and under 0°C recorded in the same parts of the country. Daily fluctuations are greatest in the hyper-arid zones, where there is little vegetation cover to moderate the temperature. In the tropical northeast and along the coast, by contrast, daily highs and lows can differ by as little as 2-5°C. Large diurnal temperature changes may act as a strong selective pressure on many plants and poikolothermic ('cold blooded') animals. Along with sporadic rainfall, high temperatures in the arid interior help create a high water deficit (map 1.2).

In geological time, the Namib Desert and its adjacent plateaus have been arid or semi-arid for many milennia. The convergence of the Benguela upwelling and the hot interior has certainly maintained, and perhaps increased, the aridity of the region in recent times.[7] Yet this convergence did not by itself generate the aridity. There is ample evidence that the Namib has been semi-arid to arid for at least 55 and possibly up to 80 million years, despite significant climate fluctuations, while the Benguela Current was forced northward along the southwest African coast only about 5-10 million years ago.[6,8,9] The slow continental breakup of west Gondwana, 130-145 million years ago,[9] set overlying conditions for the region's aridity, by shifting southern Africa to its present position astride the Tropic of Capricorn, and slowly readjusting adjacent marine currents and prevailing winds. In effect, the region has been an island of aridity in a 'sea' of more changeable climes.[10]

Map 1.1 Mean annual rainfall in Namibia



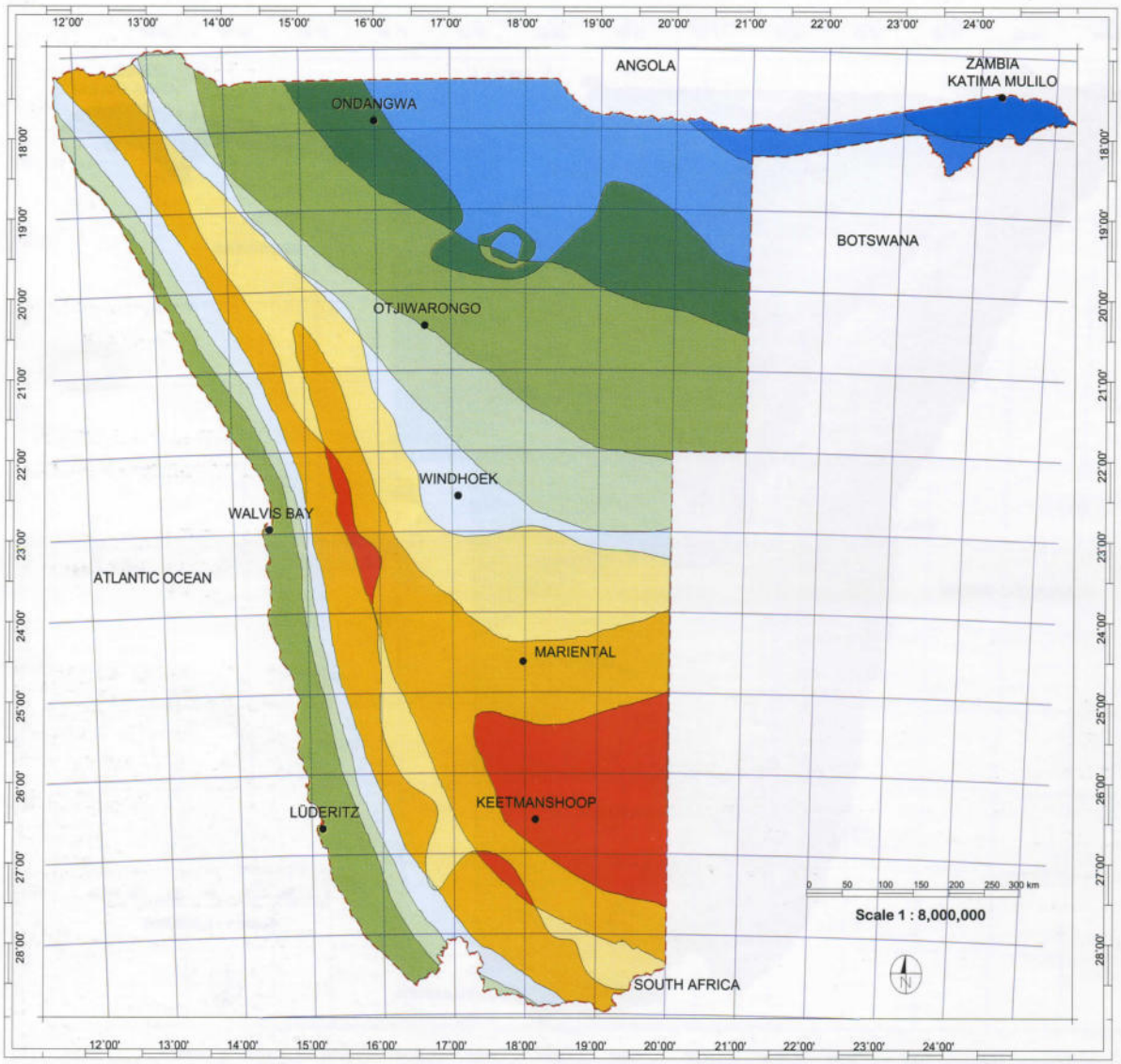
Mean Annual Rainfall

0-50 mm/yr	300-350 mm/yr	600-650 mm/yr
50-100 mm/yr	350-400 mm/yr	650-700 mm/yr
100-150 mm/yr	400-450 mm/yr	700-750 mm/yr
150-200 mm/yr	450-500 mm/yr	
200-250 mm/yr	500-550 mm/yr	Arid
250-300 mm/yr	550-600 mm/yr	Semi-Arid

Source:

**Ministry of Agriculture,
Water and Rural Development
Department of Water Affairs**

Map 1.2 ***Mean water deficit in Namibia (mean annual rainfall minus mean annual evaporation, in mm)***



Water Deficit

(Mean annual rainfall - mean annual evaporation in mm)

- -3800 to -3400
- -3400 to -3200
- -3200 to -3000
- -3000 to -2800
- -2800 to -2600
- -2600 to -2400
- -2400 to -2200
- -2200 to -2000
- -2000 to -1800
- -1800 to -1700

--- Border

• Major Towns

Source:

Ministry of Agriculture, Water and Rural Development Department of Water Affairs

This very long, very dry period has had a profound influence on the region's biodiversity. The Namib is widely called the world's oldest desert, a description which reflects not only the age of its rocks and sands, but also, indirectly, its unique species and biological communities. Today, we find our major *centres of endemism* (areas rich in species unique to Namibia or the region) not in the tropical northeast, but in the arid northwestern escarpment and southern winter-rainfall zone[10] (Chapter 2). While most of Africa has undergone ceaseless climate fluctuations, generating the expansion and contraction of savannas and forests over milennia, the continent's arid coasts have remained relatively stable centres for the evolution of desert and dry-savanna species.[7,8] Dramatic bouts of volcanism have taken place in parts of Namibia over the past 40 million years,[9] but these have had only sporadic local effects within an overall context of stability. Namibia's centres of endemism are taken up further in Chapter 2.

Geology, soil and landforms

Namibia is a geologist's paradise. With so little 'annoying vegetation' to get in the way, so to speak, and with rich ore deposits over much of the country, it is hardly suprising that Namibia is very well known geologically and geographically. Even in the 1960s, a rather broadly defined bibliography of geography and related fields in the then South West Africa contained over 2000 titles.[11]

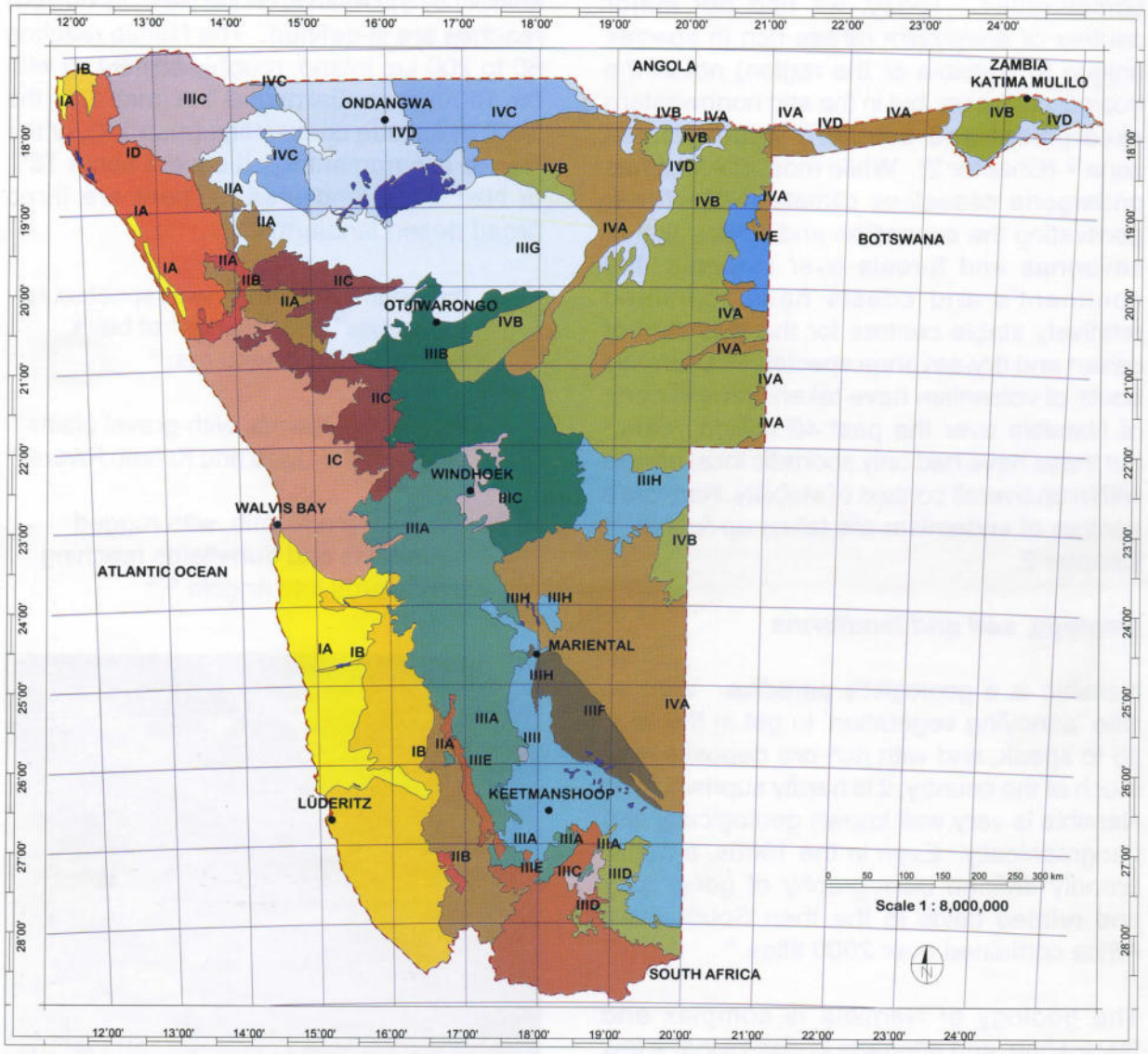
The geology of Namibia is complex and fascinating, and attempts to distill it into a few landform categories will always seem simplistic. However, although the country is divided into numerous minor landforms or geophysical zones (map 1.3), four major categories can be distinguished: **coastal plain and Namib Desert**; the broken and rugged **Namib escarpment**; the rocky **central plateau**; and the **Kalahari sandveld.**[12,13] Only the sandveld is fairly simple geologically; the other zones conceal a hodgepodge of intrusions, ridges, dykes, sills and outcrops.[14]

The Namib Desert and coastal plain give the country its name, as well as its most forbidding and distinctive scenery. Yet the Namib as a geo-ecological zone extends about 2000 km from the Carunjamba River in Angola to the Olifants River in South Africa.[6,8] Bounded sharply by the Atlantic on the west, its eastern reaches are ill-defined. The Namib reaches 80 to 200 km inland, roughly coinciding with the 100-mm annual rainfall line (map 1.1), the 1000 m altitude contour line (map 1.4), or the Namib escarpment.[6,15] It covers about 15% of Namibia's land area.[13] There are three broad desert landforms:

- the southern Namib, with spectacular "dune sea" and "islands" of black outcrops and inselbergs;[16]
- the central Namib, with gravel plains between the Ugab and Kuiseb Rivers;[15]
- the northern Namib, with rugged mountains and dunefields reaching northwards into Angola.[6,15]

Fig. 1.1 The Kuiseb River slices through the central Namib, cutting off the northward movement of dunes. Courtesy NASA.

Map 1.3 Landforms of Namibia

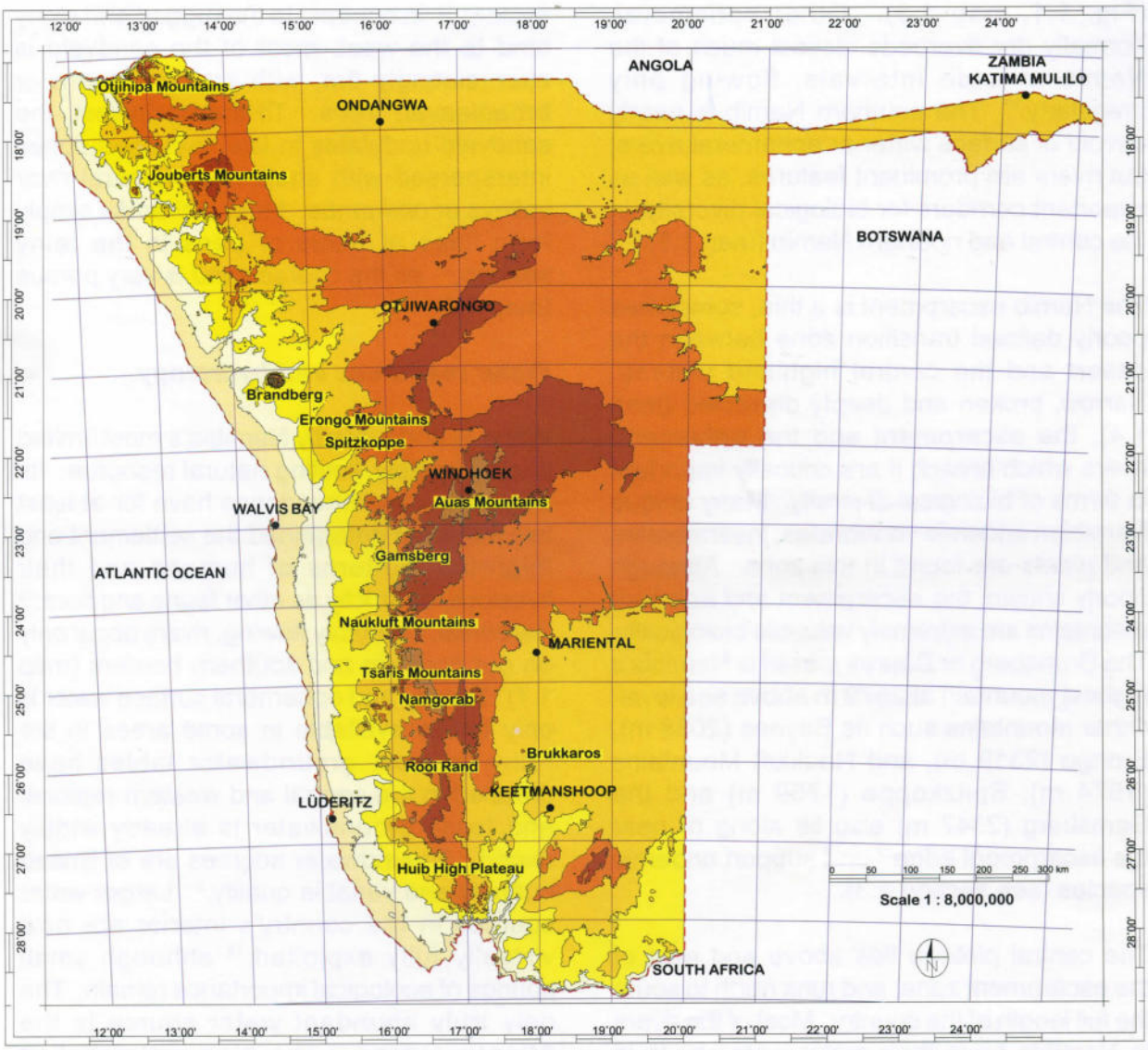


Landforms

- IA Namib sand dunes
- IB Complex of Namib sand drift and association of hills and valleys
- IC Namib desert pavement
- ID Namib hills and valleys
- IIA High mountains of the escarpment
- IIB Plateau remnants of the escarpment
- IIC Erosion surface of the degraded escarpment
- IIIA Plateaus proper of the plateau
- IIIB Plateau with ridges in the plateau
- IIIC Highlands of the plateau country
- IIID Dissected plateau fringes of the plateau country
- IIIE Foothills and slopes in the plateau country
- IIIF Plateau of soft porous Kalahari limestone in the plateau country
- IIIG Karst and hard Damara limestones in the plateau country
- IIIH Erosion forms (hills and slopes) on Karoo rocks in the plateau country
- IIII Structural hills in the plateau
- IVA Fossil sand dunes of the Kalahari
- IVB Loose sand drift of the Kalahari
- IVC Compact sandy deposits of the Kalahari Region
- IVD Flooded and overflowing areas in the Kalahari Region
- IVE Hills in the Kalahari basin
- Pan
- Border
- Major Towns

Source:
FAO 1983
AG: DP/NAM/78/004

Map 1.4 Elevation contours of Namibia (300 m intervals)



Contours

Measured in meters

0-300	1500-1800
300-600	1800-2100
600-900	2100-2400
900-1200	> 2400
1200-1500	

Border

Major Towns

Source:

Ministry of Lands, Resettlement and Rehabilitation
Division of Survey and Mapping

In reality, the Namib Desert has few sharp transitions. A dramatic exception is the Kuiseb River, which cuts off the northerly march of the southern Namib's dune sea[6] in a dividing line as sharp as a knife edge and spectacularly apparent from satellite images (Fig. 1.1, map 1.3). Other ephemeral, normally dry riverbeds dissect much of the Namib at wide intervals, flowing only irregularly.[17] The southern Namib is nearly devoid of surface water or ephemeral rivers, but rivers are prominent features, as well as important corridors for biological diversity, in the central and northern Namib (map 1.5).[6,17]

The Namib escarpment is a thin, sometimes poorly defined transition zone between the desert and the central highland plateau. Narrow, broken and deeply dissected (map 1.4), the escarpment and the ephemeral rivers which breach it are critically important in terms of biological diversity. Many unique Namibian endemic vertebrates, invertebrates and plants are found in this zone. Although poorly known, the escarpment and adjacent mountains are extremely valuable biologically. The Brandberg or Dâures massif is Namibia's highest mountain at 2579 m above sea level. Other mountains such as Baynes (2038 m), Erongo (2319 m), and Naukluft Mountains (1974 m), Spitzkoppe (1759 m) and the Gamsberg (2347 m) also lie along or near the escarpment edge[12] and support endemic species (see section 2.3).

The central plateau lies above and east of the escarpment zone, and runs north to south the full length of the country. Most of the rivers in Namibia have their major watersheds in this highland (map 1.4). It is stony and flat in places, and dramatically mountainous in others, at altitudes between about 1000 and 2000 m.[13] The capital city, Windhoek, lies between two mountain ranges running along the south and east, with the Khomas Hochland plateau undulating west to the Namib escarpment. The northwestern highlands are rugged, with broad valleys and inselbergs, while the south is a flat stony plateau dissected by deep valleys.[12] Mountains in both regions are ecologically valuable and interesting.

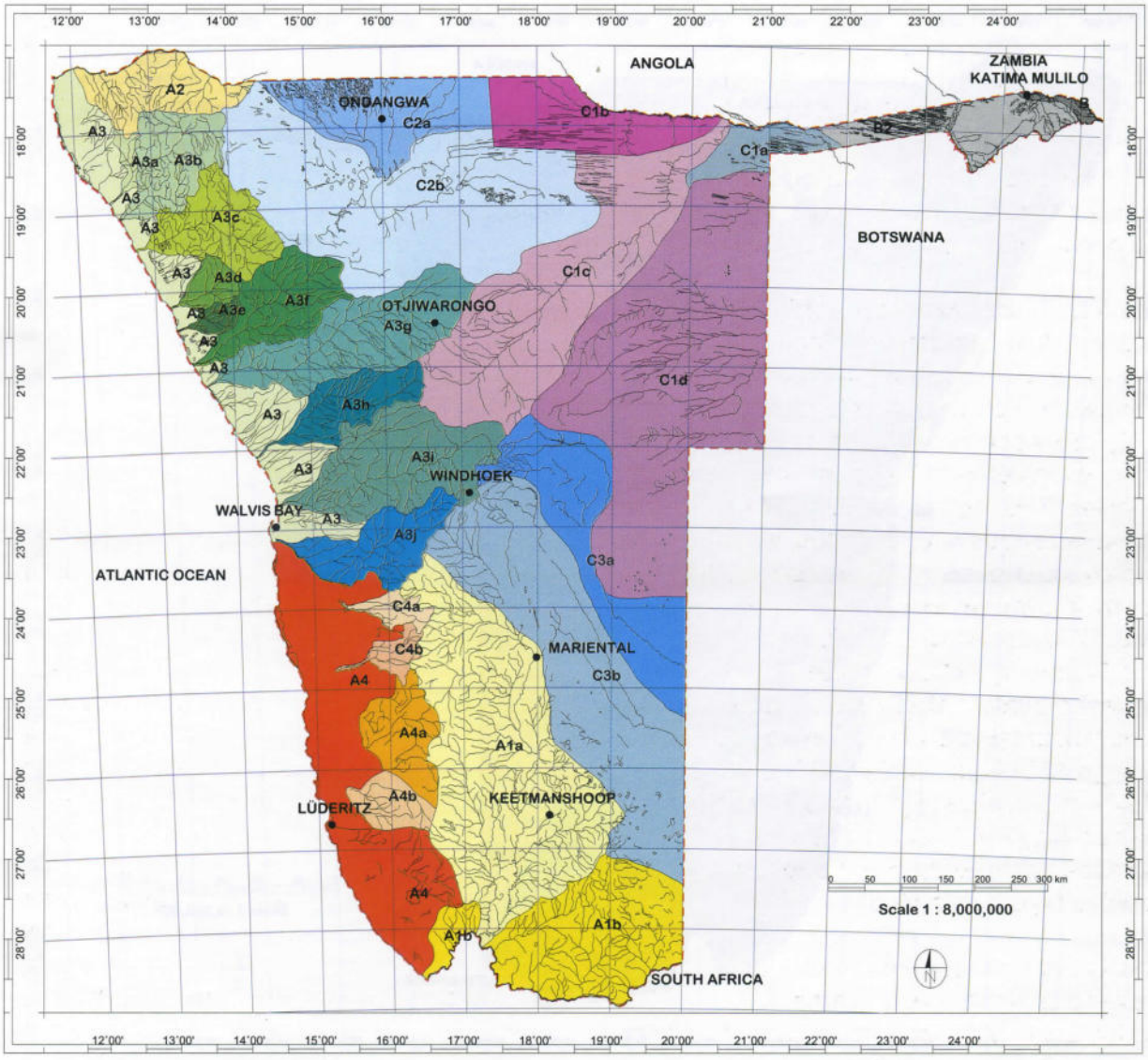
Finally, the Kalahari sandveld stretches east from the central plateau, with deep sands overlaying bedrock. A thick layer of red or pale sand is characteristic of the Kalahari, but the brittle alkaline soils of the north, including the Etosha Pan region, are also part of this system.[12] In contrast to the rugged and stony land to the west, most of the sandveld is excruciatingly flat, with sporadic thorn or broadleaved trees. To the northwest, the sandveld undulates in low, fossilised dunes interspersed with shallow ephemeral river valleys or *omiramba*. Most *omiramba* simply form lines of pools or pans in the rainy season,[12] as the coarse sand is very porous (map 1.6).

Water resources and hydrology

Water is undoubtedly Namibia's most limited and, ultimately, limiting natural resource. Its distribution and abundance have for at least two millennia determined the settlement and migration patterns of humans and their livestock, as strictly as other fauna and flora.[15] Perennial, if variably flowing, rivers occur only on our northern and southern borders (map 1.7). Patchy and ephemeral surface water is only briefly available in some areas in the rainy season, groundwater tables have dropped in the central and western regions, and fossil groundwater is already widely mined. Groundwater sources are of limited quantity and variable quality.[5] Larger water sources in the country's interior are now virtually fully exploited,[18] although small springs of ecological importance remain. The only truly abundant water source is the Atlantic Ocean. The high water deficit throughout the country (map 1.2) makes water management and storage difficult.

Such data make one wonder how economic or population growth can continue in Namibia, given the human and livestock pressure that already exists. Water management strategies to sustain economic growth are neither easy nor palatable, and include conservation, demand management, prioritisation of uses, and development of alternative sources.[18]

Map 1.5 Drainage basins or catchments of Namibia



Drainage Systems

A1a	Fish River	A3f	Huab	B2	Zambezi via Kwando	C4a	Tsondab
A1b	Orange River	A3g	Ugab	C1a	Okavango Delta	C4b	Tsauchab
A2	Kunene River	A3h	Omaruru	C1b	Okavango		
A3	North Coast	A3i	Swakop	C1c	Omatako		
A3a	Khumib	A3j	Kuiseb	C1d	Omurambas		
A3b	Hoarusib	A4	Namib	C2a	Cuvelai		
A3c	Hoanib	A4a	Tsaris	C2b	Etosha		
A3d	Uniab	A4b	Koichab	C3a	Nossob		
A3e	Koigab	B1	Zambezi, direct	C3b	Auob		

A: To Atlantic Ocean
B: To Indian Ocean
C: Endoreic Drainage

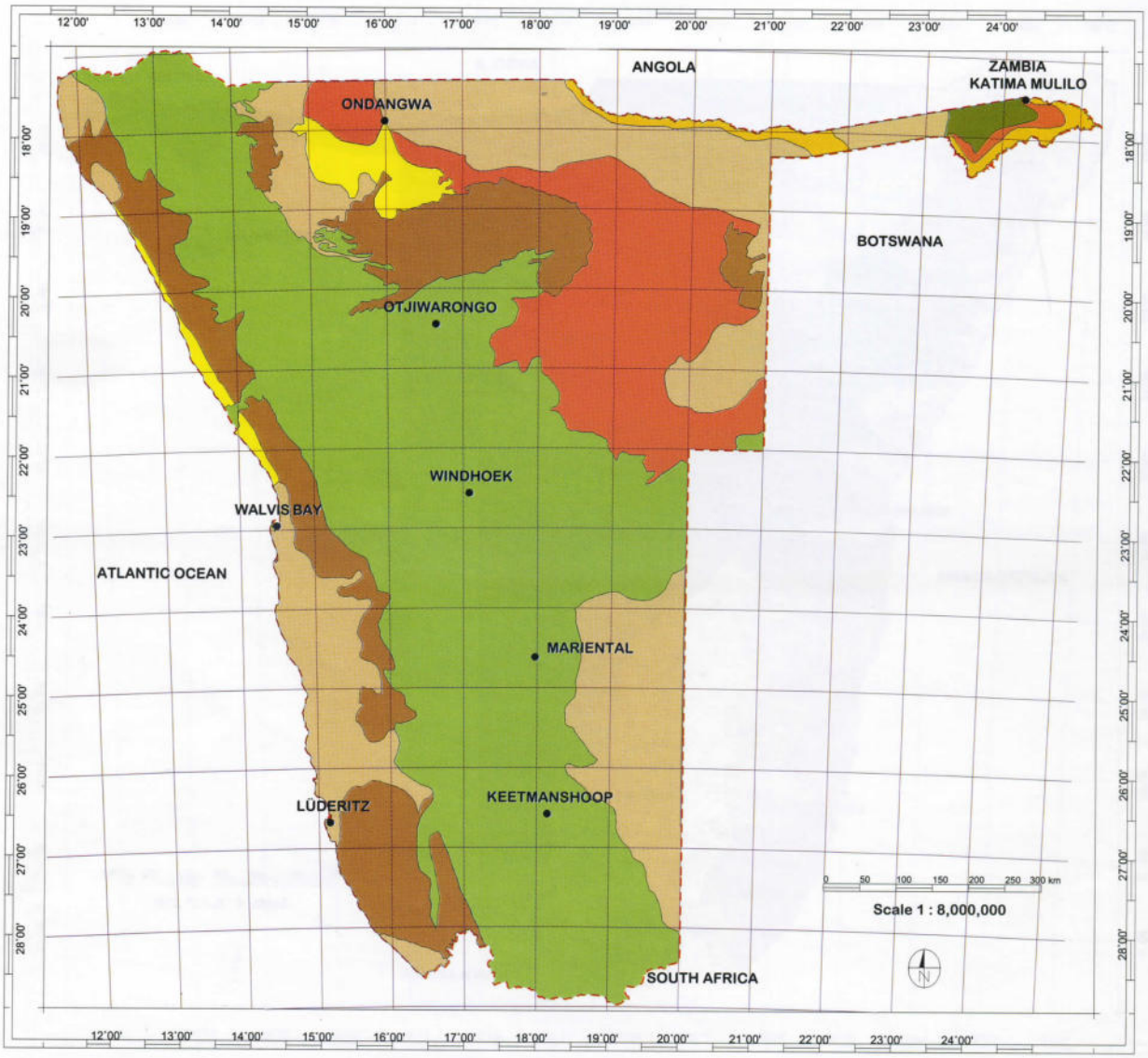
Border
Drainage Line
Major Towns

Source:

United Nations, Cartographic Unit
Department of Conference Services
New York

Jacobson et al. 1995
Ephemeral Rivers and their
Catchments. DRFN, Windhoek

Map 1.6 Simplified soil map of Namibia



Soils

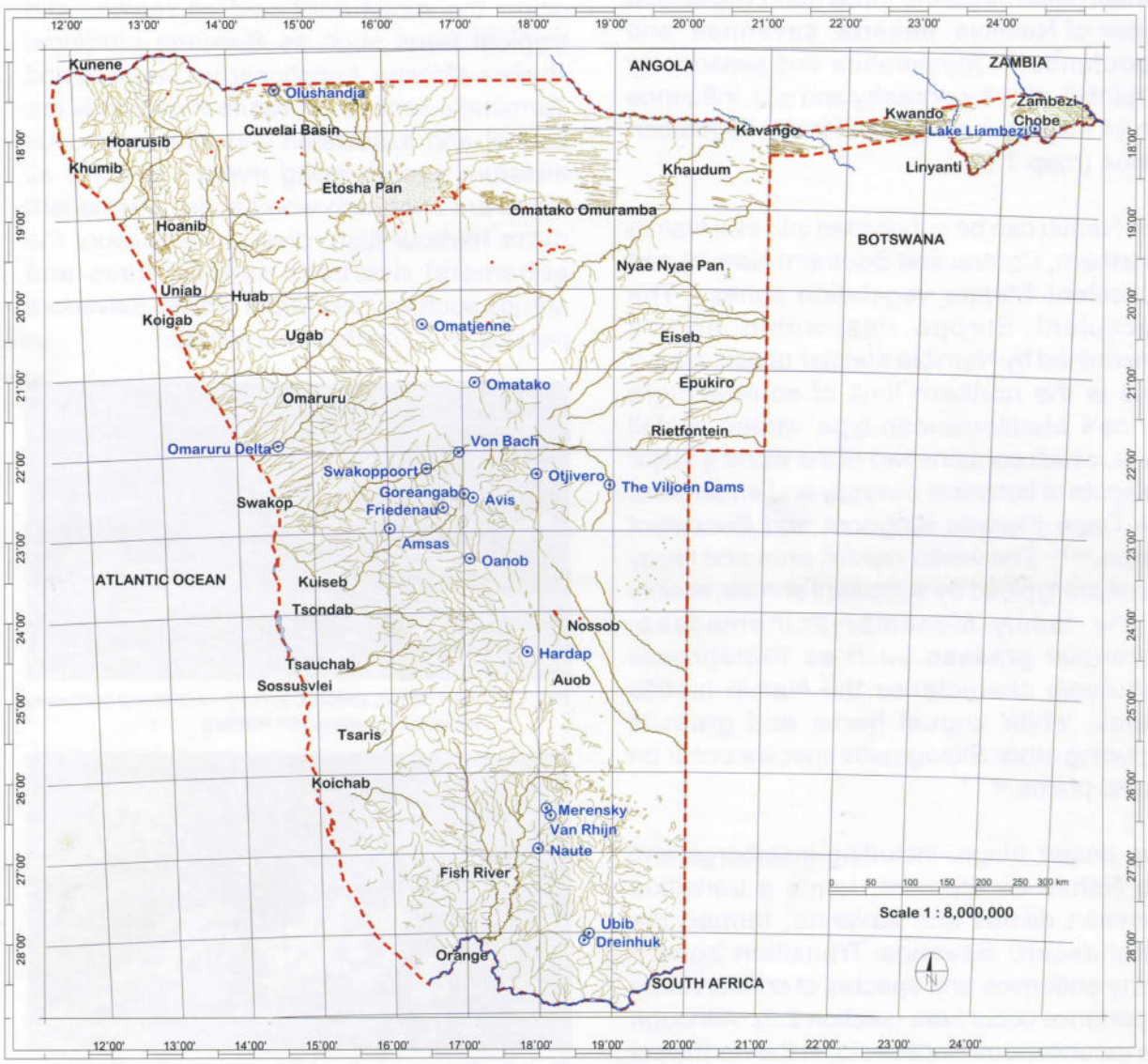
- Lithosols
- Fersiallitic soils
- Solonetzic and planosolic soils
- Halomorphic soils
- Arenosols
- Alluvial and other soils of low-lying areas
- Weakly developed shallow soils of arid regions

- Border
- Major Towns

Source:

Simplified from:
Engineering Geology of Southern Africa, Vol 4; 1985.
Map Compiled by Soil Survey Staff, Institute for Pedological Research Potchefstroom University.

Map 1.7 Wetlands and ephemeral rivercourses of Namibia



Wetlands

- Border
- Perennial river
- Non-perennial drainage line
- Ephemeral river or main drainage line

Black text indicates the names of drainage systems and pans

Blue text indicates the names of dams

- Pans
- Marshes
- Salt marshes
- Springs according to MAWR database
- Dams according to MAWR database

Source:
United Nations, Cartographic Unit
Department of Conference Services
New York

Ministry of Agriculture, Water and Rural Development
Department of Water Affairs

Vegetation zones

Namibia's steep northeast-to-west climatic gradient, plus its varied soil types and landforms, largely determine the distribution of its characteristic vegetation zones. Annual rainfall determines the three main vegetation zones of Namibia: **deserts**, **savannas**, and **woodlands**.[19] Temperature and seasonality of rainfall, plus topography and soil, influence the 14 major subdivisions of these vegetation zones (map 1.8).

The Namib can be subdivided into true Namib (Northern, Central and Southern Namib) and Succulent Steppe vegetation zones. The Succulent Steppe lies within and is determined by Namibia's winter rainfall area.[19] This is the northern limit of southwestern Africa's Mediterranean-type winter rainfall zone, which contains two of the world's major hotspots of botanical diversity and endemism, the Cape Floristic Kingdom and Succulent Karoo.[20,21] The winter rainfall area and foggy coast are typified by succulent shrubs, mainly in the family Mesembryanthemaceae. Perennial grasses such as *Stipagrostis sabulicola* characterise the Namib mobile dunes, while annual herbs and grasses including other *Stipagrostis* species occur on gravel plains.[22]

The desert fringe, including inselbergs and the Namib escarpment, forms a transition between desert and savanna, termed the Semi-desert/ Savanna Transition zone.[19] Many endemics and species of conservation importance occur here (section 2.3). Although the mountainous Kaokoveld, in the northwest escarpment zone, was classified as Mopane Savanna by Giess,[19] he recognised this as due to inadequate data. The Kaokoveld is part of the transition zone, and is extremely valuable botanically, with high endemicity (Fig. 1.2) and several monotypic general.[23]

Most of Namibia is covered by savanna, especially thorny shrub and tree savanna. Mountain, Thornbush and Highland Savannas dominate the central highlands, while Dwarf Shrub Savanna covers the southern inland plateau. Camelthorn *Acacia erioloba* and Mixed Tree and Shrub Savannas are largely confined to the Kalahari sandveld, and Mopane Savanna dominates the north-west of Namibia, east of the escarpment.

Two types of woodland are distinguished in Namibia. Forest Savanna and Woodlands cover the moist northeastern region, with tropical trees such as *Baikiaea plurijuga*, *Burkea africana*, *Lonchocarpus capassa* and *Terminalia sericea*. Riverine Woodlands are azonal and associated with the continuous moisture supply along rivers. Virtually all rivers are lined with woodlands. Permanent rivers harbour lush, diverse vegetation; the ephemeral riverbeds support trees and shrubs such as *Faidherbia albida*, *Salvadora persica* and *Ziziphus mucronata*.

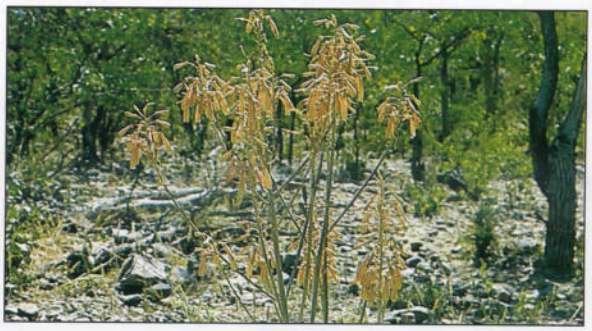


Fig. 1.2 *Aloe dinteri*, endemic to north-central and northwest Namibia. Courtesy HH Kolberg

Fig. 1.3 Three winter rainfall zone endemics: *Tylecodon aurusbergensis, Crassula aurusbergensis, Conophytum taylorianum ernianum.* Courtesy G Williamson

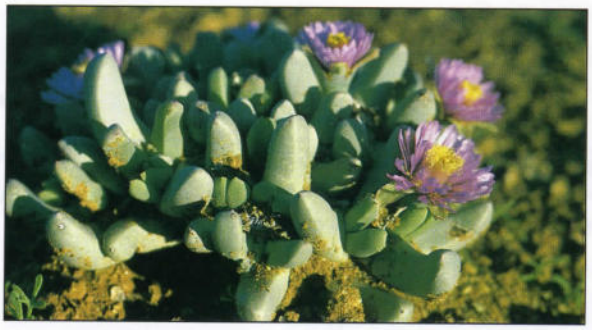
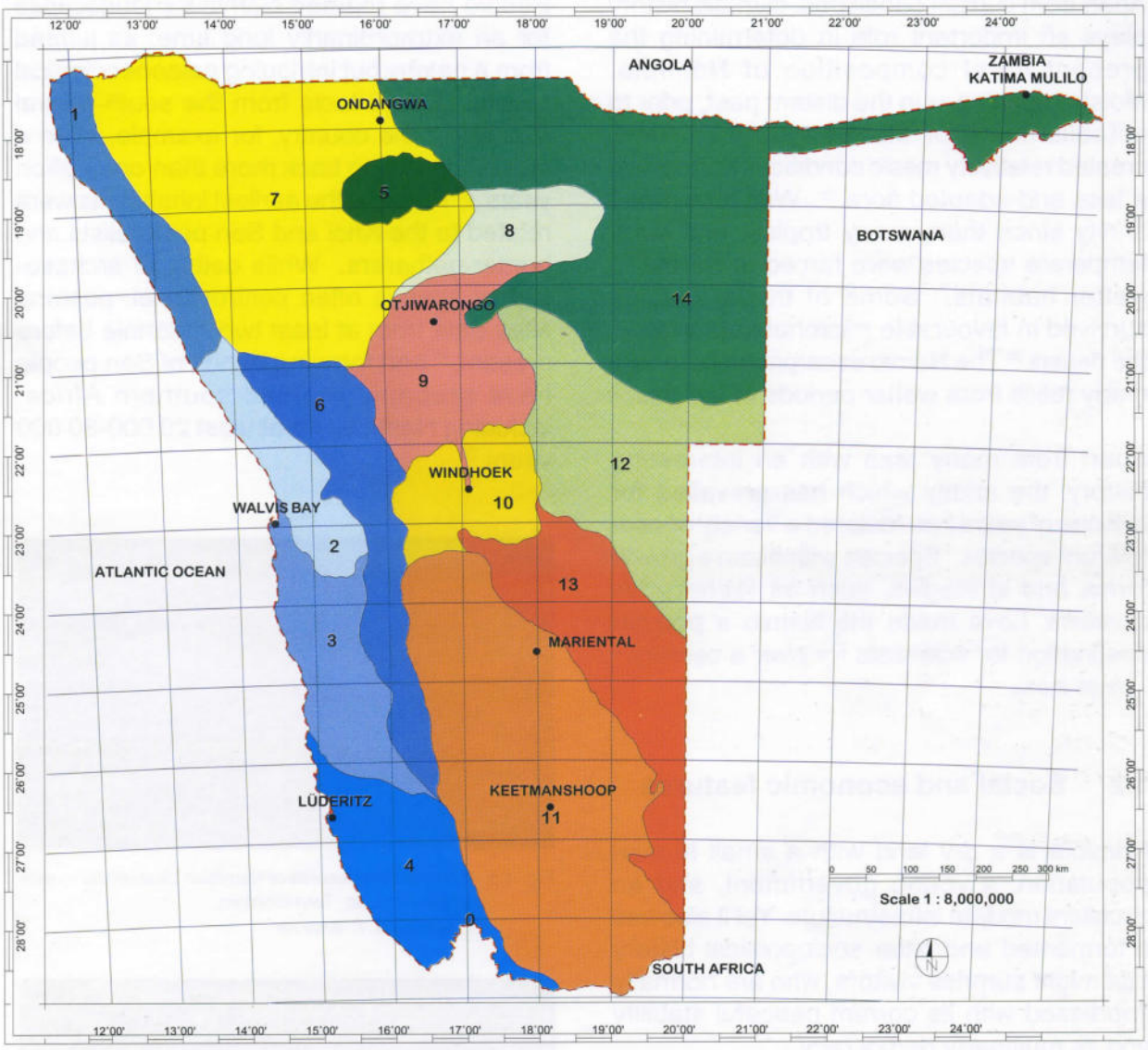


Fig. 1.4 *Dracophilus delaetianus*, endemic to the winter rainfall zone. Courtesy G Williamson

Map 1.8 Vegetation types of Namibia (Giess 1970)



Vegetation

- 1 Northern Namib
- 2 Central Namib
- 3 Southern Namib
- 4 Desert and succulent steppe
- 5 Saline desert with dwarf shrub savanna fringe
- 6 Semi-desert and savanna transition
- 7 Mopane savanna
- 8 Mountain savanna and karstveld
- 9 Thornbush savanna
- 10 Highland savanna
- 11 Dwarf shrub savanna
- 12 Camelthorn savanna
- 13 Mixed tree and shrub savanna
- 14 Forest savanna and woodland

Border

Major Towns

Source:

Giess W., 1970
Dinteria 4:5-114

What makes the Namibian flora unique? Variable environmental conditions have created a diverse flora with mainly palaeotropical floral elements in the north, cold-temperate elements in the south, and transitional elements between the two.[24] Apart from current conditions, climatic history plays an important role in determining the present floral composition of Namibia. Moister conditions in the distant past, prior to establishment of the Benguela Current, created relatively mesic conditions supporting a less arid-adapted flora.[25] With increasing aridity since then, many tropical and cold-temperate species were forced to retreat to wetter habitats. Some of these species survived in favourable microhabitats even in the desert.[26] The Namib escarpment harbours many relics from wetter periods in the past.

Apart from many taxa with an interesting history, the aridity which has prevailed for millions of years has fostered a variety of arid-tolerant species. Species with bizarre growth forms and strategies, such as *Welwitschia mirabilis*, have made the Namib a popular destination for scientists for over a century.
—Antje Burke

1.2 Social and economic features

Namibia is a dry land with a small human population, a young government, and an excellent modern infrastructure. Yet it also has a tormented and bitter sociopolitical history that might surprise visitors, who are normally impressed with its current peaceful stability and its multiparty democracy.

How have Namibia's social, economic, political and historical contexts influenced our present-day environmental policies and institutions? What legacy have they left on processes of environmental management, scientific research, conservation and land use planning? More specifically, do these contexts have a specific bearing on the biological diversity conservation strategies we must develop? The following sections sketch out an overview of these factors, and attempt to draw broad conclusions about the social, economic and political contexts in which biodiversity conservation actions must proceed.

Human palaeoecology

People have roamed Namibia's landscapes for an extraordinarily long time, as judged from a patchy but intriguing palaeoecological record. Stone tools from the south-central plateau of the country, for example, span a sequence dating back more than one million years.[27] Perhaps the earliest inhabitants were related to the Khoi and San pastoralists and hunter-gatherers. While dating of archaeological sites is often controversial, pastoral sites date from at least two millennia before present,[15] and foraging bands of San people have probably roamed southern Africa, including Namibia, for at least 20 000-30 000 years.[28]

Fig. 1.5 Early 'written' records of Namibian biodiversity — rock engravings at Twyfelfontein.
Courtesy L C Weaver

Fig. 1.6 The Naukluft holds many clues to early human settlement. Courtesy National Museum of Namibia

These early Namibians inhabited a land not very different to that of today: an arid interior and coastal plain, with a productive intertidal zone influenced by the Benguela Current. Radiocarbon dates of shellfish middens in the

Kuiseb Delta, on the Atlantic coast, range from 1870 years ago to about 130 years ago.[15] Traces of extinct freshwater springs can sometimes be found there, along with white mussels *Donax serra* and reeds *Phragmites australis*, which still inhabit patches of the coast today. From these we can infer a highly dynamic dune-lined coast, very similar to that of today, at which small groups of nomads used resources from both land and sea.[15]

An orthodox pre-history of Namibia dates the major immigration waves of cattle-owning pastoralists from east-central Africa, the ancestors of today's Herero- and Aayamba (Owambo)-speaking Namibians, to the 16th and 17th centuries AD.[29] Such accounts were intended to establish the arrival of European explorers and Bantu-speaking people at about the same time, for political reasons, and have been thoroughly refuted by archaeological evidence.[15,30,31] Williams[32] draws on oral records to trace early Owambo settlements to the 10th century AD or before. Copper and other minerals were mined and smelted by people settled in the north of present-day Namibia for weapons, utensils and ornamentation.[32] Well-established kingdoms and chieftancies, with diverse and structured economies, existed long before the arrival of Europeans in Namibia.

Political history

The written record of Namibia's history has been mainly one of bitter resource conflict. The territory had certainly not been free of conflict before European exploration and settlement, but was characterised by periodic violent clashes of nomadic pastoral clans over grazing and other rights, and somewhat more peaceful relations between settled communities. Clashes between communities in the late 1800s allowed Europeans to negotiate advantageous land-for-weapons treaties with individual chiefs. One such agreement between trader Adolf Lüderitz and the Nama chief at the coastal port of Angra Pequena (now Lüderitz) concerned rights over land which later became one of the world's most productive diamond-mining areas, and was seen as a pivotal historical event.

Namibia's substantive written history begins around this time, with key events initiated, as if by remote control, by ambitious European leaders. In 1884, Chancellor Otto von Bismarck proclaimed a German protectorate in what is now Namibia, allowing for the expansion of German control into the interior with its lucrative rangelands.[2,33] He dispatched Heinrich Göring (father of Nazi general Hermann Göring) as first Imperial Commissioner to ensure the acquiescence of Namibian kings and chiefs to German 'protection.' In Hamutenya's[33] words, since Germany was a late arrival to the scene of colonial expansion and conquest, it was hastier and more brutal than most of its colonial competitors. Merchants and speculators from that country had, by 1883, already acquired large chunks of Namibian land as private property and concessions.[33] Defending the potential export markets and resource acquisitions of these early businessmen was a substantial additional reason for Germany to stake out an aggressive presence in Namibia.

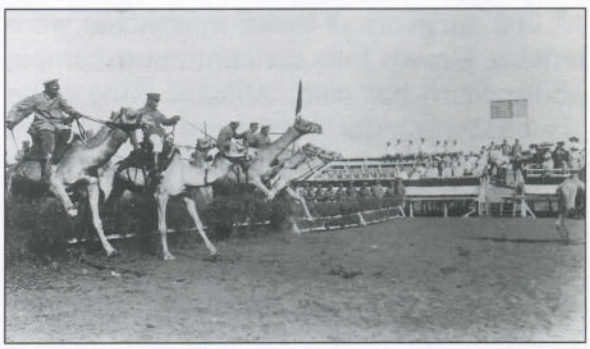


Fig. 1.7 German Schutztruppe at a camel race, c. 1910. Courtesy National Archives of Namibia

Fig. 1.8 Typical German colonial homestead. Courtesy National Archives of Namibia

The notorious Berlin Conference of 1884-85 consolidated the European hold over the entire African continent, dividing it into colonies and protectorates for political influence and natural resource exploitation. The new borders were based more on perceived resource distribution than on intrinsic cultural, geographic or ecological divides. This extraordinary process rapidly transformed Africa, including Namibia, into a 'sphere of monopoly expansion and influence.'[33]

The century following the Berlin Convention was frequently marked by appalling and brutal administrative and miltary policies on the part of successive German and South African colonial administrations. Policies and actions by the colonists to expropriate land, livestock, and other vital natural resources held by Herero- and Nama-speaking clans led to the 'Great Uprising' or 'Great War of Resistance' in 1904-1908. Of roughly eighty thousand Hereros, only about fifteen thousand survived, and many of these were driven across the Kalahari into Botswana. More than half of the Nama people, and at least a third of the Damaras, were exterminated.[33] More than 17 000 survivors of these massacres were brutally thrown into concentration camps, where nearly half died. Africans living in the 'Police Zone' after 1908 were barred from owning cattle, forced into indentured labour on settlers' farms, and progressively driven onto ethnically-divided 'native reserves.' This policy was continued with greater fervour by South African colonial planners.[2, 33]

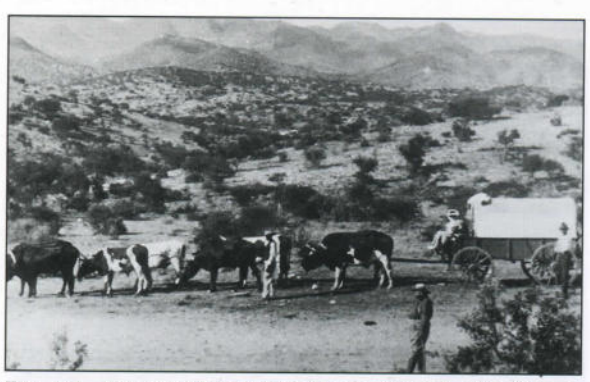


Fig. 1.9 Boer settlers in the South African-subsidised settlement scheme, c. 1925. Courtesy National Archives of Namibia

The outbreak of World War I led to military occupation of Namibia by British South Africa in 1915, supported by many Namibian kings and chiefs, and marked the end of German rule. In 1920 the League of Nations granted South Africa a mandate to administer the land, with obligations to promote the welfare of Namibians which were generally ignored.[2] A legislative assembly for whites, set up in 1925, constantly lobbied for the inclusion of Namibia into South African territory. Hopes for the restoration of land confiscated by the Germans were frustrated, as prime land was parcelled out to Afrikaans settlers under a costly subsidised settlement scheme in the 1920s and 1930s (Fig. 1.19).[2,34] Two uprisings against such policies in the 1920s were violently crushed by South African police. The German colonial programme of resource exploitation and land theft, backed up by brutal armed force, was thus continued more systematically by the South Africans.[33]

Resource conflicts also plagued Namibia's efforts to free itself from South African rule, which was subject to Cold War meddling in the interests of political influence and land control. Namibia was declared a trust territory with rights of self-determination by the United Nations in 1945, just after the UN's birth. It became a battleground for political posturing by South Africa, which rejected the UN's authority, by the UN and Namibian resistance bodies, which rejected South Africa's authority, and later by the USA, USSR and Cuba, which were engaged in wars for regional political and economic influence. The UN terminated South Africa's mandate in 1966, set up a council with authority for the territory and appointed a commissioner in 1974. The Security Council called for UN-supervised elections, endorsing an International Court of Justice ruling on the illegality of South Africa's occupation.[2] All of this failed to force South Africa from the territory. Only in 1989, when UN-sponsored elections were imminent, did the South African media report that Pretoria's war effort in Namibia and Angola was simply too costly to sustain, at a million rands per day.

Following Independence on 21 March, 1990, and the election of a multiparty democratic

government led by the Southwest African People's Organisation (SWAPO), Namibia has finally made strides to redress the resource inequalities of the past century. The national constitution supports a unitary republic with a bill of rights, an executive president and strong prime minister, a two-chamber legislature, multiparty elections, and an independent judiciary.[2] Ownership of land, water and other natural resources is vested in the State unless otherwise 'lawfully owned,' and the State must pay market-related compensation for property it nationalises or expropriates.

Land reform, so central and burning an issue throughout the colonial period, has been broached, but not substantially implemented eight years after Independence. Major public land reform conferences were held in 1991 and 1994; legislation to support reform is in effect or underway; and technical groups are studying ways to implement recommendations of the conferences. Yet public perception is that few, if any, real changes have taken place in the ownership of major enterprises, or in the distribution of land and wealth. This has posed difficulties for the government in striking a balance between its policy of national reconciliation, which aims to unite formerly divided communities, and its land reform policies, which aim to redress social and political inequality within a mixed economy (see below, 'Land use and the economy').

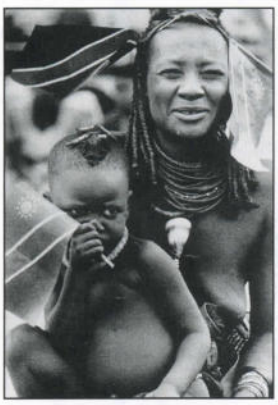


Fig. 1.10 Independence Day 1990. Courtesy National Archives of Namibia

Demography

Descriptions of Namibia commonly note that we have one of the lowest human population densities in the world, and the third lowest in Africa after Western Sahara and Botswana.[2] Namibia has nearly 3% of Africa's total land area, but only about 0.2% of its population.[13] The 1991 national census estimated our population at 1.43 million, including the Walvis Bay enclave which was then under South African control, with a projected 1995 population of 1.61 million.[1] Overall, there are about 1.7 people/ km^2. Dry countries of a similar size, such as Pakistan or Turkey, by contrast, have about 30 times the population.[18]

However, these statistics are deceptive. Namibia's sparse population density has led to much complacency, as captured in a popular pre-Independence bumper sticker, 'Sleep with a Southwester: we need more of them.' The missing ingredient in this misguided sentiment is, of course, awareness of Namibia's acute limitations in the physical ability of its land to support more people. The country's dry climate, erratic and very localised rainfall, infertile soils, and large areas of saline groundwater make most of the land unable to support much higher population densities.

Combined with highly skewed distribution of wealth, low economic productivity and inequal access to resources and appropriate technology, these constraints in effect make some areas of Namibia already over-populated, with unsustainable population densities and growth rates in several areas. Most sparsely populated regions of the country, such as in the south, cannot support significantly higher human densities due to the patchy availability of surface and non-fossil groundwater.[35]

Namibia may have a low overall human density, but our estimated annual population growth rate of 3.1% is one of the world's highest. It is the highest in southern Africa,[1] which averages 2.4% population growth, even though our country is the region's most arid. This rapid growth is certainly not sustainable. Per capita economic growth often lags behind population growth (Box 1.2; see Chapter 4). Namibia's economy grew fast in the years after Independence, reflecting an optimistic investment climate and government commitment to stimulating the economy. However, our leaders face a herculean task to maintain our current political and economic stability in the face of this population pressure.

Box 1.2 Population and economic growth in Namibia

Annual real economic growth (averaged)

	1981-89	1990	1991	1992	1993	Mean 1990-93
Real GDP growth	1.0%	0.0%	6.8%	6.8%	-1.5%	2.9%
Per capita real GDP growth	-2.1%	-3.1%	3.5%	3.6%	-4.6%	-0.2%

Source: NPC[1]

Past and projected future population growth (averaged)

	1980-85	1990-95	2000-05
Annual population growth	2.9%	3.2%	2.9%

Source: WRI [36]

The government has made large strides in managing the daunting social and health needs of the Namibian population. For example, ambitious primary health care programmes, including family planning initiatives, were launched by the Ministry of Health and Social Services after Independence. These have involved massive investment in infrastructure, staff and training.[1] Namibian women currently have an average of 6.1 children in their reproductive lifetimes.[1] Yet a woman's fertility decreases rapidly with increasing education (Box 1.3). Government efforts to improve access to health care and education, and combatting poverty, will thus help manage our population growth.

Box 1.3 Human fertility in Namibia

Mean total fertility	(children / woman)
Rural	6.8
Urban	4.7
All women	6.1
No education	8.8
Completed grade 7	7.2
Completed grade 10	4.2
Completed grade 12	3.1

Source: NPC[1]

Fig 1.11 Water is often trucked to rural settlements with no potable surface water. Courtesy Ministry of Information and Broadcasting (M Namundjebo)

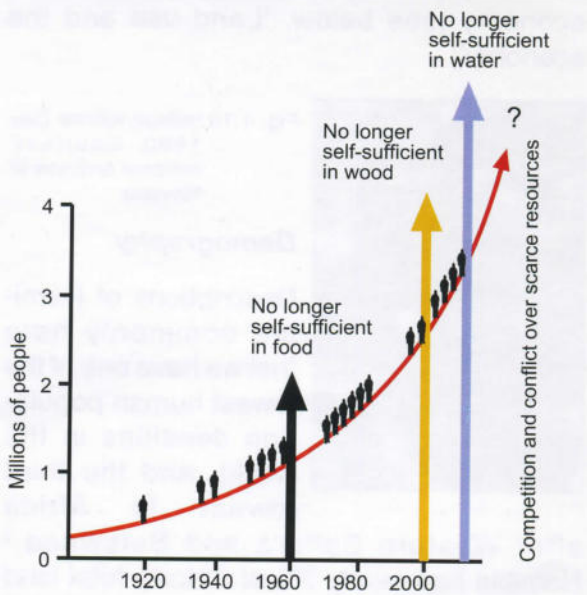


Fig. 1.12 Projected human population growth and postulated resource crises facing Namibia Courtesy C Ashley

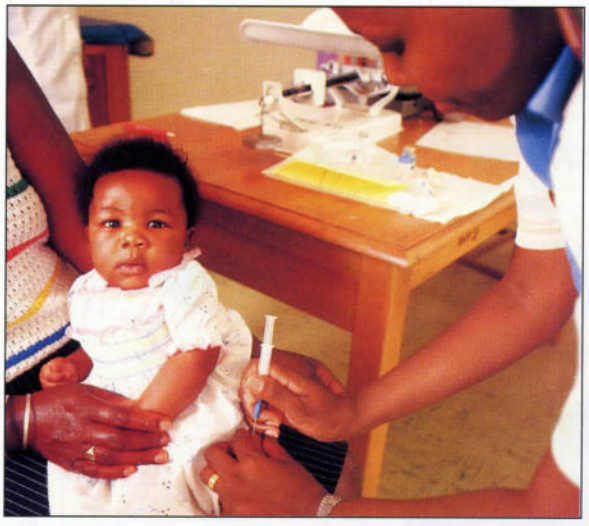


Fig. 1.13 Primary health care services have made significant strides. Courtesy Ministry of Information and Broadcasting

Fig. 1.14 A rural primary school. Courtesy Ministry of Information and Broadcasting

Box 1.4 Human mortality in Namibia

The three major causes of human death in Namibia are AIDS, malaria and tuberculosis. AIDS overtook other diseases as the top killer in late 1996. It is greatly under-reported and is not usually listed on death certificates.

Cause (all ages)	*% of total deaths*
AIDS	12.4
Tuberculosis	7.5
Malaria	6.7
Gastroenteritis	6.4
Cancers	6.2
Pneumonia	5.2
Premature birth	4.4
Chronic cardiovascular failure	4.3
Malnutrition	3.3
Cardiovascular accident	2.7
Other causes	41.3

N = 7472 deaths

Source: UNDP[37]

Land use and the economy

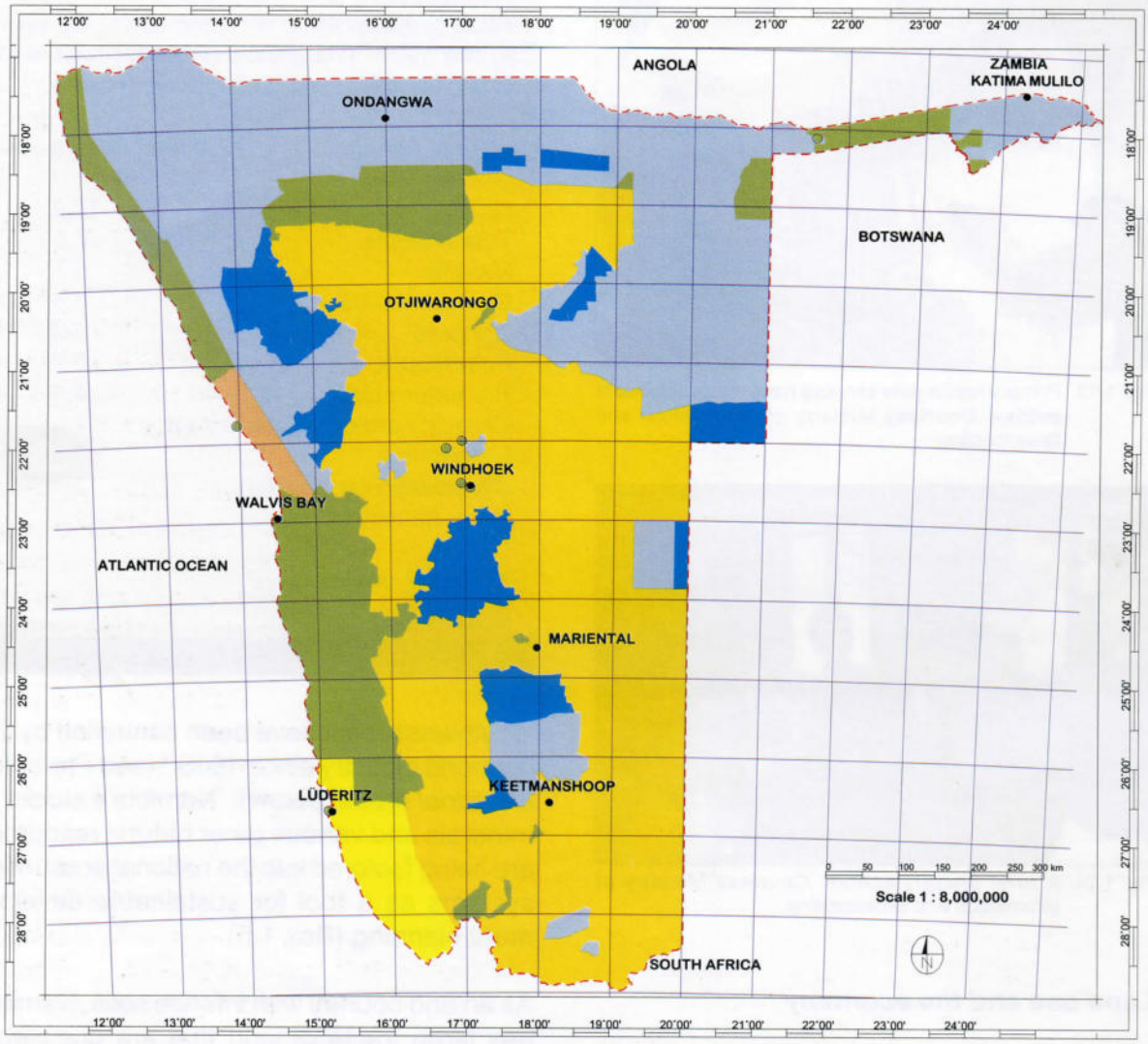
Namibia is mainly an agricultural and mining nation, with important marine fisheries. It depends heavily on both imports, such as food, manufactured goods, and technology, and exports such as beef, fish and minerals. Like many other arid developing countries, Namibia's economic output is highly sensitive to fluctuations in climate and world market prices[38] (see also Chapter 4).

Prior to Independence in 1990, mining and commercial agriculture jointly accounted for about 30% of Gross Domestic Product (GDP) and 75% of total exports.[2] The mining sector has remained extremely influential, with diamonds, uranium and base metals mined mainly for export.[2] This sector is a major landholder. Large areas on Namibia's arid southwest coast have been controlled by the diamond industry since 1908[16] (see *Protected industrial areas,* below). Namibia's stocks of minerals and various other natural resources are being factored into the national accounting systems as a tool for sustainable development planning (Box 1.5).

As an arid country with infertile soils, Namibia has large tracts of land that are unsuitable for livestock or crop production, and almost no potential for the expansion of irrigation. Food self-sufficiency by the year 2020, an oft-cited policy goal, is therefore conceivable only for specific items such as beef, mutton and fish. The subsistence farming sector produces only 1.5% of GDP, but is an essential means of livelihood for about 70% of the population.[2] GDP statistics are therefore not a very meaningful index of economic activity for most Namibians. The gap between rich and poor is desperately large: income inequalities are believed to be the highest in the world.[2]

Map 1.9 summarises the distribution of Namibia's major land tenure systems, which are outlined below.

Map 1.9 Major land uses in Namibia



Land Tenure

- State protected nature area
- Open communal area
- Sub-divided and surveyed communal farmland
- Tourist recreational area
- Restricted area for mining
- Commercial farmland

- Major towns
- Small state protected areas

Source:

Various Government Gazettes published by the Government of Namibia.

Ministry of Lands, Resettlement and Rehabilitation
Division of Survey and Mapping
1:250000 maps.

Box 1.5 Natural resource accounts

Stocks and flows of natural resources are rarely reflected in national accounting systems, despite the overwhelming dependence of most countries on their natural resource base. Namibia, like many developing countries, depends on exports of natural resources. Ensuring that our national decision-making adequately reflects the true costs and benefits of natural resources requires a system of ***natural resource accounting****, or NRA.*

Together with support from New York University, Namibia's environmental economics unit at the Directorate of Environmental Affairs (DEA) has embarked on a programme to integrate NRA principles into the national accounting system by building 'satellite accounts' for natural resources. These accounts have many uses, such as helping the government assess whether it is maximising revenue from individual resources, or which uses of water are most valuable to the national economy. NRA analysis can also help governments plan for the ultimate obsolescence of industries based on non-renewable resources, such as minerals,by investing profits in sustainable industries. The Namibian NRA project began in 1996 and has already completed several valuable analyses for policy-makers.

— Rob Blackie

Land use practices in Namibia today, towards the close of the 20th century, stem directly from the massive social-engineering policies of the colonial past. The *apartheid* 'homeland' policies of the South African administration, and the German administrative distinction between 'Native Reserves' and 'Crown Land,' played dominant roles whose shadows are still cast on the country today.[39] By reserving prime land for white settlers, both colonial powers gradually squeezed black Namibians onto land that was agriculturally marginal, prone to human or stock diseases, or both. This grim pattern was repeated throughout Africa wherever European settlers were a powerful political and economic force, but reached a zenith in South Africa and Namibia. Despite wartime disruption to South Africa's costly resettlement scheme for white farmers in Namibia, an ethnically based policy of land exclusion was well established by the 1930s.[34]

Increasingly ostracised by the UN and world community for its *apartheid* policy and illegal occupation of Namibia, South Africa in 1971 went ahead to implement recommendations of the notorious Odendaal Commission report.[34,39] This was Pretoria's most ambitious blueprint for 'separate development' in Namibia. It set up ethnic 'homelands' along the South African model, mostly at the edge of the commercially-farmed, white-occupied central highlands. The per capita allocation of land was 54 ha for blacks and 'Rehoboth Basters,' people of mixed racial descent, and 444 ha for whites.[39] These homelands were never viable in structural or economic terms, but were a way of controlling a cheap labour pool for white-owned enterprises.[34]

By the late 1970s, Namibia had a core of heavily subsidised ranching land in the 'white heartland,'[39] surrounded by much more densely settled homelands which often had poorer soil or groundwater. This state of affairs is still largely intact today. Of the roughly 6100 commercial farms in Namibia, mostly large cattle and sheep ranches, about 89% are owned by local white farmers, 9% by non-Namibians, and 3% by black Namibians.[2]

Other than mining and agriculture, conservation and tourism are collectively increasingly important in terms of land surface and GDP (see below and Chapter4). Finally, urban development is a rapidly growing land use in Namibia, albeit on a smaller scale than in many countries (below).

Agriculture and traditional land uses

Namibian agriculture is in many ways typical of dryland farming throughout the world, with heavy emphasis on livestock production. Most farmers keep goats, cattle, sheep, ostriches, game mammals or a combination thereof. Much of the land zoned for agriculture in Namibia is suitable only for nomadic or rotational grazing due to poor surface water availability, erratic rainfall and thin, infertile soils in much of the country. Only about 6.5% is suitable for mixed arable farming, where soils are suitable and mean

annual rainfall exceeds 500 mm.[1,34] Less than 5% of Namibia is under irrigation.[40] This is at or near the theoretical maximum due to water availability and salinisation risk.[18] Namibia is thus essentially a range country, with reasonably diverse rangeland uses.

An extremely important sector in terms of human livelihoods is non-commercial or subsistence farming on communal land. Most communal farmers, in addition to stock management, plant small seed crops such as millet (*omahangu*) *Pennisetum glaucum,* sorghum *Sorghum bicolor*, beans *Vigna unguiculata,* pumpkin *Cucurbita moschata*, and melons (*Citrullus lanatus* and *Cucumis melo*). Many people also gather wild foods and keep poultry (Chapter 4).

Traditionally, many of Namibia's people were nomadic pastoralists, moving animals long distances to find water and grass where it was available.[15] Pastoralism or 'transhumance' was widely practised in catchments of the western ephemeral rivers for at least 4000 years, but started to disappear with the arrival of Namibia's first colonists in the nineteenth century.[17] Movements of the OvaHimba people within the Khumib catchment were an excellent example of an appropriate rotational grazing system in arid rangelands.[17]

The introduction of communal land areas as outlined in the Odendaal Commission report[41] has interfered with this transhumance system, leading in some areas to environmental degradation. As a direct consequence of this, indigenous farmers lost their traditional ability to defend and manage their seasonal pastures or grazing areas.[42] Historically many Namibian farmers were forced to live under reserve conditions, and those who worked as labourers on commercial farms had little or no land or livestock. The traditional management practises and ecological knowledge of communal farmers can greatly assist agararian reform.[34] While some traditional practices and knowledge may be incompatible with new technologies, it is better to foster the wisdom and knowledge contained in these practises, and accept them as an integral part of modern, environmentally sustainable range management.[42]

Agricultural development in communal areas was neglected for many years. Formal extension services did not exist until recent decades, and trainers appointed to extension posts did not receive adequate guidance or supervision.[34] Financial credit and agricultural extension assistance to communal farmers has greatly improved since Independence.

Beginning in the early 1960s, veterinary cordon fences known as the 'Red Line' were erected to restrict the southward movement of cattle raised on communal farmlands.[43] These cordons were prompted by the risk of transmission of stock diseases such as bovine lungsickness (CBPP) and foot-and-mouth disease (FMD, see Appendix 6), and followed directly from a major outbreak of FMD in 1961. Discussions have gone on for some years about the possible removal of these fences to allow equal marketing opportunities for communal stock farmers, but the issue is highly controversial.

Fig. 1.15 The 'Red Line' veterinary checkpoint at Oshivelo. Courtesy Ministry of Information and Broadcasting (Asser Kangootui)

Fig. 1.16 Communal farming extension services. Courtesy B Kruger

The livestock export industry is based almost entirely in the commercial sector, south of the Red Line, and earns considerable foreign exchange. Currently, it is worth about N$800 million annually, with increasing export volumes making up for short term drops in meat prices. Eighty percent of commercial animal production (meat, meat products, live animals) is exported. Most meat exports have been to South Africa and the European Union.[43,44] Trade in canned meat from communal areas north of the Red Line has been previously been authorised under EU regulations,[43] but stringent hygiene and veterinary disease controls are more difficult to maintain in the less-developed communal farmlands.

Karakul sheep production, mainly in southern Namibia, has historically been the second most important branch of commercial agriculture after beef, but sensitivity to fluctuating international market prices for pelts has harmed the industry and greatly reduced its contribution to GDP. During the same period, wildlife farming has become increasingly important, as it is linked to the fast-growing tourism sector (see below).

Mining

Charles Darwin's cousin, the explorer Francis Galton, in 1851 noted Ovambo tribesmen smelting copper from surface deposits near Otavi.[45] Commercial mining was established at about the same time in 1854-55 with the formation of the Walvisch Bay Mining Company to exploit copper.[46]

Mining has long been the backbone of the Namibian economy, and remains the major contributor to the country's GDP and export revenues.[47] Revenues are highly sensitive to world market prices and fluctuate accordingly,[48] but commonly account for over 70% of export earnings, 11-25% of GDP, and roughly 25% of government revenues.[48,49] Although in the early 1980s mining strongly dominated the economy, contributing over 40% of GDP, economic diversification and global market prices have gradually reduced this rate to about 11% in 1995.[47,49]

Small to medium mineral deposits and mining claims occur throughout much of Namibia. The two main operations, NAMDEB Diamond Corporation in the *Sperrgebiet* (see below) and Rössing Uranium in the central Namib currently earn the country most of its minerals-related foreign exchange.[50] The *Sperrgebiet* is by far the largest mining area and the only one legally proclaimed and restricted for mining. The 186 km^2 Rössing mining area, east of Swakopmund, was historically the major water consumer of the central Namib. It has significantly decreased its consumption and now features corporate measures to limit and monitor negative environmental and health impacts of mining.

Copper and other base metals are mined from several sites and smelted at Tsumeb, and gold is mined at the Navachab site near Karibib. A major copper mine at Haib in southern Namibia may commence operations in 1999, and the feasibility of exploiting extremely pure cathode zinc deposits at the Skorpion mine is under study.[45] About 40 formal mining operations are active in the country, producing 30 commodities such as diamonds, uranium, semi-precious stones, base metals such as copper, gold and zinc, industrial minerals such as petalite and fluorspar, and dimension stones such as granite and marble.[46,50,51] Other resources of significance which are mined in Namibia include seabird guano and salt (Box 1.6). There are also sizeable offshore reserves of natural gas and oil,[52] for which extensive prospecting has taken place.

Historical links between mining and abuse of the environment are clear. Namibia is littered with the rusting remains of abandoned and unrehabilitated mines.[51] Although mining activities need not be contrary to the aims of environmental conservation, mines in Namibia were historically the realm of entrepreneurial frontiersmen who often worked the mines in conditions of great hardship and abandoned them in bankruptcy.[53] Modern mining activities rely on increasingly sophisticated technologies. Although they are increasingly accompanied by environmental assessment and monitoring programmes, certain mining activities which may significantly threaten biodiversity.

Box 1.6 The guano harvesters

The guano mining industry of the past is an instructive example of the boom and bust exploitation of a natural resource. It has also become an example of a modern industry successfully integrating economic activity and environmental conservation. After the 1828 discovery of Namibian guano deposits and the 1840s 'guano rush,' it took less than 18 months to strip centuries-old deposits which lay 15 m thick in places. Guano mining threatened breeding red data seabirds such as penguins, cormorants, and gannets. In 1987 all islands were declared nature reserves to protect their seabird populations. Harvesting of guano off mud banks at Sandwich Harbour and Walvis Bay led to a dramatic drop in the cormorant population, and a corresponding decrease in the guano that could be collected at these sites. The balance between guano harvesting and seabird roosting was restored with the erection of artificial guano platforms which offer protection from human disturbance and predators. Today, the Namibian guano enterprise has evolved into a flourishing industry which balances economic development and conservation.

— *Sources: Brown[54] and J Tarr[55]*

Marine diamond mining involves perhaps the most extensive threats (Chapter 3), which are real but currently difficult to quantify.[16,56] Beach mining for diamonds affects large coastal areas in southern Namibia, and threatens the range of species such as the Namaqua dwarf adder.[54] Tailings pumped into the sea from off-shore and on-shore operations smother rock-dwelling organisms, sand-living invertebrates and rock lobsters *Jasus lalandii*[54,56] (see Chapter 3). Heavy sediment loads in the water cause physical harm to seabed-dwelling (*benthic*) species,[56] especially at the egg and larval stages.

Offshore oil and gas exploration may pose threats to the marine ecosystem. Primary impacts of exploratory work may be the deposition of drill cuttings and mud on the seabed around the rigs,[56] smothering benthic organisms on a small scale and introducing potentially toxic compounds. These activities are discussed further in Chapter 3.

Fig. 1.17 Courting gannets. Courtesy C Beyers

The Namibian Government's stated aim is to create real wealth through environmentally acceptable and sustainable mining development, and to minimise threats posed by mining activities to the environment and biodiversity. Therefore a new Prospecting and Mining Act (33 of 1992) was formulated, with provisions to ensure good mining practices which protect the environment during prospecting and mining. Combined with new fiscal incentives for operators to rehabilitate mines and repair environmental damage, these provisions now provide a basis for environmental protection.[50] All mineral licenses require licensees to prepare an Environmental Assessment (EA), indicating the extent of any environmental pollution prior to the onset of prospecting or mining activities, together with an estimate of any potential impacts.

— *Sem Shikongo*

Fisheries

Commercial marine fisheries and subsistence inland fisheries are both important in Namibia (Chapters 2 and 3). In terms of the national economy, the marine sector is vastly more important, although freshwater fisheries form an essential component of many rural people's livelihoods.[57]

The marine fish resources of Namibia were, until recently, among the richest in the world.[56] The Benguela Current off Namibia and South Africa is one of the world's most powerful and productive upwelling systems, supporting lucrative marine industries (see Chapter 3).

Following an all-too-familiar trend, however, heavy overexploitation of pelagic fish off Namibia in the 1960s and 1970s led to the collapse of populations of several economically important fish, especially pilchard or sardine *Sardinops sagax*. This was due to a potent mix of factors, including free-for-all exploitation by increasingly large fleets from countries such as South Africa, the former Soviet Union, and Spain; lack of local control and enforcement; inadequate scientific data for the accurate estimation of fish stocks; and lack of foresight or responsibility by individual authorities in the colonial period.[58]

This history badly crippled the potential for subsequent development of the industry. Even with moderate continued exploitation, many fish species take decades to recover from population bottlenecks (see also Chapter 3). The greatest prudence is thus needed to protect stocks sufficiently in order to free the industry from the effects of past greed and overexploitation.

Despite this history, marine resources remain an important, indeed increasingly important, sector of the Namibian economy. From 1980 to 1997, fishing and its associated secondary industry of fish processing grew, as a percentage of GDP, from 1.8% to 8.5% at current prices.[48] Efforts in 1990 to secure protection of a 200 nautical mile (nm) exclusive economic zone have greatly reduced the uncontrolled overexploitation of fish resources. Resource protection could be further secured by a proposed convention to cede management control over the entire marine area between Angola, Namibia, South Africa and the mid-Atlantic islands of St Helena, Ascension and Tristian da Cunha to these governments.[59] Regardless of the size of the area under local or regional management, however, the fishing industry remains highly vulnerable to environmental variability, as well as to local overharvesting.[56]

Inland fisheries play a lesser role nationally, but are extremely important in the subsistence economies of many people in northern and northeast Namibia (section 2.9, Freshwater fish diversity). Fish from perennial and seasonal wetlands are harvested, in some cases probably unsustainably, mainly for subsistence, and are sold commercially only on a very limited basis. Aquaculture in freshwater systems has been little developed, but recent legislation is currently being drawn up by the Ministry of Fisheries and Marine Resources (MFMR), and a White Paper on inland fisheries policy was recently published.[60]

Forestry and watersheds

Namibia has a relatively long, if chequered, history of forestry management. Before the colonial era, traditional leaders in many areas exercised control over the harvesting of trees. These controls may have been effective for many centuries, judging from oral records, although they depended on individual wisdom (see Box 1.7).

The first written regulations for woodland management date from the late 19th century.[61,62] During the German colonial period (1884-1915), forest advisors such as government botanist Kurt Dinter developed management policies to support the increasing demand for timber and other wood products. A research station was started near Windhoek as early as 1900. Once South Africa took over the administration of Namibia in 1915, however, forest legislation enacted by the Germans was replaced with laws widely seen as weaker and virtually unenforceable.[62] During South African rule foresters were answerable to Pretoria, not Windhoek, and were housed in numerous ethnically-based regional administrations.

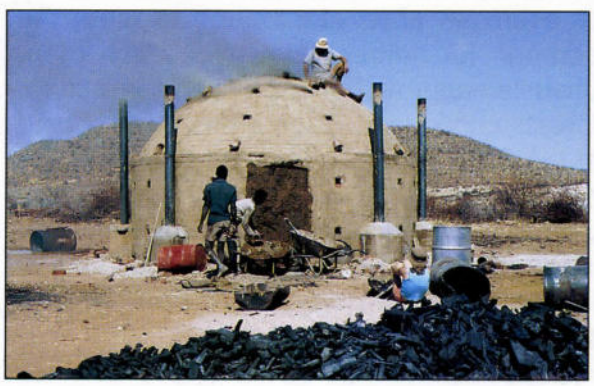


Fig. 1.18 Charcoal production. Courtesy HH Kolberg

Box 1.7 Protected forest groves: the history of Chongo- camasaku Kakambi

The Chongo-camasaku Kakambi forest lies on the southern Chobe floodplain of east Caprivi, within the territory of the Subiya villages of Mahundu and Ibbu. It is a 15 ha hummock forest, typical of the landscape patches between wet floodplain and drier hillocks. Its main trees are *Hyphaene petersiana* (*Munganda* in the Silozi language), *Lonchocarpus capassa* (*Mupanda*), *Dichrostachys cinerea* (*Muselesele*), *Piliostigma thonningii* (*Mubabama*), *Ficus sycomorus* (*Muchaba*), *Adansonia digitata* (*Mubuyu*), *Faidherbia albida* (*Muunga*), *Trichilia emetica* (*Musikili*) and *Kigelia africana* (*Mupolota*). These all occur in a range of ages.

Old people in the villages say that 70 years ago this was not a forest, but a patch of bushes only as tall as a man. At that time, flooding in the Chobe was more regular and extensive than now, and this checked the growth of vegetation. Only on small islands could the more flood-sensitive species survive. As the floods diminish in extent, woodlands are expanding. In Chongo-camasaku Kakambi, what was 'bush' has now developed into a small forest grove. People have increased the species richness of the forest. Local people say that *H. petersiana* palms were introduced using seed brought from Mbalakalunga in Botswana.

The forest was also afforded protection for its very strong cultural significance. The traditional use of Chongo-camasaku by people of Mahundu and Ibbu villages was restricted because the area was historically a burial ground for Subiya families and a site for spiritual rain ceremonies. Traditionally, only one family was allowed to enter the forest — others who did would become lost. During the second Lozi empire in east Caprivi (1864-1909), Chief Chika Liswani authorised the Kakambi family to settle in the area to protect the centre of the Subiya territory from roaming Zulu and Ndebele groups. Before he died, people would gather at his homestead, and thereafter his burial site in the forest, to ask him to bring rain.

Restrictions on use of the forest were limited. People could collect fruit and fibre as they needed. However, they could only use the forest by day, and would suffer if they entered by night. With time, though, some of the traditional restrictions eroded. Fearing that traditions would be lost altogether, the Ibbu community decided to keep the history of the Chongo-camasaku alive and to revive protection of the forest. Headman James Munihango explains:

> *'Now we are deciding to re-originate our traditional culture as well as to secure this place. We have decided to protect this area on condition that it is important for our history and because of certain plant species like Munganda and Mubuyu trees, which can be found within the forest. Sometimes, also animals are found in this Chongo-camasaku.'*

The community has decided to designate the site as a community forest. At present they are awaiting new legislation, which they hope will enable them to secure its legal protection.

— *Charlotte Flower*

The early German foresters had attempted to establish alien plantations to meet the demand for timber. However, even then, unsustainable timber exploitation in natural forests continued. Huge areas of woodland in the Okavango, Caprivi and Otjozondjupa regions (map 1.10) were heavily logged in the past. A good example is the virtual extinction in the mining region of Tsumeb and Otavi of tamboti *Spirostachys africana*, a tree exploited for use as mine props.

In places where tamboti was cut, encroachment by blackthorn *Acacia mellifera detinens* and sicklebush *Dichrostachys cinerea africana* occurred. Bush-encroached land has more recently been extensively cleared in some areas for the production of charcoal sold to the Tsumeb Corporation copper smelter, which burns about 450 tonnes per month.[63,64] Yet bush encroachment remains a significant form of land degradation on nearly 12% of Namibia's land, and carries huge costs in terms of lost productivity[63] (Chapter 4).

Box 1.8 *Indigenous fruit tree development*

Little is known of the ecology and physiology of indigenous fruit trees in Botswana and Namibia, despite their importance to rural people. Most species produce fruit even under harsh conditions, through adaptations to drought and marginal soils. Given present overharvesting in many areas of Namibia, fruit trees will no longer be abundant in a few years' time.

Development of indigenous fruit trees could improve food security, reduce dependence on arable agriculture, help arrest soil erosion, and contribute to sustainable management of marginal areas in developing countries. With this in mind, a European Community-funded project called 'Sustainable domestication of indigenous fruit trees: interaction between soil and biotic resources in some drylands of southern Africa' began in 1997. The aim is to domesticate indigenous fruit trees and to study their effect on soils. Six species, promising both for their nutritional value and cultivation potential, have been selected in Namibia and Botswana: marula *Sclerocarya birrea*, manketti *Schinziophyton rautanenii*, monkey oranges *Strychnos spinosa* and *S. cocculoides*, wild medlar *Vangueria infausta* and raisin bush *Grewia flava*. Researchers from different disciplines in Botswana, Israel, italy, Germany and Namibia are studying germination requirements, nutritional value, nutrient uptake and growth enhancement through natural fertilisers such as seaweed extracts. The Namibian contribution will be done by University of Namibia MSc students.

— Sem Shikongo

The Directorate of Forestry (DF) in the Ministry of Environment and Tourism has just completed a forest cover mapping exercise and initiated a follow-up National Forest Inventory, surveying all woodlands on communal land north of 20°S. These two projects will allow the development of an important database for forestry, biodiversity and desertification applications, and generate a quantitative assessment of forest resources. The DF has also developed an incipient Community Forest Project, and houses the Tree Seed Centre, a project to collect, store and regenerate genetic material from economically valuable indigenous trees (see also Box 1.8; section 2.7).

Fig. 1.19 Sales of woodcarvings at Okahandja. Courtesy HH Kolberg

Woodlands of course contribute directly to the national economy in numerous ways. The craft industry is a rapidly increasing source of income for rural craftspeople, with an annual sales turnover of tree-based crafts of over N$20 million.[65,66] Okavango wood carvings, for example, may earn individual carvers N$1000-2000/yr. Woodlands contribute significantly to the economy through the charcoal industry,[63] valued at approximately N$8 million/yr,[66] and play an important role in the tourism industry in terms of wildlife habitat and forage as well as their inherent aesthetic value.[66]

The Directorate of Forestry's Strategic Plan[67] holds as priorities:

- *conserving natural ecosystems for their biodiversity and other values;*
- *enhancing agricultural productivity through soil and water conservation;*
- *supporting national efforts aimed at poverty alleviation and equitable development;*
- *restricting potential climate change.*

One of the most significant functions of indigenous woodlands is the support they provide to the subsistence economy of people living on communal land. As a large majority of Namibians depend on woody plants for fuel, construction materials, tools, food and medicine (Chapter 4), the focus on eco-system functioning, land productivity and

human development in the Forestry Strategic Plan reflects that poverty cannot be alleviated in degraded environments.

The most significant environmental functions of woodlands, in a global sense, are their role as repositories of genetic and other biological diversity, and their potential impact on global and regional climate by sequestering carbon and moderating humidity.[67] Watershed (or catchment) forests play an extremely important role in the prevention of soil erosion and the regulation of water flow and quality. Where droughts and destructive floods frequently follow each other, as in many parts of Asia and Africa today, this is evidence of environmental damage to watersheds and riverine woodlands following deforestation and overgrazing. If Namibia is to avert the fate of countries such as Madagascar, Mauritius, Tanzania and Indonesia, it is essential that we protect our catchments carefully through enlightened management practices.

Woodlands in central Namibia are important protectors of the upper catchments of the west-flowing ephemeral rivers. Ephemeral rivers such as the Kuiseb, Swakop, Omaruru, Ugab, Huab and Hoanib drain the central plateau and bring life to the desert in one of Namibia's most dramatic natural processes.[17] Riverine woodlands are also important dry season grazing areas. They support an impressive variety of plants, animals and fungi (Chapter 2), as well as human and livestock populations. The perennial Kunene, Kwando, Okavango, Chobe and Zambezi Rivers in the north support dense human populations and many species of aquatic plants and fish[68] (see below, and Chapters 2 and 4).

Namibia's forest resources have, up to now, helped satisfy the basic needs of the country's low-income rural and urban households for forest products. As human populations increase, however, there is an increasing need for vigilance to ensure that woodlands are protected and developed in a sustained way, so that they meet the diverse needs of present and future generations.

— Moses Chakanga & Phoebe Barnard

Fig. 1.20 Elephants in Caprivi Region. Courtesy P Tarr

Conservation and tourism

Environment-centred tourism is a significant and rapidly increasing industry in Namibia. The country boasts an unusual blend of stark scenic grandeur, rich wildlife, diverse habitats and excellent infrastructure. Overall, tourism expanded by 166% annually[69] in the early-mid 1990s (Chapter 4). Before 1990, tourism was largely oriented towards self-catering South Africans in state-owned and -run resorts and angling spots. After Namibia's Independence, the profile of foreign tourists began to shift towards wealthier, cosmopolitan visitors. Currently, a third of all foreign arrivals in Windhoek are South African, a third are German, and a third are a diverse mix of other nationalities.[70] Many visit other countries in southern Africa as part of a regional ecotourism package.

Namibia's Tourism Development Plan predicts 540 000 foreign tourists annually by the year 2000, with the creation of 20 000 jobs and gross foreign exchange earnings of N$1 billion.[70] The Tourism and Safari Association of Namibia (TASA) in 1997 had 140 registered operators in Namibia catering for ecotourism, hunting safari and general tourism markets.[71]

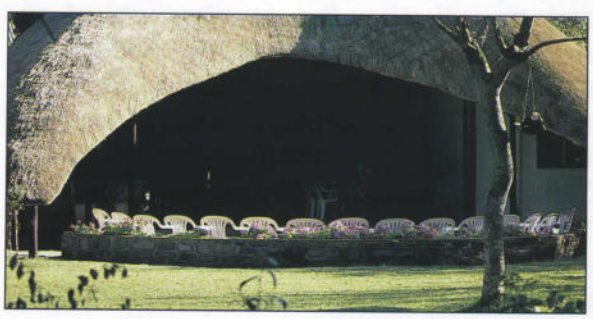


Fig. 1.21 Luxury tourism lodge. Courtesy P Tarr

Fig. 1.22 Small private bush lodge. Courtesy P Tarr

While capital-intensive tourism ventures have sprung up in Namibia from both foreign and local investments, these cater mainly for the wealthier foreign tourist. More recently, private individuals and rural communities are beginning to diversify their livelihoods into small-scale ecotourism ventures for the lower budget, more adventurous tourist (Chapter 4). Private guest farms, bed-and-breakfast concerns, small private lodges and community-run campsites have helped create a very diverse tourism industry based on scenic attractions and wildlife (Fig. 1.21).

How do these different ventures influence biological diversity conservation in Namibia? Indirectly, they have a strong positive effect in terms of income and job creation in environment-related fields at the private, community, or national levels (Chapter 4). Directly, they increase the proportion of habitats being protected in a relatively undisturbed state, considerably augmenting the network of state protected areas[72] (Chapter 2). The Namibian government has long recognised that tourism depends heavily on a pristine and attractive environment, as reflected in the combined Ministry of Environment and Tourism (MET). More recently, associations such as the Namibian Community-based Tourism Association (NACOBTA) have been founded by private and community operators in the expanding environmental tourism market (Fig. 1.22).

For rural communities, small-scale tourism initiatives can mean the difference between a life of poverty exacerbated by drought, and one of enterprise, pride and modest financial success. People in communally-held areas of Namibia used to be alienated from rights to wildlife and other natural resources on that land. Since 1996, amendments to the Nature Conservation Ordinance have allowed well-defined communities to regain the rights to manage, use, and benefit financially from wildlife (Chapter 5).

Ecotourism has been one such avenue of benefit for rural people, and can potentially flourish even faster than private tourism ventures on commercial farmland.[73] The advantages to communities are considerable, in terms of economic diversification, financial buffering against drought, job creation, use of local skills and knowledge, and training in new skills such as management, hospitality, and languages[73] (Chapter 4). However, the direct influence on biological diversity of tourism ventures, and land management practices associated with them, is much less easily quantified. Where land is protected from other forms of development for overall scenic and prisitine attractiveness to tourists, biological diversity is likely to be effectively conserved. Where game-viewing or hunting are specifically offered to tourists, however, the potential exists to manage land for the benefit of large,sought-after species, and not necessarily for the benefit of biodiversity as a whole (Chapter 4).

• *The state protected area network*

Namibia's state-controlled **protected area network (PAN)** consists of 21 parks and reserves proclaimed under section 14 of the Nature Conservation Ordinance (map 1.9; Box 1.9). These state parks alone make up about 13.8% of Namibia's land area. Two of our national parks, Etosha and Namib-Naukluft, are among Africa's biggest and most important parks. Etosha National Park (previously 'Game Reserve no. 2') was dramatically reduced in size by over 70% to gain land for ethnic partitioning under the terms of the 1964 Odendaal Commission report.[41] Prior to that, it was among the biggest parks in the world, with at least 88 000 km^2 protected in a rugged and endemics-rich area stretching from Etosha Pan to the coast (Box 1.9).

Fig. 1.23 Mountain zebras at Namib Naukluft Park. Courtesy P Tarr

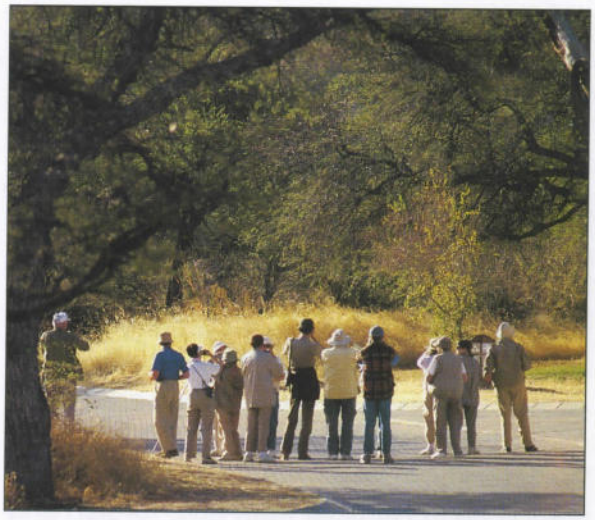


Fig. 1.24 Birdwatching at Waterberg Plateau Park. Courtesy P Tarr

Box 1.9 Namibia's state-controlled protected areas[a]

	Park	Area (km²)	Established	Comments
1	Etosha National Park[b]	93 240.00	1907	
	amended	89 834.00	1947	
	amended	99 526.00	1958	
	amended	27 554.00	1963	Odendaal report[41]
	amended	22 912.00	1975	1997 measurements (ODA)
2	Namib-Naukluft Park	49 768.00	1907	amended 5 times 1968-1990
3	Gross Barmen Hot Springs	0.10	1968	
4	Caprivi Game Park	5 715.00	1968	
5	Hardap Recreation Resort	251.77	1968	
6	Daan Viljoen Game Park	39.53	1968	
7	Cape Cross Seal Reserve	60.00	1969	
8	Ai-Ais/ Hunsberg Reserve Complex	461.17	1969	then called Ai-Ais Hot Springs
	amended	3 461.17	1988	Huns Mts incorporated
9	South West Nature Park	0.04	1970	
10	Skeleton Coast Park	8 000.00	1971	
	amended	17 450.00	1973	
11	Waterberg Plateau Park	405.49	1972	
12	Von Bach Recreation Resort	42.85	1972	
13	Nat'l West Coast Recreation Area	13 000.00	1973	
	amended	7 800.00	1974	
14	Nat'l Diamond Coast Recreation Area	50.49	1977	
15	Naute Recreation Resort	224.62	1988	
16	Mangetti Game Camp	482.92	1988	
17	Popa Game Park	0.25	1989	
18	Mahango Game Park	244.62	1989	
19	Khaudum Game Park	3 841.62	1989	
20	Mudumu National Park	1 009.59	1990	
21	Mamili National Park	319.92	1990	
Total		114 079.98		

[a] Updated from Baker.[74] As not all parks have been precisely measured with modern techniques, size data for some are not yet definitive.

[b] Pre-1963 data for Game Reserve no. 2 (now Etoshà National Park) are probably inaccurate; the park may never have been larger than *c.* 88 000 km².[75,76]

On its own, Namibia's large, relatively very well-managed state protected area network is ecologically unrepresentative, and is thus not wholly adequate as a basis for protecting our biological diversity. In some cases, private and community conservation efforts help fill this gap, but additional protection measures are needed in others. Chapters 2 and 3 identify areas of unusual ecological value, many of which need additional protection.

• *Conservancies*

Conservancies are land units managed jointly for resource conservation purposes by multiple landholders, with financial and other benefits shared between them in some way. They occur on both commercial (private) and communal (tribal) land. Most aim to enhance habitat for, and numbers of, game species such as ungulates or gamebirds, and many draw income from tourism ventures.[77] Over 10 000 km^2 of farmland has so far been consolidated into nine commercial conservancies, ranging in size from 600 km^2 to 2 300 km^2 and bound by constitutions and ecologically-sensitive land management plans.[78] Other commercial conservancies are now being formed. Many are increasing in size, as previously skeptical landowners agree to join existing conservancies.

Communal land conservancies are also being developed by some rural communities, and will mainly be very large. As of late 1997, five large communal conservancies have submitted formal proposals for gazetting. One of these is an area of about 9 023 km^2 managed by Ju' //Hoan (San) people at Nyae Nyae in the ecologically diverse Tsumkwe pan region.[79] Another is an arid region of almost twice this size in the former western corridor of Etosha National Park, stretching along the eastern boundary of the Skeleton Coast Park. The proximity of state protected areas offers rural people in these regions considerable potential for financial and economic gain,[80] making ecotourism and conservancy management very attractive land use options.

Conservancy management is a land use which complements, and does not necessarily exclude, traditional farming. It can thus diversify people's livelihoods, broaden their resource dependence as a means of coping with drought, and potentially double household incomes.[81] Many rural communities have been stimulated to form conservancies by the government's recent policy to return resource management rights and responsibilities to carefully defined conservancy committees with an approved constitution.[82] Most communities which have expressed a desire to form conservancies are expected to have formalised them by the year 1999. To compete with other land uses, however, all wildlife-based initiatives must remain financially and economically competitive,[83] which means making optimal and sustainable use of wildlife resources. Any actions undermining the principle of sustainable wildlife use may therefore jeopardise biodiversity conservation aims in Namibia.

• *Private reserves and game farms*

Privately owned **nature reserves and game farms** can play a significant role in biodiversity protection in Namibia. Some are extremely rich in endemic species, unique landscape features, or both (Fig. 1.25). Both categories are fairly abundant on commercial farmland. As of 1995 there were 148 private nature reserves totalling 7642 km^2, or 0.9% of Namibia's land area, registered with the Ministry of Environment and Tourism.[84,85] Statistics for the number and extent of game farms are unavailable, but game farming has become a multi-million dollar local industry[77,86] since 1967, when commercial landowners were granted rights to use and benefit from wildlife on their farms, subject to certain conditions.[86]

Private reserves and game farms differ in legal status and management system (see also Chapter 5) and their success in conserving biodiversity has not yet been formally evaluated in Namibia. Regulations applying to private nature reserves are generally stricter than those for game farms, so private reserve owners who wish to hunt game for commercial purposes must first deproclaim their land. Largely for this reason,

there has been an average annual loss of about 3% of all private reserves between 1979 to 1994.[85] Game farming can be both very lucrative and effective at conserving habitats. Yet because it involves deproclaiming conservation sites in the private network, it renders land less secure for conservation. Furthermore, management for desired game species may not necessarily conserve biodiversity in the broader sense.[83]

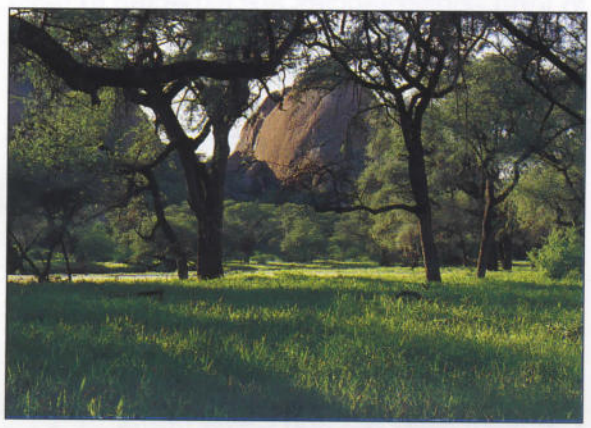


Fig. 1.25 Private nature reserve, Otjume Ost. Courtesy R Simmons

• *Protected industrial areas*

Namibia is unusual in having a vast tract of land protected by the mining industry for its own activities (Map 1.9). The 26 000 km² *Sperrgebiet* or 'Forbidden Area' is by far the largest of these areas, and has been covered by various temporary industrial concessions for nearly 90 years. Not long after diamonds were found near Lüderitz in 1908, large areas were declared strictly off-limits to anyone other than the companies granted prospecting and mining rights, which were bought up by Sir Ernest Oppenheimer after World War I to become the Consolidated Diamond Mines of South West Africa Ltd.[16]

Although mining occurs only in a narrow strip along the southern Namib coast and Orange River, a strip of desert about 100 km wide and over 300 km long was included in this prohibited area. This not only helped protect the coastal diamond areas from unauthorised access, due to the harsh terrain that would have to be crossed to reach them, but coincidentally protected some of the country's most pristine and specialised ecological communities from disturbance (Figs. 1.26-1.28). It has also kept intact many sites of high geological, palaeontological, historic and archaeological value.[16]

Environmental conservation has only recently been recognised by the mining industry as an important by-product of its land tenure. The remoteness and prohibited status of the *Sperrgebiet* have kept large inland areas from being developed inappropriately. Coastal and intertidal habitats, however, have suffered major, if localised, ecological damage from mining (Chapter 3). Three *Sperrgebiet* habitat types or areas have been identified as environmentally most sensitive:[16]

- **the Orange River valley** along the southern border is a scenically dramatic 'linear oasis' through arid terrain. It supports many succulent and fog-dependent species which occur nowhere else in the Namib or Namibia. The river mouth is a wetland of international significance, and the valley is immensely rich in marine and terrestrial fossils.

- **the Atlantic coast, offshore islands and coastal dune hummocks** harbour many endemic animals, breeding seabird colonies, and specialised fog-dependent lichens and hummock vegetation, as well as sites of historical, archaeological and palaeontological value.

- **the inland inselbergs, mountain ranges and rocky outcrops** are important ecological refuges for many highly restricted-range plant species and some rare or threatened animals. Once degraded, they are effectively impossible to rehabilitate. Mountains such as the Aurusberg and Roter Kamm meteorite crater combine unsurpassed scenic grandeur with a diverse and unique succulent flora.

These three zones must be stringently protected to ensure that biodiversity loss and other forms of habitat degradation cannot occur[16] (Box 1.10).

Box 1.10 Options for the Sperrgebiet

How can the Sperrgebiet — unique, spectacular, largely undisturbed, agriculturally unproductive, with immense unrecognised value — best be used for Namibia's present and future benefit? Currently, an agreement between the Namibian Government and NAMDEB restricts access as long as present mining operations continue, and until the possibility of further diamond reserves has been ruled out. What will then happen to the Sperrgebiet? Development strategies must be carefully scrutinised due to the vulnerability of the area. Any future mining and prospecting for diamonds or other minerals must be carried out with minimal damage to the environment. In the short term, Namibia can reap benefits from mining activities, but these accrue from non-renewable resources. A better alternative is to encourage sustainable ecotourism, thus drawing on the wilderness, scenic grandeur, scientific and historical value of the Sperrgebiet while protecting its largely pristine character. In the long run, this would be more compatible with the sensitivity of the area, and could generate considerably more revenue. Discussions about a sustainable management plan for the area have begun between the MET, MME, NAMDEB and other parties. Whichever paths are taken, Namibia should be careful not to forfeit the potential of the Sperrgebiet for future generations.

Sources: Pallett,[16] P Tarr & L van Rooyen[87]

Fig. 1.26 Central *Sperrgebiet* plain. Courtesy G Williamson

The vast natural terrarium of the *Sperrgebiet* is of extraordinarily high value in terms of biodiversity and tourism. The area forms one of the last major refuges for red data mammals such as water mongoose *Atilax paludinosus*, grey rhebok *Pelea capreolus*, African wild cat *Felis sylvestris*, cheetah *Acinonyx jubatus*, aardwolf *Proteles cristatus*, Cape clawless otter *Aonyx capensis*, brown hyaena *Hyaena brunnea*, spotted hyaena *Crocuta crocuta* and bat-eared fox *Otocyon megalotis*.[16] Many important red data wetland and seabirds rely on the Orange River mouth and islands off the *Sperrgebiet* coast. Over 700 plant species are believed to occur in the area, of which about 50 species (8%) are endemic to the *Sperrgebiet*.[88] Dozens of highly restricted plants, some endemic to single mountains, may remain unclassified.[88] We may expect this high plant endemism to be correlated with high insect endemism, through coevolutionary associations such as pollination and herbivory.[16] Ninety lichen species, all highly fog-dependent, are found there. The area also has fascinating and impressive fossil deposits dating from the Cretaceous period about 85 million years ago.

Fig. 1.27 South Elizabeth Bay dunes. Courtesy G Williamson

Fig. 1.28 *Conophytum taylorianum ernianum, Sperregebiet.* Courtesy G Williamson

Wetlands

As Namibia is so arid, its wetlands have an ecological, economic and social impact greater than one might think. Most of its wetlands are ephemeral. Only five rivers, all with their headwaters in other countries, are

perennial: the Kunene, Okavango, Zambezi, and Kwando Rivers, shared with Angola, Zambia or Botswana, and the Orange River, shared with South Africa. Almost 5% of Namibia's land area is classified as wetlands,[89] both coastal and inland (section 2.1).

Inland wetlands are concentrated mainly in the northeast of Namibia, where rainfall is much higher. The Okavango, Kwando and Zambezi Rivers are located here, with their associated tropical wetlands covering over 5000 km^2.[90,91] Further west is Namibia's famous ephemeral wetland, the Etosha Pan/ Cuvelai inland delta complex with its *oshana* drainage channels. Many of the *oshanas* are fed by seasonal *efundja* floodwaters, originating in the Angolan highlands and sometimes flowing as far south as the Etosha Pan. *Oshanas* are ecologically and economically important, receiving irregular seasonal influxes of water and nutrients. They are a key source of fish and other wetland resources for rural people in the Cuvelai Basin.[92,93] The seasonal Tsumkwe or 'Bushmanland' Pans in eastern Otjozondjupa Region are a stopover for migratory birds on their flights to and from overwintering grounds. Namibia's other very important group of ephemeral wetlands is found in the catchments of the west-flowing rivers,[17] which drain the central highlands through hyper-arid western Namibia to the Atlantic Ocean. These rivers are, in essence, linear oases for humans and many other species in the otherwise inhospitable desert.

Namibia's coastal wetlands are few in number, but highly important ecologically. As the coastline is bleak, hyper-arid and forbidding to most non-marine life, the few sheltered bays and freshwater intrusions along its 1470 km length have assumed a disproportionate ecological significance.[94,95] Coastal wetlands consist mainly of extensive mudflats, sheltered marine waters and small estuaries. Due to the productive marine upwellings of the Benguela Current (Chapter 3), and the inhospitable terrain between isolated wetland sites, Namibia's coastal wetlands are rich in species and nutrients. Productivity of the central coast in terms of intertidal life is higher than that of the north and south.[96]

Unfortunately, rather little is known of coastal wetland biota, with the exception of birdlife.[94,97] Two coastal sites, Sandwich Harbour and Walvis Bay, host almost 200 000 migratory shorebirds during peak migration periods, and are the most critical coastal wetlands for birds in the entire southern African region.[98] At our northern border with Angola, the Kunene River slices through extremely rugged and arid terrain to form a small but unusually rich estuary in the tropical warm-water zone. This lagoon is Namibia's second most species-rich coastal wetland for birds, and fourth in importance for bird densities.[95] It supports breeding Nile crocodiles *Crocodylus niloticus*, and two tropical turtles may breed there.[99,100] The high avian species richness, tropical reptile fauna, and extreme isolation from other coastal wetlands make the Kunene mouth a unique and important site. It faces a significant threat from proposed upriver hydroelectric development.

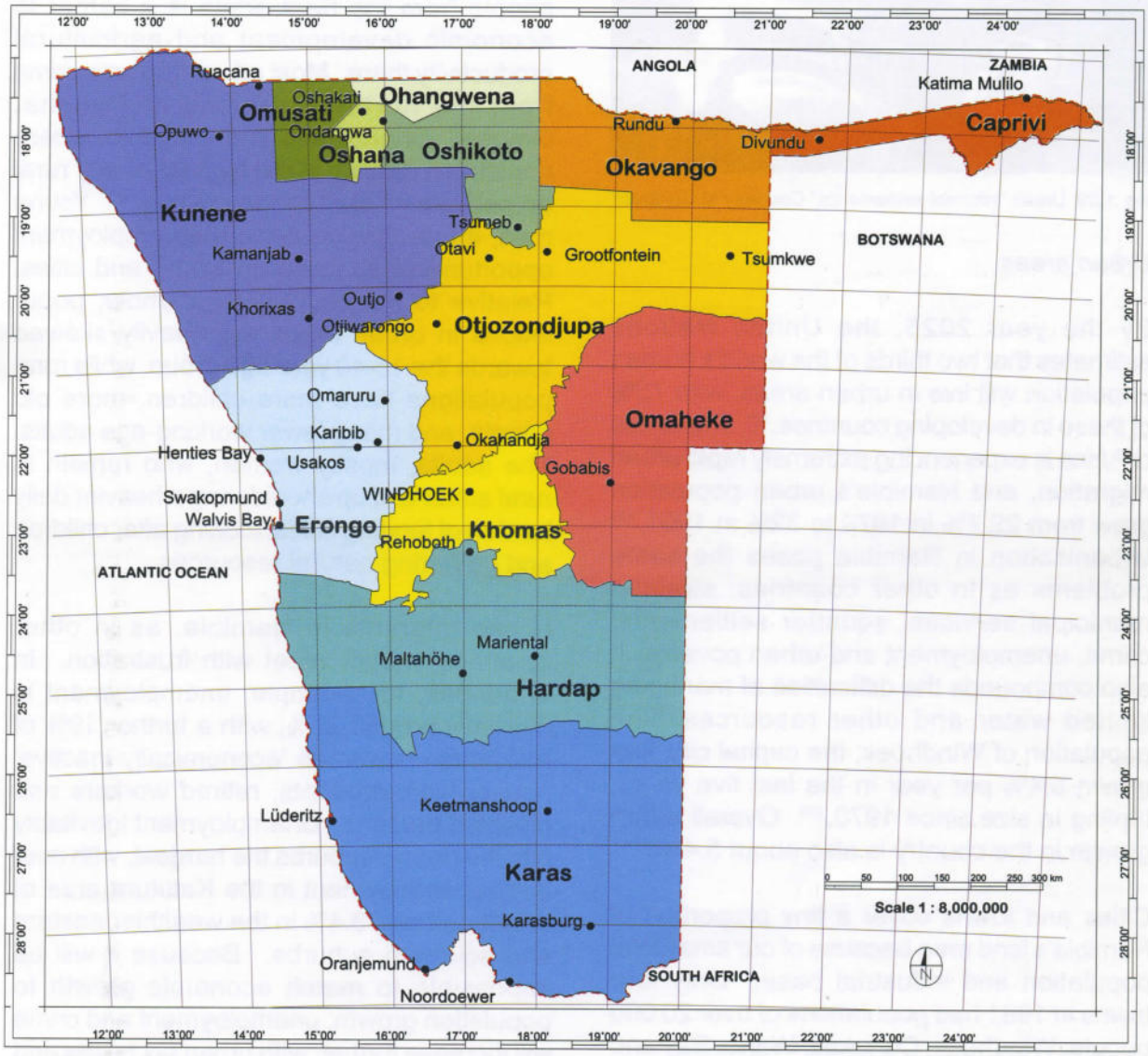
Major threats to inland wetlands include habitat alteration through agriculture and intensive settlement, overfishing in perennial rivers, invasive alien species, and livestock overgrazing in floodplain vegetation. Main threats to the biological diversity of coastal wetlands include beach disturbance from intensive angling and motor vehicle use, pollution from offshore oil exploration, and other industrial or harbour development. In the west-flowing rivers, including the Kunene and Orange, imprudent disruptions of hydrological flow through dam construction will almost certainly cause local or national extinctions of organisms adapted to these very variable rivers.[95]

Namibia acceded to the Ramsar Convention on wetlands of international importance in December 1995. It initially designated four wetlands as Ramsar sites: the Walvis Bay wetlands, Sandwich Harbour, the Orange River mouth (shared with neighbouring South Africa), and the Etosha Pan/ Cuvelai inland delta complex.[101] A further eight wetlands have been proposed for the list, as well as three of Namibia's offshore islands.

Wetlands and riparian habitats are discussed in detail in section 2.1, Ecological diversity.

—Holger Kolberg & Rob Simmons

Map 1.10 Regions and major towns of Namibia



Regions and Towns

- Okavango
- Caprivi
- Kunene
- Ohangwena
- Omusati
- Oshana
- Oshikoto
- Otjozondjupa
- Omaheke
- Erongo
- Khomas
- Hardap
- Karas
- Border
- Major Towns

Source:

Various Government Gazettes published by the Government of Namibia.

Ministry of Lands, Resettlement and Rehabilitation Division of Survey and Mapping 1:250000 maps.

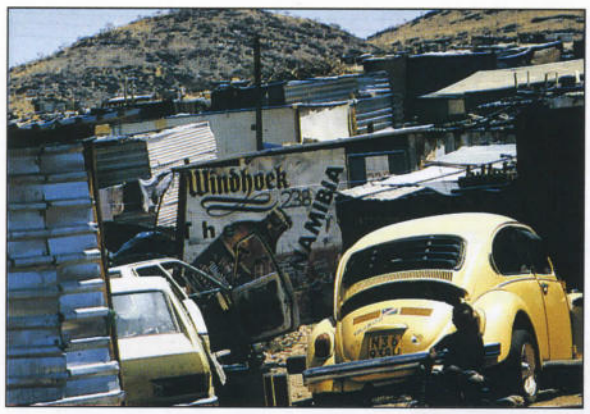


Fig. 1.29 Urban 'informal settlements.' Courtesy M Goldbeck

Urban areas

By the year 2025, the United Nations estimates that two thirds of the world's human population will live in urban areas, with 75% of these in developing countries.[102] The whole of Africa is experiencing extremely rapid urban migration, and Namibia's urban population grew from 22.7% in 1970 to 32% in 1991.[103] Urbanisation in Namibia poses the same problems as in other countries: strained municipal services, squatter settlements, crime, unemployment and urban poverty. It also compounds the difficulties of managing limited water and other resources. The population of Windhoek, the capital city, has grown 5.4% per year in the last five years, tripling in size since 1970.[103] Overall urban growth in the country is also about 5.4%.[104]

Cities and towns cover a tiny proportion of Namibia's land area because of our small total population and industrial base. Only four towns in 1991 had populations of over 20 000 people: Windhoek, Oshakati, Walvis Bay and Rehoboth (map 1.10). Rapid urbanisation may therefore seem to pose less dramatic environmental, social and economic problems than in some nations. However, due to the country's aridity and already overextended water resources, some water-thirsty towns are already effectively overpopulated at current consumption levels.[17,103] Many towns are developing in sensitive or marginal areas, including riparian zones, and on diminishing or saline aquifers. Coastal development, especially at the rapidly growing port of Walvis Bay, has led to a 10 m drop in some areas of the Kuiseb alluvial aquifer.[17] The western town of Khorixas has had an astonishing mean daily water consumption of nearly 500 litres per person, lowering water levels in its aquifer by 50 m in recent years.[17]

From a different angle, the drain of working people from the rural areas is a barrier to economic development and agricultural productivity there. Most urban migrants come from the northern regions of Oshana, Omusati, Ohangwena and Oshikoto, where population density is the highest of any rural or 'peri-urban' area in the country.[103] Young men, especially, perceive their employment opportunities as better in towns and cities. Relative to the country as a whole, populations in urban areas are heavily skewed towards the 15-40 year age group, while rural populations have more children, more old people, and many fewer working-age adults. The adults, mostly women, who remain in rural areas end up shouldering a heavier daily burden of tending fields, looking after children and gathering natural resources.

Urban migrants in Namibia, as in other countries, mainly meet with frustration. In Windhoek, for example, unemployment is currently around 22%, with a further 19% of residents classed as 'economically inactive' housewives, students, retired workers and disabled persons. Unemployment inevitably hits the poorer suburbs the hardest, with over 33% unemployment in the Katutura area of Windhoek and 3.4% in the wealthier eastern and southern suburbs. Because it will be impossible to match economic growth to population growth, unemployment and crime will increase further, with urban tax bases and municipal services declining rapidly unless urban migration can be slowed.[103]

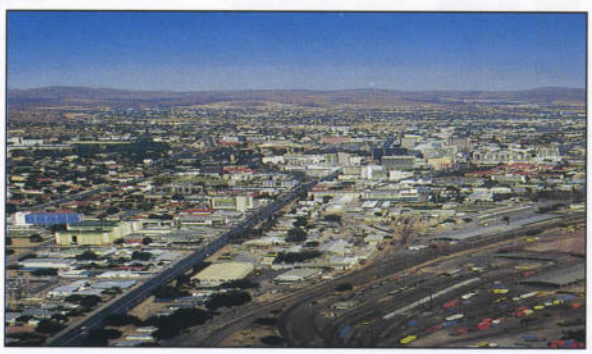


Fig. 1.30 Windhoek urban sprawl. Courtesy P Tarr

1.3 Key issues affecting biodiversity conservation in Namibia

This chapter has sketched a brief picture of Namibia's physical, social and economic environment, as well as its often grim history of natural resource conflict and political self-determination. In one way or another, each of these aspects has shaped the difficulties we in Namibia face today. It is a daunting challenge to find effective and lasting ways of safeguarding the country's superb and unique environment, so that people and their grandchildren can share in the wealth of a country which was for so long denied. These challenges become more daunting each year, as the admirable gains made by Namibia's new leaders in establishing a sound footing for development become strained by increasing population growth and unemployment.

We have tried to weave three major threads through this chapter. The first is the thread of environmental constraints. Namibia is an arid country, with thin and infertile soils, and will (from a human perspective) always be so. Development options for the country which do not recognise this fundamental reality may bring only hardship, wasted money, dashed expectations and perhaps lasting environmental damage. By contrast, development decisions and projects which make effective use of the country's natural beauty, renewable resources and human wisdom can help ensure that our children lead lives of pride and self-determination, rather than of hardship, despondency, poverty and dependency. Namibia's constitution obliges us to use our environment and resources wisely, without degrading or depleting them. Unfortunately, not all decisions are made with the necessary circumspection that our constitution requires of us, but hopefully we are learning from our mistakes.

The second thread is that of injustice in natural resource distribution and access. Namibians have fought hard for political independence and self-respect through generations of an often harrowing colonialism. Land, minerals, water, fish stocks and other resources have been developed in many ways, and squandered in others, by many different parties in Namibia's past. Our colonial history has left at least three direct legacies. One is a frontier country's legacy of boom-and-bust natural resource-based industries, some of which still suffer from past overexploitation. A second legacy is a deep mistrust among many ordinary Namibians of the aims and means of environmental conservation, since in the past, conservation often meant removal from traditional lands, denial of access to essential resources, and deepening poverty and dependency.[72] The moves Namibia has made since Independence to redress these wrongs are a good start in healing this mistrust.

However, a third legacy, and a much more positive one, is the legacy of scientific enquiry created by Namibia's colonial rulers. Important data on our biological resources, so necessary for insights on environmental change and biodiversity management, stretch back decades, and sometimes generations. These data may often be patchy, often anecdotal, and often seemingly directionless, but more often than not they are useful. Our challenge now is to build on this scientific legacy in Namibia, to focus it, and to make it more cost-effective in the support of environmental planning and management.

Finally, the third thread raised in this chapter is more fully developed in those to follow. This is the degree to which human development in Namibia is underpinned by environmental health, particularly biological diversity. The vast majority of our people live directly from the land and rely heavily on its biological resources and habitats for food, housing materials, tools, medicines, and livelihoods. Unseen biological diversity in our soil, for example, is the slim thread that keeps our rangelands, croplands and woodlands functioning. We have little idea of how this happens, nor of how our land management practices safeguard or jeopardise these essential ecosystem 'services' to humankind. Research and information on these processes deserves the most urgent support.

Although many people may regard the aims of 'nature conservation' with disdain, and equate 'biodiversity' with large huntable game, it is our hope that this book, and the lay publications to follow, will convince people that their health, their survival, and their livelihood lies in the protection of our brittle, spectacular natural environment.

— Phoebe Barnard

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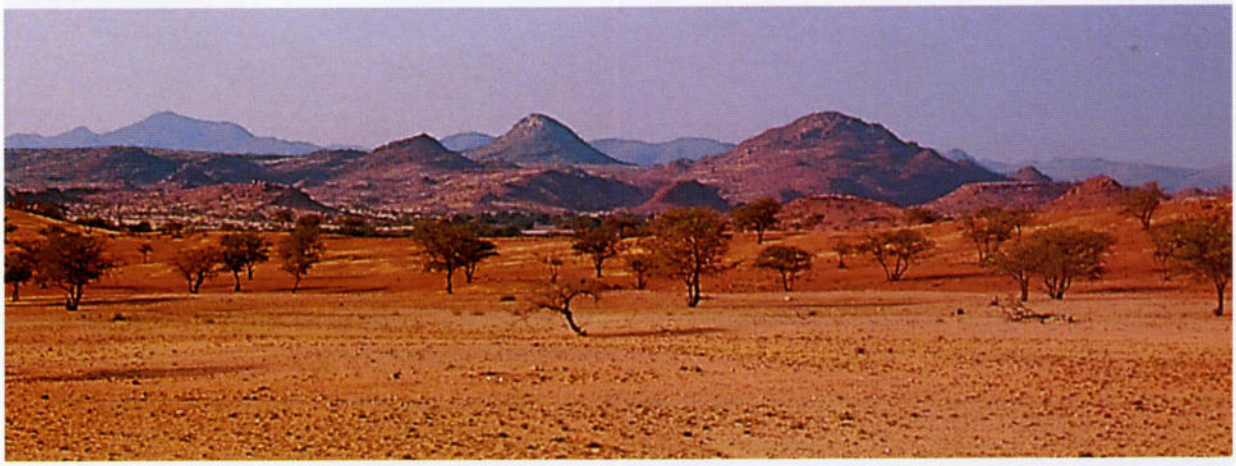
Biodiversity of terrestrial and freshwater habitats 2

Coordinated by Phoebe Barnard with Shirley Bethune (wetlands) and Herta Kolberg (genetic resources)



Courtesy P Tarr

What do we know so far about the biological diversity of our land and freshwater habitats? What are the most pressing conservation priorities for these habitats and the species they support? How can our terrestrial and aquatic diversity be safeguarded in the natural environment, and what facilities exist for *ex situ* conservation of material in gene banks and biological gardens? This chapter addresses these questions, and summarises taxonomic richness, endemism, conservation status, and related issues for terrestrial and freshwater species.

2.1 Ecological diversity in Namibia

The search for patterns is a basic aim of any science, indeed of most human endeavours. Ecologists have long tried to classify species, communities, habitats, ecosystems and biomes as a way to simplify the complex natural world.

Ecological diversity is often described broadly in terms of *biomes* or *ecosystems*. Namibia's four main terrestrial biomes (below) are a broad-brush representation of the country. Ecosystems, a middle level of organisation, are generally regarded as self-contained groups of organisms and their physical environment which together form a recognisable entity.[1] However, Namibia has no scheme for classifying ecosystems, and the Biodiversity Task Force opted not to develop one afresh, finding the concept ill-defined. Existing classification schemes for biomes, vegetation types and wetlands were felt to summarise Namibia's terrestrial and freshwater variety adequately, even if they need fine-tuning in specific areas. This chapter therefore summarises the most widely used classifications at these three levels, as indices of Namibia's ecological wealth and variety on land and water. A wetland classification has not previously been published for Namibia, so the following wetland section is longer than the terrestrial summaries.

Biomes

The most widely used classification of Namibian terrestrial biomes is that of Irish,[2] portrayed in map 2.1a. This uses an 'objective categorisation' approach[3] based on dominant and codominant vegetation life forms or structures, correlating with indices of summer aridity and rainfall seasonality (Figs. 2.1-2.8). The scheme distinguishes four major terrestrial biomes (desert, Nama-Karoo, succulent Karoo and savanna). Although animal distribution data on their own cannot realistically be used to delineate biomes, insect distribution data have helped confirm the general validity of this objective categorisation method.[2] Distributions of sedentary and non-

Fig. 2.1 Semi-arid savanna (HH Kolberg)

Fig. 2.2 Moist savanna (J Irish)

Fig. 2.3 Typical Nama-Karoo (J Irish)

Fig. 2.4 Edaphic Nama-Karoo of Etosha Basin (J Irish)

Fig. 2.5 Lowland succulent Karoo (J Irish)

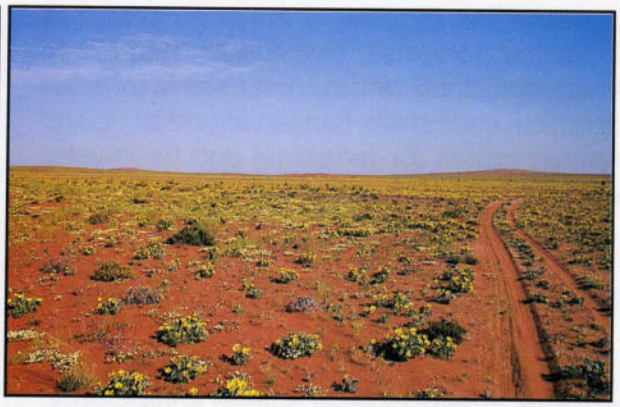


Fig. 2.6 Succulent Karoo (M Müller)

Fig. 2.7 Southern Namib (J Irish)

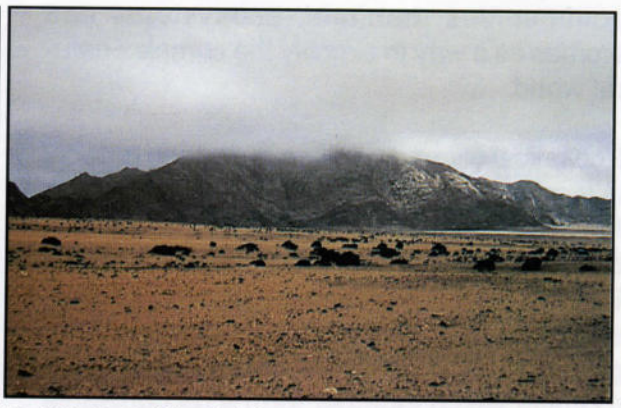
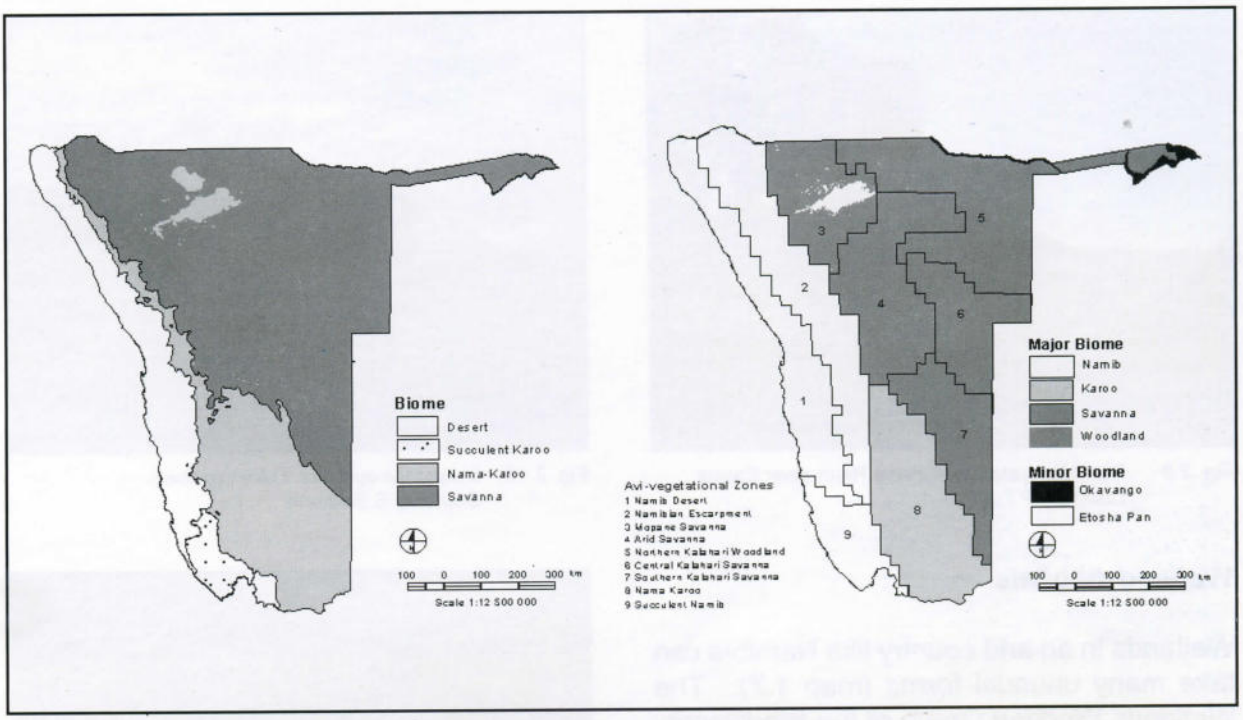


Fig. 2.8 Central Namib in fog zone (J Irish)



Map 2.1 Terrestrial ecological classifications of Namibia: (a) Irish's[2] biome scheme and (b) the SABAP scheme[6,7]

host-specific insect families correspond to these biome patterns better than to previous classification schemes.[4,5] Irish's scheme is a very useful framework on which more detailed analyses can be done of certain regions. Classification of the endemics-rich northwestern Namib escarpment as Nama-Karoo, for example, is debated by some biologists, but the overall validity of the scheme is agreed. A similar biome classification (map 2.1b) has been used by Africa's largest biodiversity project, the Southern African Bird Atlas Project (SABAP),[6] and by a recent diversity analysis of Namibian birds[7] (see sections 2.6 and 2.9).

Vegetation communities

At a finer scale, most botanists in Namibia use the system of vegetation types proposed over 25 years ago by Giess,[5] who divided the country into fourteen zones in three broad categories (map 1.8, summarised in section 1.1). As floral diversity and phytogeography underpin the diversity and geography of so many other taxa, many of the conservation status accounts for taxa in this chapter are based on Giess' vegetation types as an index of habitat diversity.

Giess' influential scheme is broadly endorsed today, although he regarded it as preliminary and based on patchy data in some areas. The escarpment also requires more detailed analysis in this scheme: it is categorised as Semi-desert and Savanna Transition in central-western Namibia, but is misclassified as Mopane Savanna in its northern sections. Ongoing work at the National Soil Laboratory and National Botanical Research Institute to develop an agro-ecological zone system may help clarify the floristic nature of some areas.

The SABAP scheme also uses nine 'avi-vegetational zones' to explain patterns of bird distribution and abundance: Namib Desert, Namibian Escarpment, Succulent Namib, Nama Karoo, Mopane Savanna, Northern Kalahari Woodland, Central Kalahari Savanna, and Southern Kalahari Savanna. The SABAP scheme attempts to merge avifaunal and floristic distribution patterns, and differs from Giess' scheme where bird distributions warrant amalgamation of vegetation types. Other minor differences appear in the classification of the northern escarpment and mopane belts.[6,7]

Fig. 2.9 Riverine systems: Kunene River near Epupa. Courtesy P Tarr

Fig. 2.10 Lacustrine systems: Lake Liambezi. Courtesy S Bethune

Wetland habitats

Wetlands in an arid country like Namibia can take many unusual forms (map 1.7). The Wetlands Working Group of the Biodiversity Task Force uses the Ramsar Convention on Wetlands definition of wetlands: *areas of marsh... or water, whether natural or artificial, permanent or temporary (ephemeral), with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.*[8] The classification of wetlands used by the Ramsar Convention has been adapted for Namibia in a previously unpublished scheme (Table 2.1; Figs. 2.9-2.11):

Riverine systems: flowing or *lotic* systems such as rivers and their floodplains and estuaries, including river mouths and freshwater lagoons.

Lacustrine systems: standing or *lentic* open water systems such as lakes, pans and impoundments.

Palustrine systems: well-vegetated lentic systems such as swamps, marshes, *vleis* or *mulapos*, springs and seeps.

Marine systems: shallow ocean overlaying the continental shelf and coast, such as mudflats, lagoons and rocky shores. Namibia has no mangrove swamps or coral reefs.

Since this chapter focuses on terrestrial and freshwater systems, Table 2.1 does not deal with marine wetlands (see Chapter 3).

Fig. 2.11 Palustrine systems. Courtesy P Tarr

Riverine systems

River systems in Namibia include both perennial rivers and their floodplains as well as the more typical ephemeral rivers, called *omiramba* in the northeast (maps 1.5, 1.7). Perennial rivers occur only on our national borders and are shared with neighbouring states. The Kunene River originates in Angola, the Okavango is shared with Angola and Botswana, the eastern Caprivi rivers (the Zambezi, Kwando, Linyanti, Chobe) originate in Zambia, and the Orange originates in Lesotho and is shared with South Africa. These rivers carry large volumes of water. Most of the mean annual runoff of the Zambezi (40 000 million m^3), Orange (11 000 Mm^3), Okavango (10 000 Mm^3), Kunene (5500 Mm^3), and Kwando-Linyanti rivers (1300 Mm^3) originates in the upper catchments in neighbouring countries, and local rainfall contributes very little.

Table 2.1 Freshwater wetland systems of Namibia

Classification	Defining characters	Namibian examples
Riverine		
Perennial rivers	Rivers that flow throughout the year	Kunene, Okavango, Zambezi, Orange, Kwando-Linyanti-Chobe Rivers
Floodplains and backwaters	Low-lying areas and depressions next to rivers	Okavango and eastern Caprivi floodplains
River mouths	Predominantly freshwater wetlands which form where rivers meet the sea	Kunene and Orange river mouths
Ephemeral rivers or omiramba	Rivers flowing only after heavy rains, sometimes not for several years	Kuiseb, Nossob, Ugab, Huab rivers, Omatako Omuramba
Oshanas	Seasonal, shallow, interlinked pans with inflow from rain and seasonal floods	Cuvelai drainage area
Lacustrine		
Floodplain and oxbow lakes	Shallow lakes in depressions or old rivercourses in floodplain areas	Lake Liambezi (now dry), small lakes in the eastern Caprivi floodplains, *e.g.* Lake Lisikili
Sinkhole lakes and caves	Small, deep, permanently filled caverns and sinkholes	Otjikoto and Guinas Lakes, Aigamas and Dragon's Breath Caves
Pans	Shallow, ephemeral, unvegetated pools in depressions filled by local rainfall or endoreic rivers	Nyae-Nyae Pan, Etosha Pan, Kalahari *pannetjiesveld*,' Sossusvlei, Tsondabvlei
Dams and impoundments	Man-made lakes formed when rivers are impounded by a dam wall	Hardap, von Bach, Olushandja Dams and numerous small farm dams
Palustrine		
Swamps	Well-vegetated wet areas with open standing water associated with perennial rivers	Linyanti Swamp
Marshes	Well-vegetated, water logged areas with little visible open water, found along perennial rivers	Confluence of the Okavango and Cuito Rivers
Vleis or *mulapos*	Seasonal or permanent shallow, vegetated pools dependent on local rainfall or fed by groundwater rising to the surface	Tsumkwe *vleis*, *e.g.* Makuri Pan
Seeps and springs	Permanent vegetated pools and streams formed by artesian waters	Sesfontein, Karstveld, Naukluft springs
Geothermal springs	Small permanent pools fed by hot groundwater rising to the surface from a great depth	Ai-Ais, Gross Barmen, Rehoboth, Warmquelle, Klein Windhoek springs
Estuarine		
Estuaries	Wetlands at the mouths of perennial rivers subject to both tidal and river inflows	Kunene River mouth

Most of Namibia's rivers, however, are ephemeral (map 1.7). They flow only for a few days each year, and often not for several years, but may store important volumes of surface- and groundwater (Box 2.1). Subsurface flow and water stored in sediments can support vegetation.

The west-flowing ephemeral rivers drain higher rainfall areas inland, channelling runoff across the Namib Desert to the Atlantic in 'linear oases' which support species normally found only in wetter areas.[9,10] Omuramba Omatako is the largest north-flowing *omuramba* (maps 1.5, 1.7), but its waters have not reached the Okavango River in living memory due to blockage by dunes and vegetation. The east-flowing Nossob River and its tributaries historically fed into the eastern Orange River catchment, but have not done so since 1934. By contrast, the south-flowing Fish River and its tributaries regularly feed the Orange.

These rivers are the focus of human settlement in otherwise dry regions.[10] Sandy rivercourses and alluvial aquifers provide year-round groundwater to riparian forests, people, their stock, and wildlife. Groundwater seeps to the surface in some places; in others the water table can be reached by digging. Gemsbok, zebra and elephant are adept at this, and the holes they dig are used by a myriad of other wildlife.

Floodplains are seasonally or periodically flooded areas adjacent to perennial or ephemeral rivers (Box 2.2). Three types occur on our rivers: The most common are *fringing floodplains*, found along rivers where flat terrain allows seasonal inundation with rising floodwaters. Less common are *riverine swamps*, more permanent wetlands found at river confluences such as the junction of the Cuito and Okavango rivers. The Okavango Swamps in neighbouring Botswana are a good example of an *endoreic floodplain* (one with no outflow).

Box 2.1 Ephemeral river dynamics

Unlike perennial rivers, in which a 'flood' is a dramatic rise in water levels, spilling the banks and inundating surrounding areas, in the normally dry ephemeral rivers a flood is any flow at all. The frequency, intensity, duration and distance of floods vary greatly. Runoff in the catchment is influenced by topography, land use, soil types and vegetation cover as well as the intensity and duration of rain.

Strong localised thunderstorms can cause very sudden floods, characterised by a wall of water which moves rapidly down a dry rivercourse, often sweeping away plants and animals. Longer periods of rain bring about more sustained floods, with single or multiple peaks. Multiple peak floods can occur with consecutive rains over many days, or rains in different parts of the catchment. Ephemeral river floods redistribute sediment, nutrients and organic debris which have accumulated in dry rivercourses and deposit these downstream or, in rare events, in the sea. Much of the water transported in an ephemeral river soaks into the sandy riverbed or evaporates, and water volumes tend to decrease with distance downstream. The recharge of alluvial aquifers beneath the rivers is vital for sustaining the ribbon of riverine vegetation associated with ephemeral rivers in Namibia. A cross-section of a typical ephemeral river shows the interdependence of surface flow in the river channel, recharge into the alluvial aquifer, and the availability of this groundwater to trees and via boreholes to man.

— Source: Jacobson et al. (1995)[10]

Fig. 2.12 Sinkhole lakes: Lake Otjikoto. Courtesy K Roberts

Box 2.2 Floodplain dynamics

Annual or periodic floods are essential to the productivity of floodplains. Floodplains typically have a dry period followed by inundation as rivers rise and spill their banks. A highly productive flooded period follows, and then the floodplain gradually dries. In the dry season, floodplains provide lush grazing and fertile soil for crops. When inundated, they provide rich nursery and feeding areas for fish, amphibians, birds, and other aquatic fauna, and support a diverse flora.

As both the Okavango and Zambezi rivers receive most of their flow from the Angolan and Zambian highlands respectively, it takes some time for the floodwaters to reach Namibia. The flood peak caused by Angolan rains in January/February only reaches Rundu in March/April, and Maun, Botswana, in June/July. The delay in flooding allows the floodplain depressions to fill with rainwater and support the life cycles of ephemeral pool fauna such as ostracods, fairy shrimps, snails and tadpoles. These must complete their life cycles before the pools are linked by flooding and predatory fish can enter. During annual floods, fish migrate from the river into the newly inundated floodplain which provides ideal breeding and feeding habitat. Floodplain fish typically include small species such as the Zambezi parrotfish Hippopotamyrus discorhynchus, *the larger African pike* Hepsetus odoe, *several cyprinids and the unusual many-spined climbing perch* Ctenopoma multispinis. *As the floodplain waters recede, the fish return to the mainstream. This is when they are most easily caught, and fish traps and fences set across side channels are a common sight at this time.*

Fig. 2.13 Kwando floodplain, Caprivi. Courtesy K Roberts

Estuaries and river mouths are found at the lowest part of a river and usually contain a mixture of fresh and salt water. River mouths are predominantly freshwater, while estuaries are subject to both tidal and river inflows. Water, nutrients and sediment flow out with river floods and in with the incoming tide. Sediments deposited as the water meets the resistance of the sea form wide mudflats.

Although dominated by river water inputs, the river mouths of the Orange and Kunene rivers have been termed estuaries, and are indeed subject to some tidal influence.[11] The Kunene River mouth and lagoon are vulnerable to flow alteration caused by the proposed Epupa Hydropower Scheme. A dam built upstream would reduce the volume of river water reaching the mouth, as well as the duration and intensity of floods. This will, in turn, reduce the scouring necessary to keep the river mouth from silting shut, and decrease essential nutrient inputs.[11,12]

Lacustrine systems

Most large standing waterbodies in Namibia are man-made, including 12 government dams on ephemeral rivers and numerous smaller farm dams. The proposed Epupa Dam, at 280 km^2, would be by far the largest of these. Namibia has few natural lakes, of three main types:

- small, deep, permanent sinkhole lakes and caves (*e.g. Lake Otjikoto, Lake Guinas, and Aigamas Cave)* (Fig. 2.12);
- larger, relatively shallow ephemeral floodplain or oxbow lakes on seasonally flooding rivers (*e.g. Lake Liambezi, now dry, in eastern Caprivi*) (Box 2.3, Fig. 2.15);
- very shallow ephemeral lakes and pans (*e.g. Etosha Pan, Lake Oponono, Sossusvlei, Tsondabvlei, Tsumkwe Pans such as Nyae Nyae, and Kalahari 'pannetjiesveld' pans*).

Sinkhole lakes and caves are characteristic of dolomite, and form as water penetrates cracks in the dolomite and leaches away the rock. This process gradually forms larger water-filled underground caves; sinkholes

form when the roof of an underground cave collapses. The sinkholes and caves of the Mountain Savanna and Karstveld vegetation type (map 1.8) near Otavi, Grootfontein and Tsumeb are ecologically extremely important due to the presence of endemic invertebrates and fish (see section 2.9). For example, southern Africa's only true cave fish, the endangered cave catfish *Clarias cavernicola*, is found only in Aigamas Cave.[13,14,15,16] These habitats and their unique fauna are especially vulnerable to pollution and groundwater level changes, and great care must be taken when planning large scale abstraction.

Box 2.3 The vanishing lake: Liambezi

Lake Liambezi in eastern Caprivi is Namibia's best known temporary floodplain lakes. The explorer Selous reported a large water-filled lake in 1879. Large floods in the Zambezi in 1952 and 1958 filled the previously-dry lake, but throughout the 1980s lake levels steadily declined until the lake dried up in 1989.[17] It has not filled since then. In 1986 the lake covered 406 km², of which 189 km² was open water and the rest well-vegetated marginal marsh.[18] At this stage the lake was about 3 m deep and mostly covered by a variety of submerged plants. Phragmites *reedbeds and stands of cattail (*Typha*) and papyrus (*Cyperus*) lined the lake margins and shallower areas. Water lilies* Nymphaea capensis *and* N. lotus *shaded the water surface, along with dense mats of the invasive aquatic weed* Salvinia molesta. *The lake supported a wide diversity of species including 54 types of algae, 28 of zooplankton[19] and 43 species of fish[20,21] in the open water. For a short time a small commercial fishery of about 60 fishermen on the lake supplied the Katima Mulilo market.[20]*

Fig. 2.14 Oshanas are important in groundwater rechange. Courtesy K Roberts

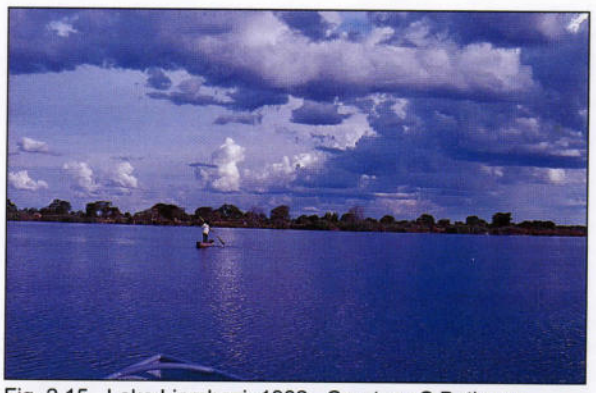


Fig. 2.15 Lake Liambezi, 1982. Courtesy S Bethune

Pans are shallow depressions periodically filled by rain or discharge from endoreic rivers (map 1.5), which dry out too rapidly to sustain much plant growth. For example, the Etosha Pan fills via the Cuvelai Drainage System only after very large floods (*efundja*) once every 7 - 10 years. On these occasions, it is briefly transformed into important habitat for aquatic invertebrates such as fairy shrimps which are adapted to ephemeral habitats, and for amphibians and wetland birds, particularly breeding flamingos and pelicans.[22,23] The *oshana* system (Fig. 2.14), which is classified as riverine, is a series of smaller, linked pans in the Cuvelai system, which when inundated support up to 151 plant, 43 crustacean, and 19 fish species.[24,25] The largest *oshana* is Lake Oponono, which receives floodwaters about twice every three years. The flooding *oshanas* recharge groundwater, supply both surface and shallow groundwater to people, wildlife and livestock, renew grazing, and bring fish southwards (see section 2.9 and Chapter 4). The Cuvelai system supports more people per unit area than any other non-urban region in Namibia.[26]

Sossusvlei, in the central Namib dunefields, forms the end of the Tsauchab River. The catchment receives less than 200 mm of rain a year; floodwaters only reach this endoreic pan after exceptional rains. The 15 km² pan is surrounded by some of the world's highest dunes, as well as camelthorn trees *Acacia erioloba*, spiny *Cladoraphis spinosa* grasses, and *!nara* plants, *Acanthosicyos horridus*. During the brief wet periods, several types of algae, copepods, ostracods, cladocerans and wetland birds have been recorded.[27]

Fig. 2.16 Epupa Falls. Courtesy P Tarr

The many smaller ephemeral pans scattered across Namibia are of ecological importance as a temporary water source for people and as habitats for unique communities of aquatic biota. When wet, they support a variety of desiccation-resistant crustaceans with rapid life cycles.[28] The harsh conditions have led to speciation: 42 ostracod species have been collected from ephemeral pans or pools in the northern Namib, 18 of which are thought to be endemic to Namibia. There is still much to learn about these very arid ephemeral pans.

Impoundments are created by the damming of rivers for water storage or hydroelectricity generation. All large state dams in Namibia are water storage reservoirs built on ephemeral rivers (map 1.7). Many central Namibian towns depend on this water; for example Windhoek is supplied by the von Bach (50 million m^3) and Swakoppoort Dams (69 Mm^3) on theSwakop River, and the shallow Omatako Dam (45 Mm^3) on the Omuramba Omatako. The largest dam is Hardap Dam (300 Mm^3) on the Fish River, which supplies the town of Mariental and the Hardap Irrigation Scheme. Much of this water is wasted by extremely inefficient flood-irrigation practices.

Aside from storing water, impoundments support a variety of aquatic and wetland biota. Unlike natural lakes, there is often no marginal zone of plants, due to water level fluctuations caused by water withdrawals and irregular inflows. Rooted plants never become established since water levels rise and fall unpredictably. This has profound ecological effects, as it prevents the establishment of sheltered areas for young fish and invertebrates.

The creation of an impoundment can have serious environmental consequences. A dam creates a water body where none existed, such as on an ephemeral river, or alters a perennial river into a lake, in which case the river biota must either adapt to non-flowing conditions or die. New dams are often extremely unstable ecosystems. Nutrients from decaying, previously terrestrial plants may promote nuisance plant growth, such as the explosive growth on Lake Kariba of *Salvinia molesta* in the 1960s, which characterised a 14-year unstable phase.

Namibia is one of very few countries in the world which builds dams on ephemeral rivers. Although extremely valuable for water supply, impoundments have two main drawbacks. First, they effectively cut off the natural supply of water, nutrients and silt essential for downstream ecological functioning. Second, the long retention times of water in the dam can cause water quality problems.

Palustrine systems

Palustrine systems or well-vegetated standing waters include permanent marshes and swamps, less permanent *vleis* or *mulapos*, and seeps and springs fed from groundwater. They occur mainly in wetter parts of Namibia, and are associated with perennial rivers, higher rainfall, or shallow groundwater.

Marshes and swamps are well-vegetated lentic wetlands with permanently waterlogged soils, often found alongside perennial rivers and lakes. They are very important in terms of high biodiversity and productivity, nutrient cycling, and moderation of floods. Marshes typically have little visible surface water, while swamps have visible open water or lagoons, as in the case of Botswana's Okavango Delta.

The ecologically valuable marsh at the confluence of the Cuito and Okavango rivers resembles a vegetated floodplain at the peak of productivity. In the dry season the water is shallow, stagnant, and often oxygen-poor due

to rotting organic debris. Such marshes support dense stands of reeds and some papyrus, and a variety of sedges and trees adapted to waterlogged soils, such as the forest waterberry *Syzygium gerrardi*. They serve as refuges for floodplain fish such as African pike *Hepsetus odoe* and blackspot climbing perch *Ctenopoma intermedium*, and are habitat for bilharzia and malaria vectors.[29]

The little-known Linyanti Swamp in eastern Caprivi closely resembles the much better-known Okavango Delta, with a 'permanent swamp' section supporting a rich array of species, and a 'seasonal swamp' or floodplain which fluctuates between terrestrial and aquatic phases. Vegetation includes emergent plants such as reeds and papyrus, rooted submerged plants such as oxygen weed (*Lagarosiphon*), rooted plants with floating leaves such as water lilies (*Nymphaea*), and free floating plants such as duckweed (Lemnaceae).

Vleis or *mulapos* are shallow, well-vegetated lentic pools, seasonally filled with water and covered with grass. They are usually smaller than swamps and marshes, and often depend on local rainfall. Namibian examples include the rainwater pools in forests of the Caprivi, Okavango and Otjozondjupa Regions (map 1.10) and the Kalahari sandveld (map 1.3). These are analogous to the *dambos* of Zambia and Zimbabwe. Although temporary, these wetlands support a wide variety of animals adapted to surviving dry periods. For example, the rainwater pools of eastern Caprivi support a remarkable endemic fish, the Caprivi killifish (*Nothobranchius*). Like the invertebrates of temporary ponds, these fish reach maturity before the ponds dry out, and lay drought-resistant eggs which survive in the dry mud until the ponds fill again.

Springs and seeps form small permanent or semi-permanent wetlands, fed by groundwater which rises to the surface and flows away. They are scattered throughout the arid and semi-arid areas of the country, such as Sesfontein and Orupembe in the Kunene Region, where they provide the only permanent source of water to wildlife and people. Typical springs and seeps have a freshwater "eye" where the water surfaces, but water becomes more saline with distance from the eye. As water evaporates rapidly, the edges of these wetlands are often encrusted with salt. The animal communities living in these springs vary along these salinity gradients. Some more permanent seeps, such as those along tributaries of the Kunene River, support endemic fish such as *Kneria maydelli* (see Appendix 13).

Fifty-seven geothermal (hot water) springs are known to occur in Namibia, of which 24 are natural springs and the rest are artificially tapped sources or artesian boreholes. Ten of these have been studied in some detail,[30] and range in temperature from 24.9°C for Osterode Süd to 66°C for Gross Barmen. These springs feature 28 kinds of algae. Green algae (Chlorophyceae) occur only in cooler springs but diatoms and blue-green algae (Bacillariophyceae and Cyanophyceae) occur in all, with blue-green algae dominating the hotter waters. The three hottest springs, Ai-Ais, Gross Barmen and Rehoboth, have been developed as tourist resorts. Geothermal springs in Windhoek also induced the first settlement of the capital over a century ago.

— Shirley Bethune

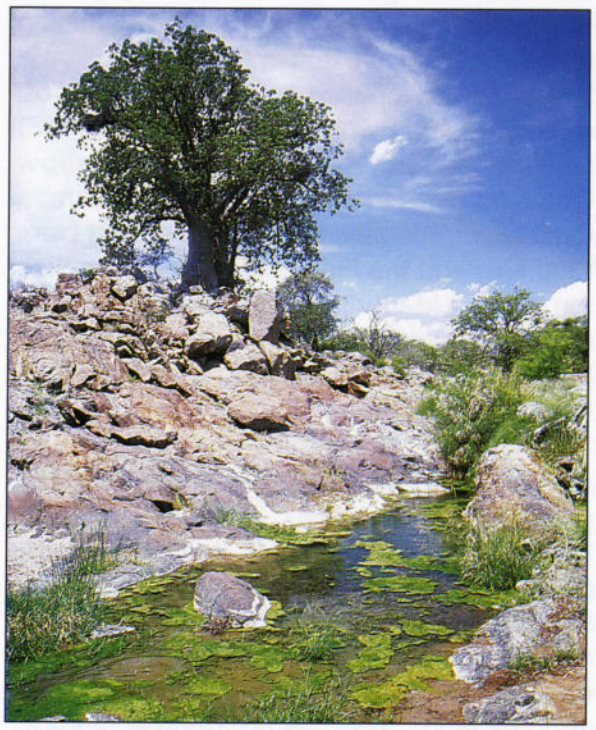


Fig. 2.17 Geothermal spring. Courtesy K Roberts

Fig. 2.18 *Euphorbia namibensis.* Courtesy G Williamson

2.2 Environmental change

Natural climatic variability

Rainfall is without a doubt the main limiting factor in arid environments such as ours.[31] Globally, where rainfall is very sparse, it is also very variable in both space and time, and this is also true of Namibia. This strong climate variability within and between years has spawned a high degree of natural variability in ecological communities.

In arid environments, the influence of single or 'episodic' events such as a year of exceptionally high rainfall or a severe drought can be felt for years or decades.[32] Such events can indeed drive environmental change. The effects of variation in rainfall are often concentrated in habitats such as ephemeral pans or rivers, and these habitats may provide a more obvious record of episodic events and the resultant environmental changes.

Long-term climate variation

Rainfall runoff in perennial or ephemeral rivers reflects several factors, including current and recent rainfall, vegetation cover, and overall habitat condition. The low runoff recorded at Victoria Falls on the Zambezi River during the early decades of this century was similar to that observed today.[33] Yet for about 30 years in mid-century, the runoff volume was about double. The record is not long enough for us to know if these large scale changes are part of a long term cycle or simply random variation. Significant changes in habitats and ecological communities must nonetheless have accompanied these natural variations, certainly in the headwaters of the Zambezi and possibly throughout the Zambezi Basin, including northern Namibia. Similarly, Lake Liambezi on the Kwando and Chobe Rivers has varied several times this century between a perennial lake teeming with fish and a dry depression (Box 2.3).

Namibia was apparently drier in the height of the last Glacial Maximum. This is suggested by Kalahari dunes, some now vegetated, by the *oshana* ephemeral rivercourses of northern Namibia,[34] and by linear dunes south of Okahandja. Yet other evidence suggests that rainfall was higher during the Glacial Maximum, and that the ephemeral rivers of western Namibia carried heavier flows and greater silt loads than they do today.[35,36] Whichever interpretation is correct — and both scenarios may have occurred — it is certain that climate changes were followed by habitat changes throughout Namibia.

Organisms in arid environments can often cope better with variation in available moisture than those in wetter environments. An evolutionary history of adaptive response to small scale natural habitat changes may allow at least some species to adapt to minor anthropogenic environmental changes.[31] As a result, biodiversity loss in the face of moderate environmental change may be somewhat less in variable environments than in more constant ones, at least in theory.

Changes in socioeconomic and natural environments

Humans and their changing lifestyles have influenced the natural environment in Namibia for many centuries. The first inhabitants were hunter-gathers (section 1.2), and herding and crop-growing appear to have developed less than a thousand years ago.[26] These changes in land use allowed human populations to increase significantly.[37] Such quantum shifts had major effects on natural habitats, some of which were cumulative, such as those accompanying the reduction of wildlife and the increase of livestock.[10] Reductions in species diversity of ungulates, changes in their distribution, and changes in herd behaviour and predator densities, must have affected habitat structure and composition.[99]

The shift from nomadic to sedentary lives

The establishment of agriculture in Namibia also accompanied a shift from nomadic or semi-nomadic herding practices to sedentary lifestyles. Areas which had been used occasionally for grazing or water following rain, or only as refuges during drought, were now used more continuously by people and livestock.[10] Although not well documented, such changes in land use have undoubtedly affected habitats in many ways.[38]

Another major change was the modification of shifting agriculture as human populations grew. Since the soils of northern Namibia are poor in nutrients, they can only support crops for a few years without fertilisation. With low population pressure, people could shift their fields as needed to newly cleared lands. More people practising dryland cropping probably meant that fields were located closer to one another, and more land was cleared.[38] The rapid increase in human populations has been one of the most powerful agents of environmental change.

The shift to active water management

Human lifestyle changes have provoked changes in the way water is managed. In present-day Namibia, surface water is retained mainly in artificial impoundments, which are all built on ephemeral rivers (section 2.1). As well as directly inundating habitats with water, land surrounding the new water body is affected by land use changes associated with the impoundment. By altering the frequency, duration and volume of floods in ephemeral watercourses, dams alter the habitats downstream, often dramatically. In Namibia, many dams have been built in single catchments, with cumulative effects which depend on the sensitivity of downstream habitats and the relative position of dams.

A documented example of habitat alteration is the lowering of the water table in the Otjimbingwe district, which has eliminated the potential for crop production in the bed of the Swakop River and its tributaries. This was the result of two large dams built in the upper Swakop catchment to meet Windhoek's water demands.[39] Another example is the death of hundreds of ana trees *Faidherbia albida* and some previously perennial wetlands in the Huab catchment (Fig. 2.19), downstream of several large and many small farm dams.[10] A change associated with the construction of all large state dams in Namibia, however, is the creation of small, perennial wetland habitats immediately below the dam wall.[40]

Groundwater management has also led to widespread habitat change. Boreholes have frequently been drilled in areas where water was not previously available. In principle, this allows grazing pressure to be distributed over a larger area, and contributes to better livestock and natural resource management. However, it also provides the basis for permanent occupation by people and stock, accompanied by widespread habitat change. Livestock-induced changes following the drilling of boreholes include overgrazing and selective grazing, excessive trampling in a limited area, creation of distinct paths along which erosion can occur, and bush encroachment. Human settlement-induced changes at new boreholes include overuse of wood, wildlife and resources, as well as concentration of livestock.

The permanence of these changes is not entirely clear. In some areas, changes may be rapidly reversed with several years of above average rainfall, with little or no lasting habitat degradation.[41] In others, habitats may never recover their pre-settlement features.

Fig. 2.19 The links between biodiversity loss and desertification need clarifying. Courtesy MAWRD

Fig. 2.20 Borehole pump at Khowarib. Courtesy E Marais

Fig. 2.21 Omatjette - Omaruru border fence. Courtesy E Marais

In a few cases, groundwater management has led to a loss of water resources *per se.* Most geothermal springs in Windhoek have dried up as the water table was lowered by municipal boreholes, eliminating habitats associated with these natural hot springs.

In other areas, water tables have dropped considerably, with unknown consequences.[10] Overextraction of groundwater from alluvial aquifers has caused localised habitat degradation. The lower Kuiseb River, a source of water for central Namib coastal towns, is a case in point. There the lowered water table has caused the death of natural vegetation, most notably ana trees, and a loss of production of *!nara* melons.[10]

Fencing and control of fire

Fencing and fire have a major influence on habitat and species diversity. In Namibia fencing is often used as a substitute for, rather than a tool of, good management. When livestock are confined in fenced areas for some time, they tend to use the available grazing or browse in a selective manner, leading to short term and possibly long term habitat change. Bush encroachment may be one manifestation of the incorrect use of fencing. In communal farmlands, fencing is being used as a tool by richer farmers to secure land for themselves, leaving many smaller-scale farmers crowded into less space. Landscapes associated with fenced farming are often far removed from their natural state — occasionally enhanced in some way, but more often degraded.

Fire as a management tool can have different effects in different habitats. The frequent fires set in Namibia's sub-humid northeast accelerate habitat degradation by reducing species richness, lowering nutrient availability and altering habitat structure (Box 2.4[38]). Where fires are prevented, as in the drier farming areas, the result can also be reduced biodiversity and the build-up of moribund vegetation. Mismanagement of fire in any form is a powerful force for habitat alteration.

Box 2.4 Fire and habitat change

African savannas and woodlands have evolved with fire, and fire has powerfully shaped their biological communities. Yet the frequency, scale and timing of fires have changed greatly during the recent centuries of human influence and population growth. These changes, to which some species may not easily adapt, can be a major agent of biodiversity loss.

A dramatic multiple satellite image analysis of the frequency and extent of fires in Caprivi Region[38] shows that fully 60% of Caprivi's vegetation was burnt between 18 April and 2 October 1996. This happened mainly through many localised fires, perhaps up to 3000, rather than a few widespread fires. It may be the increased frequency of fires which is most harmful to biodiversity. Annual fires have prevented seedling establishment of valuable trees such as teak Baikiaea plurijuga *and kiaat* Pterocarpus angolensis, *and mature trees are eventually killed by frequent fires. Large areas are now encroached by dense thickets of* Terminalia sericea, Combretum *spp. and* Dichrostachys cinerea, *causing valued grazing areas and timber resources to become scarce.*

— Source: Mendelsohn & Roberts 1997[38]

Other socioeconomic shifts

Environmental change has also been induced by ongoing changes such as the shift from a subsistence to a cash economy, from animal to machine ploughing, and from exclusively rural to urban living. Where people have a purely subsistence economy, for example, excessive use of natural resources is neither desirable nor encouraged. With the shift to a partial or full cash economy, based primarily on natural resources, overuse of these resources is possible and to some extent encouraged. All of these factors, of course, have been greatly exacerbated by rapid human population growth.

Environmental degradation

The term environmental degradation is often used from a human perspective, referring to loss of productivity of land or other resources. It can also refer to biodiversity loss, which itself can underpin loss of productivity, or to a reduction in largely subjective factors such as aesthetic values. Degradation is often a slow process. It may be noticed by the people causing it, but may not be regarded as a solvable, or even a serious, problem.

Environmental degradation has taken place for a long time in Namibia. The first recorded example may be the overuse of woody vegetation in the Owambo kingdoms for homestead construction and copper smelting.[26,42] Trees are today still used mainly in the northern regions for subsistence — for fuel, homestead construction, and fencing to enclose crops (Chapter 4). Rapid population growth has severely stressed the remaining resources. Degradation in the region is manifested not only by deforestation but also by the symptoms of overgrazing, reduced soil fertility, and soil erosion. The integrity of the extensive *oshana* ephemeral wetlands has been severely compromised, due mainly to loss of woody vegetation and associated habitat quality, but also to other habitat changes induced by population pressure.[26]

Deforestation takes a slightly different form further east in the Okavango and Caprivi Regions. Fire is by far the biggest cause of deforestation there, largely for clearing croplands or 'improving grazing.' The amount of land cleared for crop agriculture in four areas of Caprivi since 1943 has grown by an average of about 4% per year, similar to recent average population growth.[38]

Bush encroachment is a major form of degradation, especially on commercial farms in the central, eastern and northern areas.[43] Dramatic increases in the density of thin-stemmed woody species have reduced the overall productivity and carrying capacity of both livestock and wild mammalian herbivores. Bush encroachment is a serious economic problem, accounting for annual losses of over N$100 million on commercial farmlands alone (Box 4.9). The evidence is contradictory, but it appears that there has been major land conversion from open grasslands to dense bush in the current century.[43] Although this could be part of a natural cycle, it is likely to be accelerated by poor grazing management. Such large-scale alterations of habitat can be rapidly induced by farming practices.

Expectations of the environment

Despite humans' extraordinary environmental impact, many impacts are neither planned nor desired by people. People have expectations of the values and benefits to be provided by the environment, however. Such expectations may be based on lessons learned from less arid nations, which may be unrealistic for Namibia.

People commonly expect that the environment will provide enough water for any conceivable use. Large and small dams and boreholes have been developed irresponsibly across Namibia in response to these expectations. The use to which this water is then put contributes to both negative and positive environmental changes, and may induce change further afield by requiring development of additional supplies. The expectation that 'water is from God' and should thus be free has contributed heavily to degradation around waterpoints. A newly implemented cost recovery system may help reduce these environmental impacts.

People may also expect a stable or steadily increasing income from the environment, no matter how many others are doing the same. Yet natural resources are finite if used unsustainably, and variable in space and time. This is often forgotten as more and more people try to earn a living from livestock or dryland cropping. In arid regions like Namibia, the concept of carrying capacity is only useful if understood to be a variable, not a constant. When misused, the concept can contribute to bush encroachment, reduced productivity or other kinds of environmental degradation.

Predicted environmental change

Habitat degradation related to socioeconomic change will probably continue well into the foreseeable future. With a human population doubling every 23 years and, at the same time, depending mainly on natural resources, degradation can be expected to accelerate.

Fuelling this degradation are increasing expectations of improved livelihoods and higher incomes, which are exacerbated by politicians' promises. When combined with a lack of political will to implement sometimes unpopular measures required for sustainable resource use, accelerated environmental change is inevitable.

The rate of urbanisation in Namibia is almost double the overall rate of population growth (section 1.2). This population shift is likely to have an increasing effect on environmental change. While it may mean a smaller proportion of people attempting to subsist directly from natural resources, resource demands from the urban population, and investment in rural livestock herds by urban-based absentee owners, will all contribute to environmental change in rural areas.

Global natural resource markets

Namibia is, to a limited extent, part of the global natural resource market. The mining and export of diamonds and uranium have disturbed habitats in vast, if localised, areas of the Namib Desert. Export beef production from an arid environment not ideally suited to this form of land use, and the past focus on export of karakul sheep pelts (section 1.2), have already caused extensive habitat alteration. Should Namibia become further involved in global resource marketing, for example of hydroelectric or natural gas energy, the accompanying environmental change may be great. Small-scale natural resource transfers, such as the production of crafts for tourism or charcoal for export, contribute to localised environmental changes. So may the unsustainable exploitation for the global market of resources such as plants for the pharmaceutical industry (*e.g.* Box 4.10). However, the global ecotourism market offers enormous potential for land uses which promote biodiversity conservation in Namibia (Chapter 4).

Waste, pollution and climate change

Most forms of waste production and pollution are relatively limited in Namibia, although they may degrade key resources and habitats such as rivers. The main large-scale source of pollution is savanna burning, a major source of atmospheric greenhouse gases,[44] which is regularly practiced in much of northeastern Namibia. In addition to habitat changes caused by repeated fires (Box 2.4), the influence of these gases on the southern African atmosphere may be considerable.

The first sign of global climate change is predicted to be increased climatic variability. Due to Namibia's natural variability, changes may be very difficult to detect. Only long term data sets and careful analyses will help us differentiate natural from anthropogenic climate variability. In addition to increased variability, the overall trend is likely to be increased temperature and decreased rainfall, which would cause increasing aridity.

The Benguela upwelling system has a major impact on Namibia's climate (section 1.1), especially west of the Namib escarpment. There is little consensus on how the Benguela will change in the long term. It will almost certainly become more variable, but it is not clear exactly how, nor how this may affect the regional terrestrial environment. Extrapolating from a South African analysis,[45]

bioclimatic regions are likely to become more arid in Namibia. Semi-arid parts of the country are predicted to become arid, with a temperature increase of several degrees. This means that up to about 97% of Namibia will be arid and a small portion, now sub-humid, is likely to become semi-arid. These shifts in bioclimatic regions will have dramatic implications for the natural environment and biodiversity conservation. As people with their livestock attempt to adapt to these changes, we can expect environmental change in Namibia to accelerate, especially in intensively used habitats such as wetlands.

In summary, environmental change in Namibia is an ongoing process driven by many factors, both natural and human-induced. All habitats in Namibia are affected by this ongoing change to different degrees.

— Mary Seely

2.3 Areas of high species endemism

Africa's arid southwest, roughly centred on Namibia, is a major zone of evolution for groups such as melons (Cucurbitaceae), some families of succulent plants, fishmoths (Lepismatidae),[46] solifuges or sun-spiders (Solifugae),[47] geckos[48] and tortoises. Namibia is obliged by its Constitution and the Convention on Biological Diversity to protect its *endemic* species, which are unique and occur nowhere else. This section summarises the major areas of Namibia which are rich in endemic species. A taxonomic overview of the numbers of endemic and other species in Namibia is given in section 2.9.

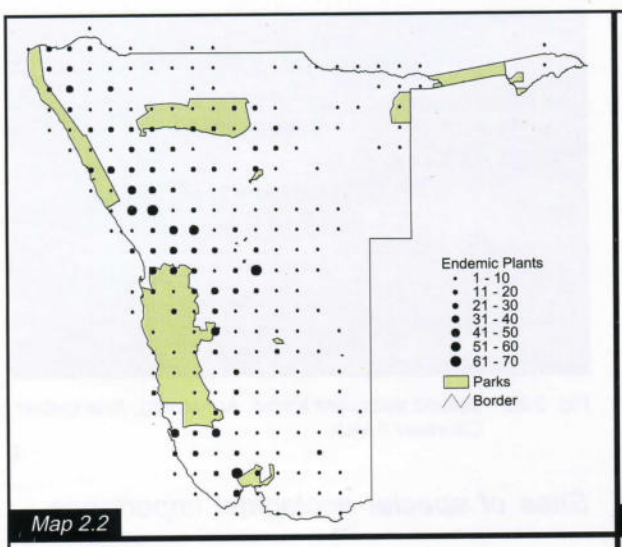
A recent analysis of endemism patterns[49] has shown that most Namibian endemic plants, invertebrates, amphibians, reptiles, mammals and birds are found in a zone running along, and to the west of, the Namib escarpment (maps 2.2-2.7). There is also an important region of endemism for succulent plants, reptiles and invertebrates in the Succulent Karoo Biome (see map 2.1). Congruence between endemism hotspots, particularly on rocky substrates, is remarkably high, implying broadly similar speciation processes.

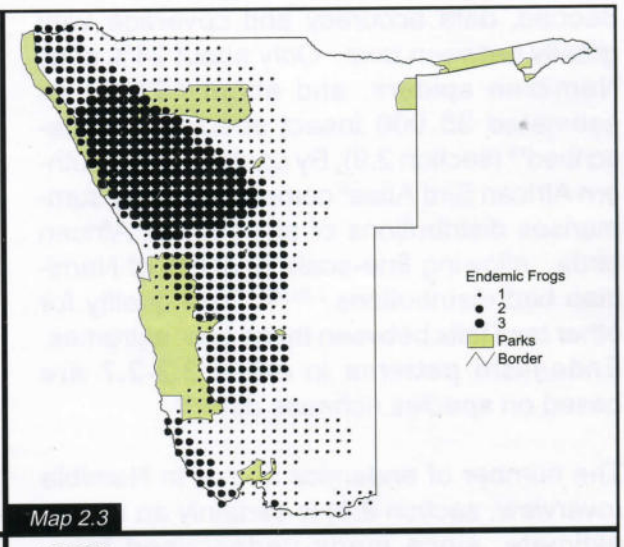
Areas of endemism and species richness overlap poorly for endemic vertebrates, which are mainly arid-dwelling, as richness is highest in the mesic wetlands and woodlands. However, the correlation between endemism and richness for succulent plants, insects and arachnids is relatively high.[49]

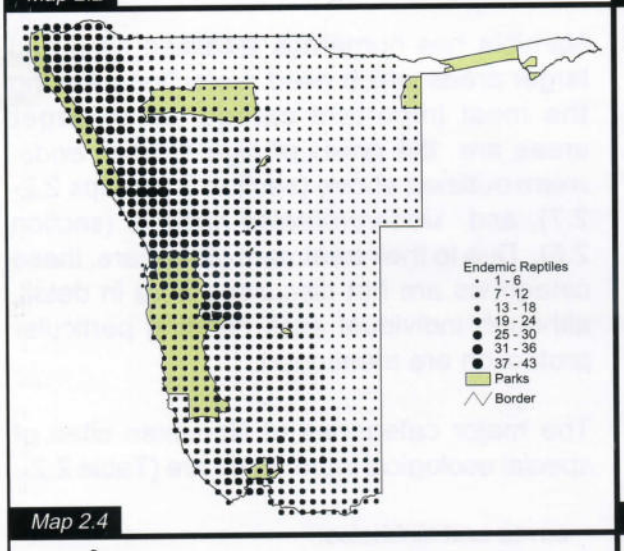
Centres of endemism for plants and vertebrates fall mainly outside state protected areas, as few parks were established with biodiversity indices in mind.[50] The similarity of endemism patterns in different taxa[49] is a strong argument for developing additional protected areas, using creative non-traditional conservation approaches, to safeguard Namibia's unique biota (section 2.6).

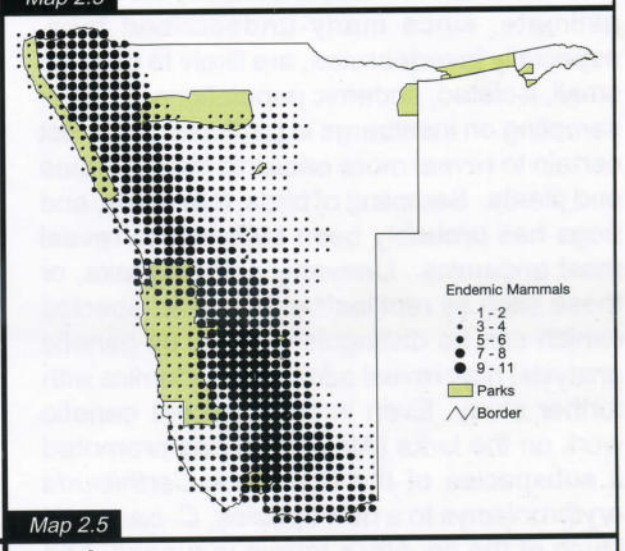
Broad-scale analyses of endemism contend with certain problems. First, the use of the term 'endemism' is not consistent in Namibia. Vertebrate zoologists tend to class a species as endemic if 75% or more (frogs, reptiles and mammals) or 90% or more (birds) of its total range occurs within Namibian political boundaries. For insects, arachnids, flowering plants and freshwater fish, a species is endemic if 100% of its range falls within Namibia. Except for fish, most endemics in these groups are found in the Namib Desert or escarpment. This ancient desert stretches marginally into southwest Angola and northwest South Africa, so political boundaries dissect ecological ones, and Namib Desert endemics are not necessarily restricted to Namibia. Also, political instability in Angola means that the Namibian near-endemics occurring there may be essentially unprotected. For now, Namibia must assume greater responsibility for their conservation.

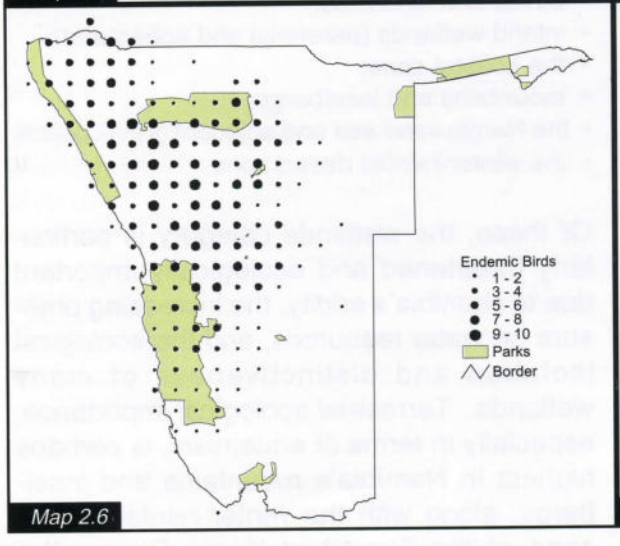
Fig. 2.22 Endemic *Namibia pomonae*, the *Sperrgebiet*. Courtesy G Williamson

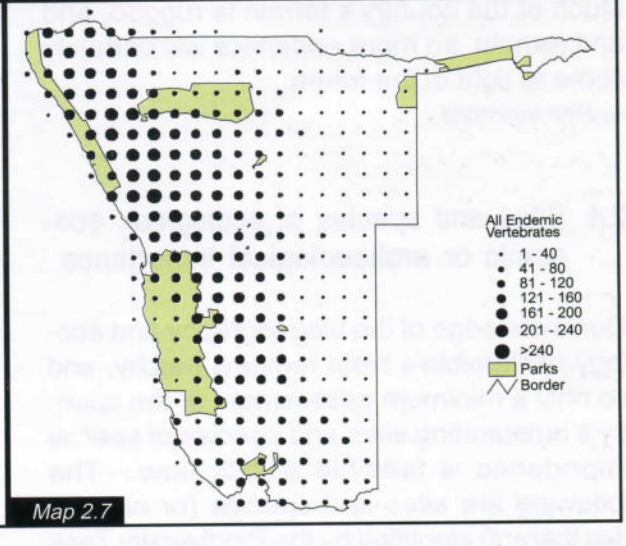












Maps 2.2 - 2.7 Patterns of endemism in Namibian plants and terrestrial vertebrates in relation to protected areas.

Maps show the species richness distribution of endemics for: (2.2) plants; (2.3) frogs; (2.4) reptiles; (2.5) mammals; (2.6) birds and (2.7) vertebrate taxa combined. The plant map is a preliminary analysis and is thus shown at the half degree-square level to minimise sampling bias.[49]

Second, data accuracy and coverage vary greatly between taxa. Only about 24% of all Namibian spiders, and about 18% of an estimated 35 000 insect species, are described[49] (section 2.9). By contrast, the Southern African Bird Atlas[6] comprehensively summarises distributions of all southern African birds, allowing fine-scale analysis of Namibian bird distributions.[7,51,52] Data quality for other taxa falls between these two extremes. Endemism patterns in maps 2.2-2.7 are based on species richness data.[49]

The number of endemics known in Namibia (overview, section 2.9) is certainly an underestimate, since many undescribed taxa, especially invertebrates, are likely to occur in small, isolated, endemic populations. Further sampling on inselbergs in particular is almost certain to reveal more endemic invertebrates and plants. Sampling of birds, mammals, and frogs has probably been sufficient to reveal most endemics. Unevenly sampled taxa, or those such as reptiles[53] with 'cryptic' species (which can be distinguished only by genetic analysis) may reveal additional endemics with further study. Even in birds, recent genetic work on the larks (Alaudidae) has promoted a subspecies of the dune lark *Certhilauda erythroclamys* to a new species, *C. barlowi*.[54] Much of the country's terrain is rugged, arid and remote, so more endemics will certainly come to light in the future.

— Rob Simmons

2.4 Sites and species of ecological, economic or archaeological importance

Our knowledge of the biogeography and ecology of Namibia's biota remains patchy, and so only a minimum assessment of the country's outstanding sites and species of special importance is feasible at this time. The following are sites and species (or categories thereof) identified by the Biodiversity Task Force and other specialists. All merit urgent individual consideration for some form of conservation protection where this does not yet exist or is not yet secure. This assessment needs to be updated regularly as our knowledge base improves.

Fig. 2.23 Upland succulent Karoo, Aurusberg, *Sperrgebiet*. Courtesy J Irish

Sites of special ecological importance

Namibia has numerous localised sites and larger areas which need protection. Among the most important categories of larger areas are the *areas of high species endemism* outlined above (section 2.3, maps 2.2-2.7), and *underprotected habitats* (section 2.6). Due to their treatment elsewhere, these categories are not discussed here in detail, although individual sites needing particular protection are mentioned.

The major categories of Namibian sites of special ecological importance are (Table 2.2):

- caves and sinkholes;
- inland wetlands (perennial and ephemeral);
- the coastal zone;
- mountains and inselbergs;
- the Namib sand sea and adjacent gravel plains;
- the winter-rainfall desert zone.

Of these, the wetlands category is particularly threatened and ecologically important due to Namibia's aridity, the increasing pressure on water resources, and the ecological isolation and distinctiveness of many wetlands. Terrestrial ecological importance, especially in terms of endemism, is perhaps highest in Namibia's mountains and inselbergs, along with the winter-rainfall desert zone of the Succulent Karoo Biome, the Namib gravel plains, and the Namib sand 'sea.' In all of these categories, we have only an extremely fragmentary knowledge of the resident biota and their status. Research in these areas is a matter of national and regional priority.

Table 2.2 Sites of special ecological importance in Namibia

Category	Site	Known distinctive values
Northeast wetlands	Zambezi River frontage*	Biotic richness; red data birds, plants, etc.
	Okavango River frontage*	Biotic richness; threatened plants and insects
	Isolated pools, eastern Caprivi	Endemic Caprivi killifish (*Nothobranchius*)
	Impalila Island	Biotic richness, red data spp., unique vegetation communities on basalt
Border rivers	Lower Kunene River	Endemic fish; edible oysters and shrimps; habitat threatened by Epupa Dam
	Lower Orange River	One fish endemic to lower river; two others endemic to the river basin are threatened
Ephemeral pans	Tsumkwe Pans **	Biotic richness; endemic crustacea; red data birds; habitat/resource for people and wildlife
	Cuvelai Basin/ Etosha pans	Biotic richness; important ephemeral pan habitat; breeding red data birds; resources for people; significant basis of Namibia's tourism industry
Ephemeral rivers	particularly Ugab, Huab, Hoanib and Hoarusib Rivers	Biotic richness; large desert-dwelling mammals; high value for human subsistence and tourism
Karst caves/ sinkholes and springs	Aigamas, Arnhem and Dragon's Breath Caves; Lakes Guinas and Otjikoto; Ongongo Falls	Endangered cave catfish (*Clarias cavernicola*); endemic Otjikoto tilapia (*Tilapia guinasana*); endemic or restricted insects and crustacea; habitats threatened by water abstraction
Coastal wetlands	Kunene River mouth	Transition zone; sea turtles; migrant shorebirds
	Orange River mouth	Migrant shorebirds (Ramsar site)
	Sandwich Harbour	Biotic richness; 36 fish spp; migrant shorebirds (important Ramsar site); red data birds
	Walvis Bay lagoon	Biotic richness; migrant shorebirds (most important Ramsar site)
	Lüderitz lagoon	Migrant shorebirds; seabird breeding site
	Cape Cross	Cape fur seal and seabird breeding site
Coastline	entire coast	Biotic richness (arachnids, birds, lichens)
Offshore islands	All 18 islands	Seabird breeding sites; rich marine fauna plus artificial guano platforms
Namib escarpment and inselbergs, especially northern (Kaoko) escarpment	general:	Phylogenetic relicts; high endemicity
	Brandberg	High endemicity (plants, reptiles, insects); major rock art sites; threatened by tourism pressure
	Otjihepa Mountains and Baines Mountains	Highly restricted-range and vulnerable biota (shorthead barb; butterfly *Acraea brainei*)
	Otavi Mountains	Biotic richness (plants, birds)
	Aurus Mountains	Botanical richness and endemism, scenic value
	Karas Mountains	Botanical richness; endemic insects, lizards
	Waterberg Plateau	Biotic richness (lichens, plants, birds); Cape griffon breeding site, endemic insects and lizards

(continued)

Table 2.2 (cont.)

Category	Site	Known distinctive values
Escarpment, mts and inselbergs (cont.)	Erongo Mountains	Botanical richness; endemic vertebrates
	Auas Mountains	Highly-restricted range butterflies, lizard
	Hunsberge	Vertebrate richness and endemism
	Brukkaros	Endemic rodents
	Tiras Mountains	Endemic reptiles
	Campbell's Valley, near Helmeringhausen	Highly restricted-range lizard, *Cordylus campbelli*
Granite domes	Omaruru district domes	Biotic richness and endemism (vertebrates, probably other taxa). Habitats are on private and communal farmland and need protection
Namib gravel plains	Coastal fog belt	Biotic richness and endemism (lichens, arachnids, insects); habitat threatened by off-road driving
Winter rainfall zone	Aus area; *Sperrgebiet* incl. Aurusberg, Roter Kamm	Biotic richness and endemism (succulent plants, arachnids, insects); scenic grandeur
Sand dunes	Southern Namib dune 'sea'	High endemicity (arachnids, insects, lizards)
Major tourism areas	Spitzkoppe	Biotic richness and endemism; habitat somewhat threatened by tourism pressure
	entire Kaokoveld	High endemicity; habitat and cultural integrity threatened by tourism pressure
	Sesriem Canyon	Scenic grandeur; habitat threatened by tourism pressure

* *River frontage includes riparian belt, floodplains including oxbow lakes and other features, open water and river bed. Quartz outcrop biota near Andara on the Okavango River merits special attention.*
** *Tsumkwe Pans are widely known as 'Bushmanland Pans' and have wildlife tourism potential.*

Sites of special archaeological importance

Namibia's remarkable archaeological heritage is a major national treasure, and well known internationally. The country has a rich array of rock paintings and engravings, some many thousands of years old and, just as valuable, a wide array of 'archaeological landscapes' which represent a detailed record of the palaeoenvironment and early human land uses (Table 2.3). The most famous rock art sites at Brandberg, Twyfelfontein and Spitzkoppe have been jeopardised by tourism pressure, and a lack of education among the public and tour guides about the value and preservation of these sites. Training of rural rock art guides has recently been initiated through the auspices of the Southern African Rock Art Research Association.[55]

Namibia's varied 'archaeological landscapes' include about 5000 sites documented by the Archaeology Laboratory of the National Museum of Namibia. These have immense value in illuminating major environmental changes in Namibia, up to 50 000 years BP, as well as the impact of early human land use strategies, mainly over the last 1000 years.[56] These palaeoenvironmental records are found in landforms and deposits of five types: (a) spring tufas and other evaporite deposits, such as pans; (b) relict beaches on pan margins and the coast; (c) unconsolidated cave and rock shelter deposits; (d) bone breccia deposits and caves containing speleotherms; and (e) coeval site distributions showing land uses, *e.g.* precolonial nomadic pastoral, agricultural or riverine settlements and colonial farming settlements.[56]

Table 2.3 Sites of special archaeological importance in Namibia

Category	Site	Known distinctive values
Rock art sites	Brandberg (over 1000 sites)	Best-studied, varied and generally well-preserved art; threatened by tourism pressure
	Spitzkoppe	Varied and accessible art; threatened by tourism pressure
	Twyfelfontein	Varied and accessible art including engravings; tourist guide training a priority
	Apollo 11 Cave	Painted slabs dated to 27 000 y BP; also engraved slabs. Entry by permit only
	Erongo Mountains	Numerous sites on private farmland, *e.g.* Philipps Cave (Farm Amieb), Farm Anibib, Farm Omandumba, accessible by private guided tours
Palaeoenvironment record sites (see text)	c. 5000 sites registered by National Museum of Namibia Archaeology Laboratory	Only reliable source of long-term environmental change data, including prehistoric land uses

Sources: S-A Pager[65]*, J Kinahan*[56]

Precise sites identified in Tables 2.2 and 2.3 may be the easiest for which to secure protection in terms of new draft environmental legislation (Chapter 5). This draft legislation provides for a category of "Sites of Special Scientific and Environmental Interest." Priority candidates for proclamation under this heading will be caves, sinkholes, inselbergs and granite domes with high biodiversity value, and rock art and palaeoenvironment sites. Legal clarification is needed for Brandberg, already a National Monument. The Ministry of Environment and Tourism must initiate consultative planning processes to identify precise sites in which to secure some form of feasible protection for all categories in Tables 2.2 and 2.3.

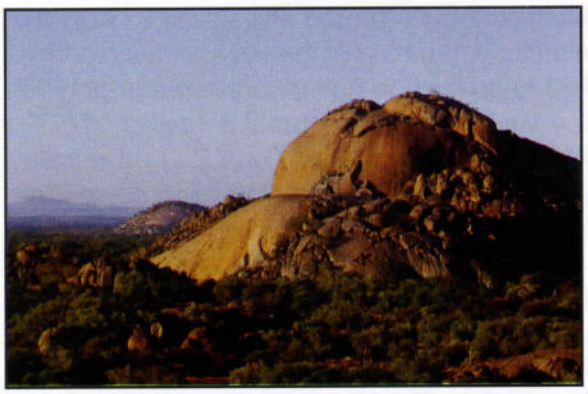


Fig. 2.24 Granite domes, Omaruru District. Courtesy R Simmons

Species of special ecological and economic importance

To an ecologist, of course, all species have ecological importance and a significant, if perhaps subtle, ecological role. However, the process of developing national biodiversity strategies requires prioritisation of a country's conservation resources. This is a difficult and ethically troublesome task for those involved.

Namibia's major categories of 'ecologically important species' are, in terms of national and international responsibility:

- **Endemic species**, which occur only in a specified area such as Namibia, the Namib Desert, or southern Africa;
- **Red data species** (endangered, threatened and vulnerable species, especially those imperilled globally);
- **Keystone and umbrella species**, for which conservation measures have a significant impact on other biota in the same habitat.

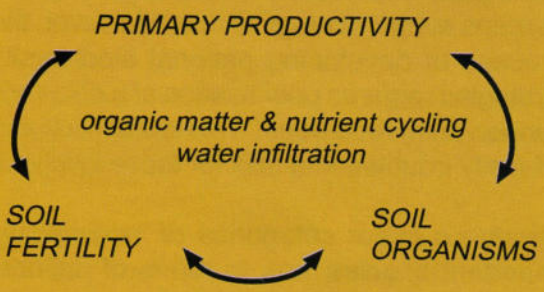
The summaries of conservation status for Namibian taxa (section 2.9) incorporate these major categories, particularly the first two. There is a need for identification of potential keystone and umbrella species in Namibia as

a national priority, as this may in certain cases allow some rationalisation of biodiversity conservation efforts.

Some economically important species in Namibia are identified in Table 2.4. Clearly, this is a very incomplete list. For example, hundreds of palatable grass and shrub species are collectively important in rangeland agriculture. Equally, although few people could imagine assigning an economic value to termites, aside from their role as a subsistence food for some people, their value in maintaining the productivity of agricultural savannas is probably immense (Box 2.5). This helps demonstrate the interaction of ecological and economic value.

Box 2.5 Termites in agricultural savannas

Soil organisms play a significant role in maintaining soil fertility and primary productivity, by carrying out important ecological processes such as the cycling of soil organic matter, nutrients, and water. Ecosystem functioning may thus be impaired by the loss of soil biodiversity.



In arid Namibian ecosystems, termites are among the most important of these organisms, perhaps through their effects on soil structure, organic matter and water infiltration. Since healthy ecosystems support a diverse soil fauna, termite abundance and diversity may serve as a useful indicator of the status of ecosystem processes. As part of Namibia's Programme to Combat Desertification, experimental work on ecosystem functions mediated by termites will be combined with historical and current data on biogeography to assess the role of termites in maintaining the productivity of Namibian lands.[57]

Source: Juliane Zeidler[57]

There are two main categories of economic importance reflected in Table 2.4: species of importance in subsistence and commercial harvesting, which have 'positive' economic values, and agricultural pests and disease vectors, which have negative values. More information on the conservation status and uses of these and other species is given in section 2.9 and Chapter 4, and a summary of fish species of ecological importance is given in Appendix 13.

— Barbara Curtis & Phoebe Barnard

2.5 Threatened species: case studies

Namibian species with better known conservation management histories are red data mammals and birds, and commercially valuable marine species and their predators. Of these, black rhinos, cheetahs, wild dogs, greater and lesser flamingos, and Cape griffons are dealt with here. Marine species treated in Chapter 3 are pilchards and African penguins. The historical data are not of equal reliability, but some weaknesses are identified below.

Black rhinos: holding on against the odds

In the last three decades, black rhino *Diceros bicornis* populations in Africa have declined by 97%,[58,59] due almost entirely to the lucrative black market trade in rhino horn. Rhino species worldwide are under immense threat, and the chances of global population recovery appear slim.

Namibia has Africa's largest unfenced population of black rhinos, and about 97% of the world's population of the subspecies *bicornis*. Rhino protection has thus been a priority for the Ministry of Environment & Tourism (MET). Management activities (Box 2.1) have been generally effective at maintaining population levels in recent years.

Before the early 1800s, black rhinos were widely distributed in Namibia except for the Kalahari and western Namib, which lack surface water. Populations have since declined drastically due to hunting, human settlement,

and recently poaching for the horn trade. This decline slowed dramatically in the 1980s. There are no reliable population estimates prior to 1984, when Namibia held around 450 rhinos. In 1996, the national population was about 650 rhinos. Of this total,120 occur in the arid communal land of the Kaokoveld (Kunene Region), which lacks formal conservation status. After most of Game Reserve No. 2 was deproclaimed in the 1960s (section 1.2), wildlife in this area was nearly decimated by poaching gangs, colonial officials, contractors, and local people newly armed in Namibia's war of liberation.[60]

Table 2.4 A sample of Namibian species of economic value

Species or group	Description/ source of value	Conservation threats
Gracilaria	Red marine alga, mariculture	
Terfezia pfeilii	Truffle-like fungus	Harvesting sustainability unknown
Termitomyces schimperi	Large delicious mushroom, symbiotic with termites	Harvested on small scale (subsistence and commercial)
Harpagophytum procumbens	Kalahari medicinal plant	Threatened by overexploitation
Pterocarpus angolensis	Subtropical tree used for carvings and furniture	Threatened by overexploitation
Cucurbitaceae	Melons, agricultural potential	Unknown
Sclerocarya birrea	Subtropical fruit tree with diverse subsistence values	Often protected informally
Cleome spp.	'Wild spinach,' subsistence use	Unknown
Lepidoptera	Butterflies collected and traded	Some threatened by overexploitation?
Mantica horni, *Mantichora* spp.	Rare collectors' insects	Threatened by overexploitation?
Imbrasia belina	Mopane caterpillars	Threatened by overexploitation?
Usta wallengreni	Mopane caterpillars	Threatened by overexploitation?
Termites	Some destroy grazing	Unknown
Locusts	Some are crop pests	
Mosquitoes	Some are disease vectors	
Alien invasive insects	Livestock pests or crop pathogens	
Macrobrachium vollenhoveni	Edible freshwater shrimp	Threatened by Epupa Dam
Mutella dubia	Edible freshwater mussel	Unknown, harvested for subsistence
Bulinus globosus	Human schistosome vector	
Bulinus tropicus	Livestock paramphistome vector	
Biomphalaria pfeifferi	Human schistosome vector	
Lymnaea natalensis	Livestock liverfluke vector	
Chaceon maritae	Deep-sea crab, harvested	
Jasus lalandii	Spiny rock lobster, harvested	
Sardinops ocellatus	Pilchard, harvested	Past bottlenecks via overharvesting
Engraulis capensis	Anchovy, harvested	
Pyxicephalus adspersus	Bullfrog, subsistence use	Threatened by overexploitation?
Tortoises, six species	Subsistence use, pet trade	Threatened by overexploitation/ trade
Python anchietae	Dwarf python, pet trade	Threatened by illegal trade
Bitis spp.	Dwarf adders, pet trade	Threatened by illegal trade
Francolins	Gamebirds, harvested	
Quelea quelea	Major pest bird on crops	
Arctocephalus pusillus	Cape fur seal, harvested	
Manis temminckii	Cape pangolin, medicinal trade	Threatened by illegal trade
Diceros bicornis	Black rhino, horn trade	Threatened by illegal trade
Loxodonta africana	African elephant, ivory trade	Secure in southern Africa

Box 2.6 Rhino management in Namibia : countering a 'total onslaught'

Namibia has invested substantial public and private funds in several pioneering rhino management strategies (see also Box 4.12). These include:

- *'community game guards,' patrol units controlled by rural communities with donor funding as part of a broader community-based conservation and tourism approach;*[61]
- *the Wildlife Protection Service (WPS), an anti-poaching patrol unit of the Ministry of Environment and Tourism;*
- *a custodianship programme, in which rhinos are 'loaned out' to well-guarded private farms meeting stringent requirements; and*
- *dehorning of rhinos as a deterrent to poachers.*[62]

Dehorning has been through an experimental and controversial period in Namibia.[62-68] *Since the start of dehorning there has been less poaching, but Namibia is still evaluating the dehorning programme in light of potential side effects, poaching of hornless animals elsewhere in southern Africa, and financial costs.*

The community game guard programme, which provides incentives for local people to manage rhinos and other wildlife for longterm benefit, has been highly successful.

From 1967 to 1977, 68 rhinos were moved from the Kaokoveld to augment a small population of about 150 inside the Etosha National Park, now totalling 480 rhinos. A group of 27 rhinos was moved in 1989 to the Waterberg Plateau Park from Etosha and the former Damaraland (Erongo and southern Kunene Regions). After about seven initial translocation mortalities, this growing population currently numbers 28. Forty-two Etosha rhinos have also been translocated onto private farmland since 1993 as part of a custodianship programme (Box 2.6); these have increased to 48 animals. Finally, 11 rhinos have been moved to smaller parks and sanctuaries since 1989, and losses to disease and other natural causes have been balanced by calving rates (Fig. 2.25).

The serious threats faced by rhinos in Africa leave management authorities little room for error. While current management tactics such as anti-poaching patrols, translocation, and custodianship (Box 2.6) are designed largely to counter the immediate threats, they are only the first phase of a conservation strategy involving close monitoring, intensive management and husbandry which is necessary to ensure the long term viability of rhino populations under changed circumstances. The Namibian Government has three long term goals: 1) to increase the national black rhino population to 2000 animals, 2) to develop and institute a national rhino conservation plan, and 3) to introduce a sustainable use scheme. New and innovative conservation measures, possibly including the legal trade of horn, need to be investigated to enable the recovery of rhinos in Namibia and elsewhere.

-- H-O Reuter & Phoebe Barnard

Fig. 2.25 Female rhino and calf. Courtesy H-O Reuter

Fig. 2.26 Courtesy P Tarr

Cheetahs: a Namibian stronghold

Cheetahs, *Acinonyx jubatus*, have declined or become extinct due to habitat degradation and human pressure in much of their former range, including north Africa and southwest Asia. The Cat Specialist Group of the IUCN Species Survival Commission (IUCN/SSC) ranks cheetahs among the more vulnerable felids in sub-Saharan Africa.[69] Yet large populations remain in east and southern Africa. Namibia holds a substantial number of cheetahs, perhaps the largest population of any single country. The IUCN/SSC and MET have just produced the only national cheetah conservation plan in the species' range.[70] The relatively high cheetah population is reflected in an annual non-commercial export quota of 150 live cheetahs or trophies. This contrasts with five in Botswana and 50 in Zimbabwe, the only other countries in which cheetahs are legally exported.[71]

Cheetahs have fared surprisingly well on ranches and pastoral lands in east and southern Africa[70,72] (Fig. 2.26). In Namibia the vast majority are thought to live on commercial farmland, mainly in the north-central areas.[70,73] Most other large predators, such as lions *Panthera leo*, leopards *P. pardus*, and hyaenas *Crocuta crocuta* and *Hyaena brunnea*, have been extirpated from farms. Commercial farmers are allowed to kill cheetahs which threaten their livestock, and this is the greatest limiting factor to cheetah populations. Livestock farmers have traditionally regarded cheetahs as pests and frequently trapped and shot them. This perception remains today, but is changing in some areas due to the public relations efforts of two Namibian-based NGOs, the Cheetah Conservation Fund (CCF) and AfriCat.

Before the colonial era, Namibia was a much more transitory place for wildlife, with vast seasonal migrations of springbok *Antidorcas marsupialis* which were a major prey item of cheetahs. Conversion of land to commercial agriculture brought boreholes, fences, large herds of cattle, sheep and goats, and guns.[70] This land conversion decimated the springbok populations through fragmentation, restriction from their habitual range, and culling by farmers: springbok were not only eaten, but killed as perceived competitors of sheep. It also may have reduced cheetah numbers directly from persecution and habitat alteration via overgrazing, fire control, and bush encroachment.[70]

Seventy years ago, an indirect survey of large predators (Table 2.5) estimated that 3010 cheetahs occurred in Namibia.[74] This was based on magistrates' discussions with farmers and policemen, and is probably very unreliable. However, it does suggest that cheetahs have been more widespread than lions and hyaenas throughout this century.

More recent cheetah population estimates vary widely, with little agreement about the direction of longterm trends. Joubert and Mostert[75] reported two estimates: 6252 cheetahs on commercial farmland from replies to a questionnaire, and 5000 cheetahs nationwide in a second estimate by the Directorate of Nature Conservation, precursor of the MET. These data suggested a cheetah density of roughly one per 100 km^2 over about two thirds of the country.[70] Joubert & Mostert[75] and Gaerdes[76] felt cheetah numbers to be on the increase, as lions and hyaenas disappeared and kudus *Tragelaphus strepsiceros*, an alternative prey species, grew common. At the same time, however, a pan-African survey[77] put the population at only around 1500 - 3000. This report proposed that Namibian cheetahs were in decline due to the live animal trade, and predicted their extinction on Namibian farms by 1980.

A decade later, Morsbach[73] used field data, based on radio telemetry, to estimate 2000 - 3000 cheetahs nationwide, or one resident adult per 50 km^2 in optimal habitat in the north-central farmlands. While Joubert *et al.*[78] had reported 'healthy, and probably increasing, populations on farms,' Morsbach felt that record levels of persecution by farmers and the decimation of kudus by a rabies epidemic were harming cheetah populations. He noted the folly of trying to estimate numbers without basic data on population structure.

The most recent (1992) MET farm survey estimates about 2350 adult cheetahs, an apparent decline of 25% from 1972.[70] If judged by the percentage of farmers reporting cheetah presence, rather than estimates of numbers, there has been about a 10% decline since 1982.

Less is known of cheetah densities in protected areas. For Etosha National Park, a report in preparation has analysed preliminary data gathered as part of the predator-prey study of Gasaway *et al.*[79] to yield a density estimate of one cheetah per 80 km^2 on the short-grass plains south and east of Etosha Pan.[70] In the broadleaved woodland of Khaudum Game Reserve, Stander *et al.*[80] used transect spoor counts to estimate an extremely low density of one cheetah per 1666 km^2 (0.05-0.07 per 100 km^2). Outside the reserve, density was twice this estimate (one per 833 km^2). Khaudum contains similar small antelope densities to Etosha or just outside Khaudum, but also numerous lions (1.2 - 1.7 per 100 km^2), hyaenas (1.6 - 2.3 per 100 km^2) and leopards which may discourage cheetahs from setting up territories.[70]

Overall, habitat changes in Namibia may have favoured cheetahs, despite their persecution by commercial farmers.[70] Two popular beliefs about cheetahs are that they have benefited during the 20th century by the eradication of direct competitors such as lions and hyaenas, and that bush encroachment has hampered their hunting ability. Both of these are countered by a wide review of game surveys and ecological studies.[70] Rather, lions and hyaenas have probably always been fairly rare in Namibia due to the lack of surface water. Bush encroachment has favoured kudus, and probably aids rather than hinders the cheetah's hunting success. Nowell[70] models the past dynamics of the cheetah population based on past removal rates by farmers, and concludes that the current population in Namibia is between 2000 and 3000 adults and sub-adults. This population fluctuates with changes in its ungulate prey base caused by drought and disease. When fewer game are available, cheetahs probably take more livestock, leading to increased retaliation by farmers until game species recover. Due to their large litter size and the lack of competing large predators which might otherwise kill cubs, Namibian cheetahs can potentially recover quickly from a decline.[70,81] They are increasingly trapped for live export for reintroduction to reserves elsewhere in southern Africa, as a result of efforts by the Cheetah Conservation Fund and AfriCat to reduce conflict with farmers. This could bring significant revenue directly to Namibian farmers, and not just to game dealers.[70]

— Phoebe Barnard

Fig. 2.27 Bush encroachment in Namibia has probably favoured kudus, a prey species of cheetahs. Courtesy P Tarr

Wild dogs: everywhere on the run

Wild dogs or African hunting dogs, *Lycaon pictus* (Fig. 2.27), are under pressure everywhere on the African continent and have been eliminated from large areas of their former range.[82,83] Outside southern Africa, small and probably non-viable relict populations occur still in the wooded savanna zones of sub-Saharan Africa. In the Serengeti, which should have been one of the best protected areas for wild dogs, they have been drastically

reduced in the past 100 years by a combination of human encroachment and diseases carried by domestic dogs.[83]

In Namibia, large parts of the country are widely thought to be too arid for wild dogs. However, since their range in the 17th and 18th centuries included southwestern and northern parts of the Cape Province in the Nama-Karoo biome,[82] this was probably not always the case. A canid jaw recovered in 1995 from a recently-exposed peat bank at Sandwich Harbour, south of Walvis Bay, is almost certainly of a wild dog,[84] suggesting that they may have ranged opportunistically and widely along the riparian and coastal zones of the hyper-arid Namib Desert.

The 1926 magisterial survey of large predators (Table 2.5) generated estimates for wild dog populations by district. These are highly unreliable, and probably reflect public loathing and fear of wild dogs, especially in the farming communities. In the district of Outjo, for example, an estimate of 8000 dogs was reported, which is surely exaggerated by at least an order of magnitude. However, even inaccurate figures suggest that wild dogs seventy years ago were much more widespread than today.

Today, wild dogs are endangered in Namibia, as in other areas, but their numbers appear stable in a 61 100 km^2 area in northern Namibia, of which 3842 km^2 is protected.[80] There are somewhere between 242 and 1235 individuals in Khaudum Game Reserve, eastern Otjozondjupa and eastern Omaheke Regions,[80] with minimum home ranges of three packs estimated at 1756, 1342 and 789 km^2 and an overall density of 0.61 - 3.1 animals per 100 km^2.[80] In addition to these areas, wild dogs range infrequently across Okavango, former Owambo[85] and Caprivi. As packs cross routinely into adjacent Botswana, and possibly Zambia and Angola, protection is difficult without regional committment. In Namibia, the much reduced present range of wild dogs unfortunately corresponds closely with land earmarked for resettlement by Herero cattle farmers, many of whom hunt wild dogs with their domestic dogs at heel.[86]

Table 2.5 Estimated numbers of cheetahs and wild dogs in Namibia, 1926[74]

District	Cheetahs	Wild dogs
Aroab	60	0
Bethanie	50	300
Gibeon	200	500
Gobabis	500	1500
Grootfontein	no data	no data
Karibib	no data	100
Keetmanshoop	100	32
Lüderitz	no data	0
Maltahöhe	no data	50
Okahandja	200	400
Omaruru	20	400
Otjiwarongo	800	520
Outjo	no data	8000
Ovamboland	80	200
Swakopmund	no data	0
Warmbad	no data	0
Windhoek	100	50
Namutoni/Etosha	900	2000
Total	3010	14 052

Due to their susceptibility to canine distemper, adenovirus and parainfluenza virus,[87,88] all of which are present in sympatric domestic dogs, wild dogs are unlikely to persist in Namibia in any form of multiple-use protected area that allows contact with humans, their vehicles, or domestic dogs. Once introduced into a pack, these viruses can attack all individuals rapidly through the elaborate greeting rituals which involve mutual licking and grooming.[87] Establishment of some form of large core wilderness area for wild dogs and other sensitive species is an urgent conservation priority.

— Phoebe Barnard & Flip Stander

Flamingos: declining in southern Africa

Flamingos are among the most specialised and conspicuous of birds. Greater and lesser flamingos, *Phoenicopterus ruber* and *Phoeniconaias minor*, are long-lived waders which breed sporadically at only two main sites in southern Africa: Botswana's Makgadikgadi Pans and Namibia's Etosha National Park. There are occasional minor

breeding attempts by lesser flamingos at sites such as South Africa's Lake St Lucia. On Etosha Pan, flamingos have experienced only four major breeding events in 40 years. Non-breeding or breeding failure often occurs because high evaporation rates rapidly dry the pan, and up to 100 000 flightless chicks may starve at such times. Flamingo pairs breeding in Etosha thus have extraordinarily low recruitment (0.040 young per pair per year), which by extrapolation suggests that if they bred solely at Etosha, they could replace themselves only by breeding for between 38 and 50 years with 100% offspring survival.[89] Actual chick survival from fledging to adulthood is about 46%, so Etosha flamingos would have to breed for an unrealistic 83 years[89] for Etosha to be a viable breeding site on its own. There are insufficient data for population viability assessment of any other flamingo breeding site in Africa.

Like many other wetland birds of arid regions, however, flamingos do not necessarily breed solely in one site, but shift opportunistically to alternative sites as these receive rainfall. Therefore, the non-viability of Etosha as a flamingo breeding site might not pose a problem if flamingos could breed successfully at other sites in the region. Unfortunately, alternative sites in Africa are increasingly under threat from soda ash mining (Lake Magadi, Lake Elementeita, Sua Pan) or potential damming (Lake Natron). Other than Etosha, only the small Lake Nakuru in Kenya falls within a protected area.

Estimates from both southern Africa and the continent as a whole suggest population declines of 20% - 40% in both species over the past 20 years (Table 2.6). The Namibian coast and inland pans regularly support 84% (40 000 of 47 000) of the southern African population of greater flamingos, and 85% (34 000 of 40 000) of southern African lesser flamingos.[90] Conservation efforts are thus best focused in Namibia.

To reverse poor breeding success, breeding islands with a moat deep enough to retain water for the three-month breeding season have been suggested as the only feasible solution.[89] The rearing of chicks abandoned in seasons of widespread breeding failure has again recently proven unsuccessful in terms of recruitment to future generations.[91] By contrast, schemes using artificial islands with moats to enhance breeding have been successful for over 15 years in the Camargue, southern France, a site which remains the only consistently active colony in Europe and north Africa. These methods should be tried in Namibia, either on minor pans of the Etosha system or in the already altered habitats of the coast.

Flamingos are partly victims of their own specialisation. Their population decline has, however, been exacerbated by long periods of low rainfall and habitat degradation at many of their breeding sites. Some form of active conservation management is necessary to reverse this decline.

— Rob Simmons

Table 2.6 Flamingo population declines in Africa

	1975	1995	% decline
Southern Africa			
lesser flamingo	55 000	40 000	27
greater flamingo	75 000	50 000	33
All Africa			
lesser flamingo	5 057 000	4 029 000	20
greater flamingo	165 000	85 000	48

Sources: Cooper & Hockey,[96] Kahl,[97] Dodman & Taylor[90]

Fig. 2.28 Flamingos at Sandwich Harbour. Courtesy P Tarr

Cape griffons: life on the edge

The Cape griffon (or Cape vulture) *Gyps coprotheres* is endemic to southern Africa. Once found soaring around Table Mountain, the species today has undergone a major range contraction and now has the smallest diistribution of any Old World vulture.[92] It nests on cliffs and travels long distances in search of carcasses. World population numbers are presently put at 4400 breeding pairs, up from a 1976 estimate of 2500 pairs and 10 000 individuals.

In Namibia, Cape griffons were seen commonly in the early 1970s in the Namib-Naukluft Park,[93] but are rarely seen there today. At least eight extinct colonies are known, mainly from the edge of the Namib Desert.[94] In their Namibian stronghold on the sandstone cliffs of the Waterberg Plateau Park, there were estimated to be 300 birds in 1969. In the next 16 years their numbers plummeted 95% to about 15 individuals and 3 nests.[94] In an effort to save this tiny colony a vulture restaurant was set up in the 1980s, providing at least one ungulate carcass per week.[95] This scheme slowed and began to reverse the rapid decline, but records and observations in 1995-97 show only five non-breeding adults.

Other, more subtle, factors seem to have contributed to the demise of the Cape griffon in Namibia. One of these is bush encroachment in the Waterberg area since the turn of the century. This appears to have greatly reduced the ability of vultures to find and use animal carcasses. Decimation of browsing ungulates through epidemics, such as the severe rinderpest outbreaks of 1897-1905,[98] can lead to the establishment of *Acacia* seedlings over vast grassland areas, slowly changing an open landscape to a bush encroached one.[99]

The decline of this vulture, a process perhaps started by landscape changes, has been rapidly hastened by indiscriminate poisoning. Persecution of vultures even within protected areas has continued[100] and the bird's survival into the next milennium, with less than 5% of its 1969 population, is thus more a matter of chance than certainty.

— Rob Simmons

2.6 Underprotected habitats

Namibia has a state-controlled protected area network of 21 proclaimed parks and reserves (Box 1.9, map 2.8), which make up about 13.8% of Namibia's land area. At first glance this is an impressive figure, which comfortably exceeds the 10% recommended by IUCN to be set aside for conservation. In addition to 10% of overall land area, it is Namibian government policy[101] that 10% of vegetation types, or 'all ecological regions and their major variations,' be explicitly represented in the protected area network.

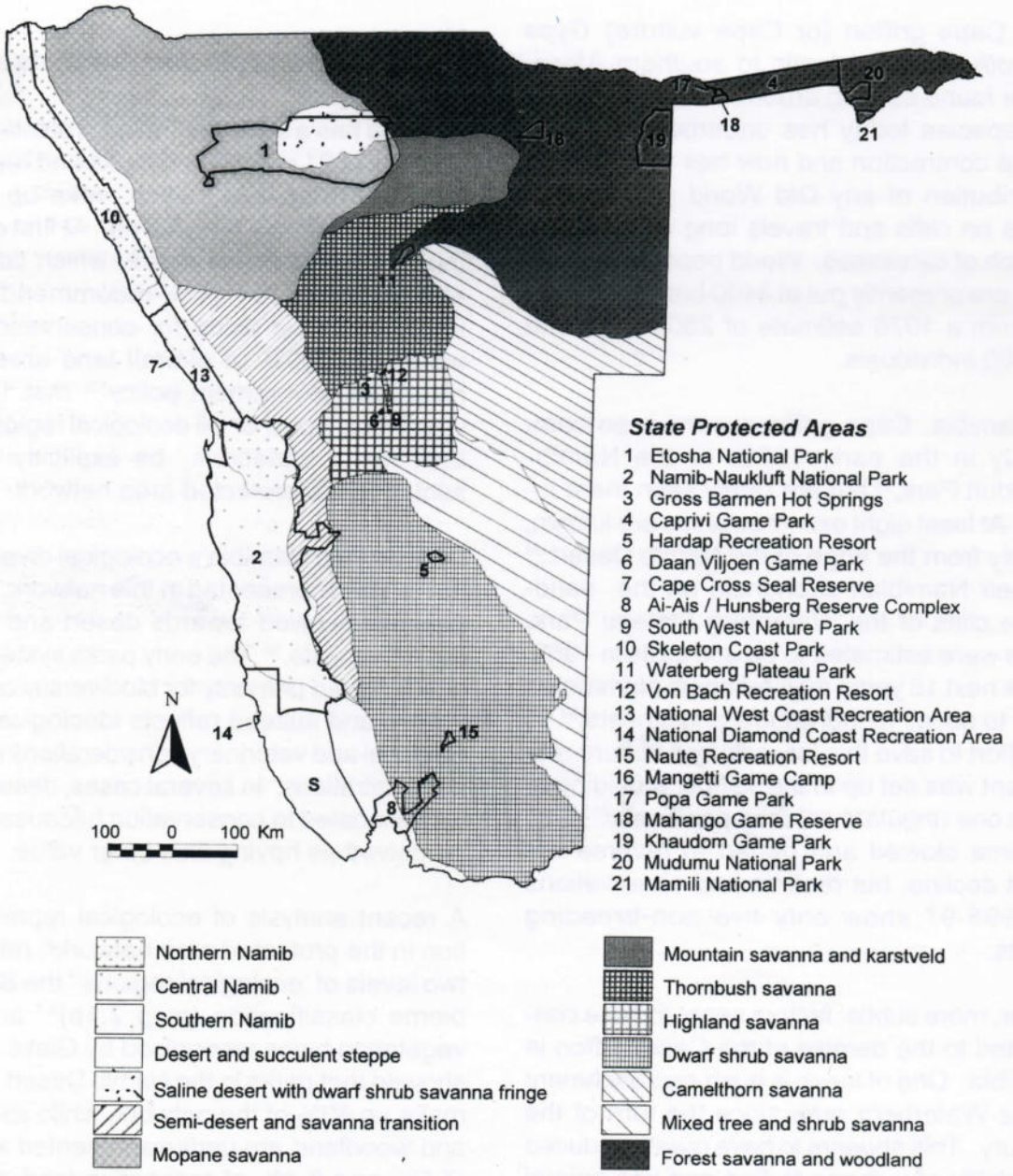
Despite this, Namibia's ecological diversity is not evenly represented in this network, which is highly skewed towards desert and saline desert habitats.[50] The early parks system was not designed primarily for biodiversity conservation, and instead reflects ideological, recreational and veterinary considerations of past administrations. In several cases, desert land was allocated to conservation because it was perceived as having little other value.

A recent analysis of ecological representation in the protected area network[50] relied on two levels of 'ecological regions:' the SABAP biome classification (map 2.1b)[6,7] and the vegetation types recognised by Giess.[5] This showed that parks in the Namib Desert biome make up 69% of the network, while savanna and woodland are underrepresented slightly (7.5% and 8.4% of respective land areas). The Karoo biome is badly underrepresented relative to the 10% target (1.6%)(Table 2.7).[50]

Table 2.7 Distribution of state protected areas in the four major biomes of Namibia[a]

Biome	Proportion of land area (%)	Total protected area (km²)	Proportion of biome (%)	No. of protected areas per size category (km² x 100): < 1	1-10	10-200	>200
Woodland	17	11 766	8.4	1	3	3	0
Savanna	37	22 704	7.5	4	1	0	1
Namib	32	77 728	29.7	1	1	3	1
Karoo	14	1 882	1.6	0	2	0	0
Total/ mean	100	114 080	13.8	6	7	6	2

[a] *Major biomes as in Fig. 2.1b*[6,7]



Map 2.8 The Namibian state protected area network and the 14 major vegetation zones.[5] *S = Sperrgebiet diamond mining concession, currently not part of the state network.*[50]

At the finer scale of vegetation types, 4 of 14 desert vegetation types are comprehensively protected, with 67% to 94% representation in the protected area network, but six savanna types are virtually unrepresented (Fig. 2.30). Mountain Savanna, a unique vegetation type (Fig. 2.29), is wholly unprotected.[50] Thornbush Savanna, Highland Savanna, Dwarf Shrub Savanna, Camelthorn Savanna, and Mixed Tree and Shrub Savanna are all badly underrepresented, with 0-2% coverage in the protected area network (Fig. 2.30).

These vegetation types are purely terrestrial. Turning to wetlands, virtually all types summarised in Table 2.1 are underprotected. For example, our species-rich perennial rivers are restricted to our borders, where they are shared with neighbouring countries and in heavy demand for water abstraction.[33] They are thus in need of special conservation measures including stringent legal protection (Box 2.7), but are poorly protected in Namibian reserves (Table 2.8).[102] Ephemeral pans other than those in the Etosha system are underprotected, and ephemeral rivers need conservation attention in their upper and middle catchments, where human densities and resource demands are greatest.[10]

To what extent is the ecological skew in the state protected area network mitigated by other conservation approaches, such as conservancies, private nature reserves and game farms (section 1.2)? So far, these approaches appear to balance the state PAN reasonably well in terms of vegetation types.

The nine commercial conservancies established by late 1997 include those in the Highland Savanna (three conservancies), Thornbush Savanna (two), Forest Savanna and Woodland (one), Mountain Savanna and Karstveld (one), Mopane Savanna (one) and Camelthorn Savanna (one), with several conservancies overlapping adjacent vegetation types slightly[50] (map 1.8). These land units collectively account for more than 10 000 km^2 of farmland, and range in size from about 600 km^2 to 2 300 km^2. They will be mapped in the near future, allowing more precise analysis of ecological coverage.

Communal land conservancies also show excellent potential for balancing the state network. Of the five communal conservancies now at advanced stages of development, the 9 023 km^2 Nyae Nyae Conservancy (Tsumkwe District) in the Forest Savanna and Woodland vegetation type should be a valuable model of community management.[103] Other conservancies include a roughly 910 km^2 area joining Mudumu and Mamili National Parks in Caprivi.[50] Caprivi has extremely high overall species richness, and offers significant potential for a transboundary multiple-use protected area with parks in Angola, Botswana, Zambia and Zimbabwe.[38]

Several very large conservancies are forming in the former western (Kaoko) corridor of the old Game Reserve No. 2, now Kunene and Erongo Regions. These will stretch along the eastern border of the Skeleton Coast Park, covering Northern Namib, Central Namib and escarpment (Mopane Savanna) vegetation types.[50] Ultimately, about 50% of the land formerly occupied by Game Reserve No. 2 could again be protected in this way.[103] Not only will this provide communities with incentives to safeguard land with high conservation value, but it will also create a mosaic of formal and informal protected areas stretching to Angola's Iona National Park.

Box 2.7 Protection of riparian corridors

Not only are wetlands poorly represented in the state protected area network, legal provisions for safeguarding wetlands are weak and piecemeal. The only current legislation explicitly protecting riparian corridors in Namibia is a paragraph (14) in the Forestry Act of 1954 which makes it an offence to damage or remove any plant or part of a plant from a river or within 100 yards of a rivercourse without a permit from the landowner. This and related legislation is often disregarded and unenforced, and fines are not punitive. The MET's Wetland Policy promises protection of riparian zones in the future. Environmental legislation is currently under review (Chapter 5) and it is essential that protection of riparian corridors be included and enforced in both commercial and communal areas.

— Shirley Bethune

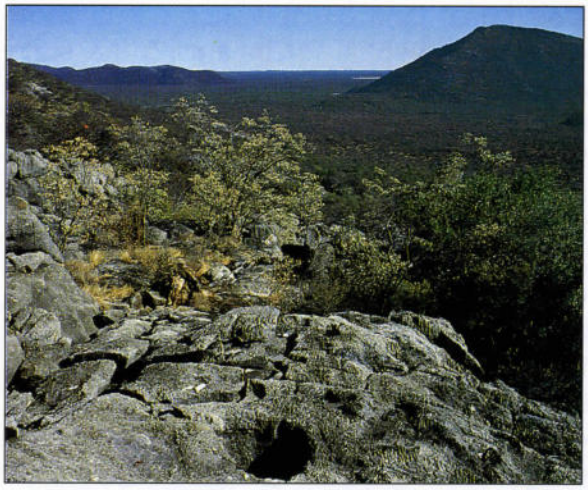


Fig. 2.29 Mountain Savanna is currently wholly unprotected by the Namibian parks system. Courtesy E Marais

Table 2.8 Lengths of Namibian perennial rivers and approximate lengths protected in reserves[102]

River	Length in Namibia (km)	Protected %
Kunene	340	12
Okavango	470	3
Kwando-Chobe	484	18
Zambezi	152	0
Total	2076	Mean 10.6

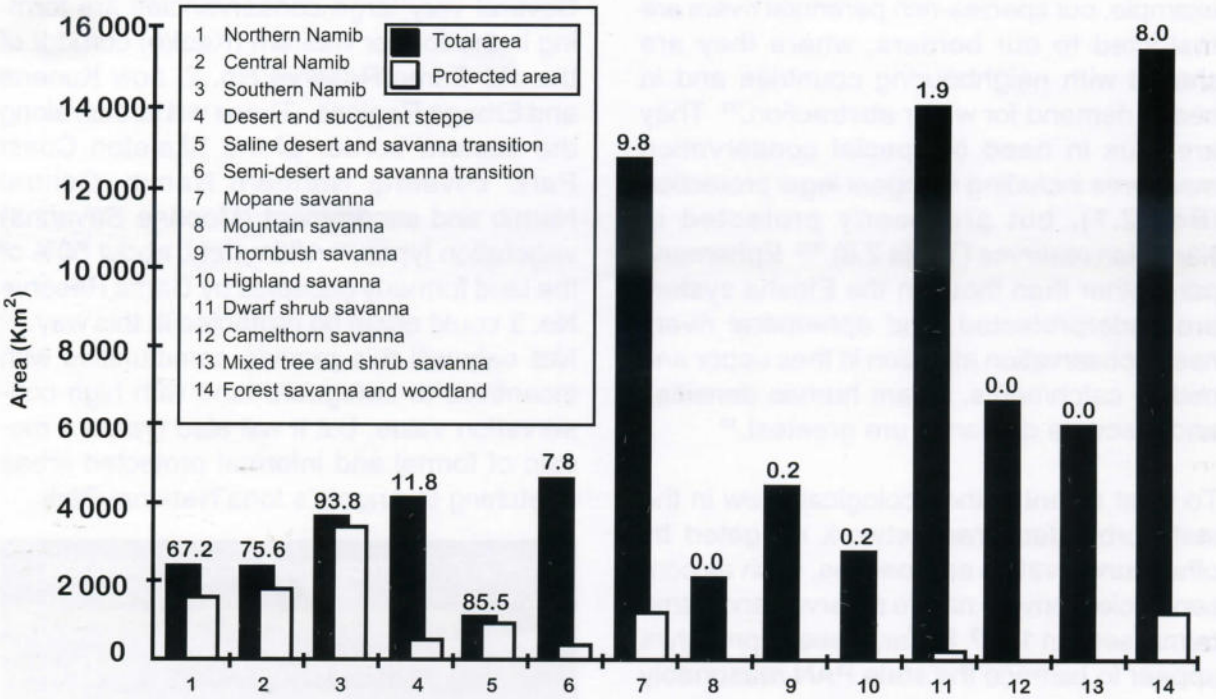


Fig. 2.30 Percent representation of the 14 major vegetation types[5] in Namibia as a whole (dark bars) and in state protected areas (white bars).[50] Numbers atop the bars are percentage representation in the protected area network.

Probably the most significant gaps in habitat protection are Namibia's two priority areas for endemism: the northern Namib (Kaoko) escarpment, along with the nearby inselbergs and granite domes of the Kunene and Erongo Regions, and the *Sperrgebiet* winter-rainfall region in the Desert and Succulent Steppe vegetation type.[49] The Kaoko escarpment forms an important regional centre of endemism. This escarpment, including the Brandberg massif and nearby inselbergs and granite domes, is the most important endemism hotspot for vertebrate taxa in both Namibia and Angola (maps 2.2-2.7).[49] For example, among the highest avian endemism in Namibia occurs locally within the Kaoko escarpment zone at the intersection of vegetation types containing rocky terrain, especially granite domes, and major river courses.[49,52] These habitats fall largely on private farmland, and deserve urgent action in cooperation with landowners to ensure longterm protection (Table 2.9).

The *Sperrgebiet* is part of the Southern Namib centre of endemism, abutting South Africa's floristically rich Richtersveld succulent steppe.[155] The 26 000 km² *Sperrgebiet* diamond mining area has been managed by multinational interests for most of this century (section 1.2). The concession agreement for this biotically valuable and endemics-rich area expires in about 2020, at which time the *Sperrgebiet* may be included in some form of biosphere reserve adjoining the Richtersveld National Park in South Africa.[50] Sections of this area have been abandoned by the concessionaire, but will remain under its protection until a land use plan is developed.

Optimal protection of the Kaoko and Southern Namib centres of endemism requires transboundary conservation, and indeed this has been discussed by all three countries for some years. If the Kaoko and *Sperrgebiet* regions can both be incorporated into some form of multiple-use park by Namibia (see Box 5.3), this would create an unparalleled multi-zoned conservation area stretching from Iona National Park in southern Angola to the Richtersveld National Park in South Africa. The ecological uniqueness and endemism of this landscape is extraordinary by regional and international standards (Fig. 2.31).

More localised centres of endemism which have been recently identified[49,102] include the extinct volcanic crater of Brukkaros and the karst caves and sinkholes of the Mountain Savanna vegetation type. Ephemeral pools and mineral springs, and 'islands' of dune, gravel plain, mountains and rocky hillsides in the Namib Desert habitat mosaic, are intrinsically valuable for endemics.[47,49]

Major regional river systems, such as the Okavango and Zambezi, contain numerous 'catchment endemics'[102] which need regional protection via established international committees.

Nearly 85% of Namibia's land is zoned for potential or actual agricultural use, so effective biodiversity protection also means working outside the formal protected area network to improve the sustainability and diversity of farming practices. Agricultural biodiversity planning is at a fairly early stage in Namibia, but a working group is now being established of specialists from the Biodiversity Task Force, others within the Ministry of Agriculture, Water and Rural Development, and NGOs to develop strategy and practical forms of implementation at the landscape, habitat, species and genetic diversity levels. Two important existing programmes in this context, the Sustainable Animal and Range Development Programme (SARDEP) and the Northern Regions Livestock Development Project (NOLIDEP), do not have an explicit biodiversity focus but work with farmers to improve the overall sustainability of rangeland management. A key institute at the genetic diversity level is the National Plant Genetic Resources Centre (below), housed in the agriculture ministry.

— Phoebe Barnard

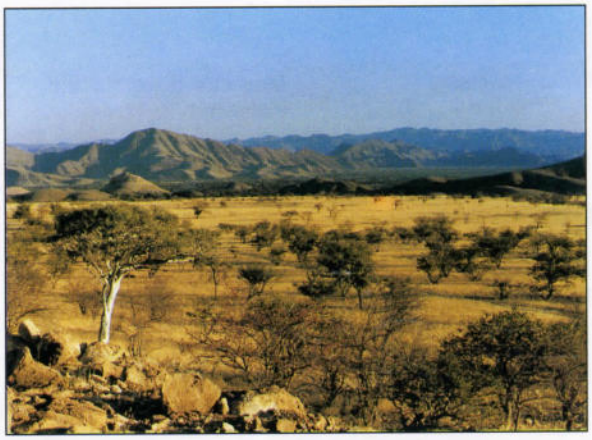


Fig. 2.31 The northern, Kaoko section of the Namib escarpment is one of Namibia's top priorities for conservation protection. Courtesy R Simmons

Fig. 2.32 The Caprivi Region offers valuable opportunities for regional consolidation of transboundary multiple-use or 'people's parks'. Courtesy LC Weaver

Table 2.9 Summary of top priorities for additional terrestrial and freshwater conservation protection in Namibia[50]

Region or locality	Vegetation zones	Suggested approach/ comments*
Kaoko escarpment, Brandberg and nearby inselbergs and domes	Mopane Savanna, Semi-Desert and Savanna Transition	Transboundary multiple use park with conservancy zones linking Skeleton Coast, Etosha and Iona (Angola) National Parks. Would protect important ephemeral river and inselberg habitats. Top endemism zone; also region of appropriate traditional land management.
Sperrgebiet	Desert and Succulent Steppe	Transboundary national park linking Namib-Naukluft Park and Richtersveld (South Africa) National Park. Top richness and endemism zone.
Caprivi woodlands, river floodplains and riparian vegetation	Forest Savanna and Woodland	Transboundary 'people's park' or multiple use park Mahango Game Reserve, Caprivi Game Park, Chobe National Park (Botswana) and Okavango Delta (Botswana) with conservancies in Caprivi. High richness zone, many red data species, some endemics.
Otavi Mountains	Mountain Savanna and Karstveld	Multiple sites of interest or strictly protected area to supplement existing conservancy, protecting karst sinkhole and cave endemics and sites of botanical importance. High richness and endemism zone.
Brukkaros Crater	Dwarf Shrub Savanna	Communal conservancy / site of interest for endemic species and geological history.
To be identified	Thornbush Savanna Highland Savanna Camelthorn Savanna Mixed Tree and Shrub Savanna	Commercial and communal conservancies, sites of interest or private parks (*e.g.* Arnhem Cave) or multiple use parks. Savanna types important for supporting agriculture and other land uses, currently virtually unprotected

** Comments on protection strategy refer to protected area categories in draft legislation (Chapter 5, Box 5.3) as well as to conservancies. Reference should also be made to Tables 2.2 and 2.3 for additional categories and sites of ecological and archaeological importance.*

2.7 *Ex situ* conservation facilities

Botanical facilities

Ex situ conservation of plants and their genetic material is relatively new to Namibia. After Independence in 1990, the country joined the Southern African Development Community (SADC), and a National Plant Genetic Resources Programme was initiated as part of the regional SADC Plant Genetic Resources Centre (SPGRC) Project. The value and development of indigenous plant genetic material had received little attention in Namibia before then. National capacity is developing slowly, since most infrastructure and expertise must be newly developed.

The National Plant Genetic Resources Centre

The SPGRC project aims to conserve all plant genetic resources in the region and promote their use. The project was started because the threat of genetic erosion in the region was believed to be growing.[104]

Under this project a National Plant Genetic Resources Centre (NPGRC) was established in the Ministry of Agriculture, Water and Rural Development (MAWRD) as a section of the National Botanical Research Institute (NBRI) in Windhoek. The Namibian Government built a new complex, completed in 1992, to house the NPGRC. Its facilities comprise an office, documentation room, seed threshing room, laboratory, deep-freezer room, and walk-in cold room, with other facilities shared with the rest of the NBRI. Essential equipment is linked to a stand-by power supply.

Important equipment was provided to the NPGRC through an agreement between SPGRC and the Swedish International Development Authority (SIDA), but running costs are met by the MAWRD. Specific projects may be funded through the SPGRC project, which in turn is funded by the five Nordic countries. Since 1994, SPGRC is also supported by contributions from SADC member states, which must assume full financial responsibility for the project in 2005.

A curator was trained under the SPGRC project to MSc level and began work in 1993. Overall, five staff positions (two researchers, two technicians and one assistant) have been allocated by MAWRD to the NPGRC. By 1997, only one researcher, a technician and an assistant had been employed.

At present, the NPGRC's storage capacity is almost filled. Storage space for the project will double, however, and the remaining 50% of capacity should take an estimated three years to fill. Currently all germplasm is accepted for storage. Once a basic collection of important germplasm has been stored, the NPGRC will be more selective. In future, only local germplasm accompanied by sufficient passport information will be stored.

The collection so far contains only Namibian material, both wild species and crops. There are over 1900 accessions, of which over half (53%) are of pearl millet, the main crop in Namibia, mostly collected by ICRISAT in 1991. Most accessions of wild species are of indigenous Cucurbitaceae. The majority of accessions are duplicated at the SPGRC regional centre in Lusaka, Zambia. As the collection is still very young, it does not yet represent the country's diversity. The millet collection is relatively representative, but by no means complete. Many accessions also need to be multiplied or regenerated, and most other species are poorly or not at all represented. Managing the collection is a problem due to staff shortages, but this situation should improve with the help of staff in other sections of the MAWRD.

Namibian material is collected according to a priority list identified by the NPGR Committee (Appendix 3). This lists wild and cultivated species considered to be of great value or in danger of genetic erosion. Collection is done by the NPGRC or the National Herbarium of the NBRI. Collecting missions of foreign institutes in Namibia are obliged to deposit a subsample of each collection at the NPGRC; in the past five years six such collections have been received. Collecting missions for specific crops are carried out according to the needs of agronomists, who meet once a month to advise the NPGRC.

Random sampling is used wherever possible for both crops and wild species. General collecting of wild species is mainly opportunistic according to rainfall, and planning has recently been aided by the use of Vegetation Index Maps generated with NOAA satellite data.[105]

Almost all material from wild species in the collection is collected at the request of foreign taxonomists. The NPGRC receives very few requests for wild material to be used in breeding projects or evaluation of agricultural potential. Locally, germplasm is used by MAWRD scientists for the Sorghum and Pearl Millet Improvement Programme and research on the potential of indigenous cucurbits.

Fig. 2.33 *Citrillus lanatus* seed diversity in Namibia. Courtesy C Mannheimer

The NPGRC collection database is entered into DBase IV, which is used by all NPGRCs in SADC to facilitate data exchange, and backups are sent annually to the regional SPGRC facility. The PRECIS Specimen Database, developed by the South African National Botanical Institute in Pretoria, was implemented at the National Herbarium in 1996, and will facilitate both *in situ* and *ex situ* conservation activities considerably.

The NPGRC tries to use crop experts to carry out seed characterization and evaluations, due to staff shortages. When supplying seed, the NPGRC has a contractual requirement that information obtained using the seed must be fed back to the NPGRC. As there is so far no legislation backing up this request, one-time users of the NPGRC can get away with not responding. Users requesting seed again receive it only if feedback on previous requests was obtained. Legislation to back up these agreements is in preparation.

The NPGRC intends to regenerate material once the viability of the seed falls below 85% for crop species or 65% for wild species. Once crop accessions have been tested for viability, multiplication and regeneration will be done in collaboration with SPGRC or the MAWRD Subdivision of Agronomy.

Other botanical facilities

At present no arboreta, field genebanks or botanic gardens are involved in *ex situ* conservation in Namibia. Land for a small (11 ha) botanical garden in Windhoek is being developed by the NBRI and Ministry of Environment & Tourism as personnel and financial circumstances allow. This will complement conservation activities, mainly by raising public awareness. The MAWRD's Namibia Root Crops Research Project plans to establish field genebanks for cassava *Manihot esculenta* and sweet potato *Ipomoea batatas* at Bagani. Both locally available germplasm and material from the SADC region will be held there.

Genetic resources of indigenous trees are being developed by the Tree Seed Centre Network, a joint project of the MET's Directorate of Forestry, the Southern African Development Community (SADC) and the Canadian International Development Agency. This project collects, tests, stores and regenerates seed from economically valuable indigenous tree species in Namibia, as part of a regional programme.[106]

Finally, international herbaria with holdings of Namibian plant specimens have been summarised in Appendix 4.

— *Herta Kolberg*

Fig. 2.34 Pearl millet or *omahangu*, *Pennisetum glaucum*, is a focus of the NPGRC. Courtesy HH Kolberg

Animal facilities

Genetic material and traditionally preserved specimens are held at the National Museum of Namibia, which maintains significant collections of many animal groups in addition to cultural, archaeological and historical material. Some of the major collections, breeding facilities and other *ex situ* conservation facilities are outlined below. Namibia has no substantial facilities for the *ex situ* conservation of any live animal species for captive breeding purposes.

Invertebrates

The most comprehensive *ex situ* facility for any invertebrate group is the Namibian National Insect Collection (NNIC) at the National Museum of Namibia. The NNIC maintains a core collection of *ca.* 500 000 specimens, and 250 000 - 500 000 additional specimens. This includes representatives of all orders and most families recorded from Namibia, though ectoparasitic fauna are poorly represented. About 50% of the collection is identified to genus, and 20-40% to species. Species identifications are usually identified by an acknowledged systematist working on the taxon. Most identified specimens are beetles (Coleoptera), which also make up about 60% of the collections.

The NNIC is actively promoted abroad, and *ca.* 40 000 specimens from ten orders are presently on loan to researchers worldwide. A core library of entomological information is maintained, and an on-line information service on Namibian insect diversity, taxon holdings, and geographical coverage is being developed. An active, goal-oriented programme to extend the scope and coverage of entomological diversity is pursued, and where possible other expertise and institutions are involved in programmes. Researchers are encouraged to deposit voucher material from Namibia in the NNIC, particularly taxa new to science, to promote local reference and information sources.

Important *ex situ* sources of Namibian insect material are listed in Table 2.10. Most comprehensive and specialized collections contain some representative material from Namibia. "Important" is a value judgement based on criteria, such as geographical and taxon coverage of Namibia, historical importance, information accessibility, number of specimens and number of type specimens.

At present there is no known live *ex situ* facility for indigenous insects, though small, temporary facilities are sometimes kept for research or public education at the Desert Ecological Research Unit (DERU) at Gobabeb in the central Namib Desert. One captive breeding facility exists for an alien insect used in biological control of an aquatic weed (Box 2.8).

Other than insects, the National Museum of Namibia holds substantial collections of other invertebrates, especially arachnids, some myriapods (Table 2.11), and aquatic invertebrates. There are *ca.* 23 000 aquatic specimens representing 12 phyla, 39 orders, 497 families and 992 species. All these collections, plus those of three vertebrate classes, have been managed by a single curator. Many groups are well known, but it is difficult even to estimate how fully some collections reflect Namibian diversity.

— Eugéne Marais & Eryn Griffin

Box 2.8 A facility for biological control

A biological control agent breeding facility in Katima Mulilo was set up by the Department of Water Affairs (DWA) of the MAWRD. The DWA took responsibility in 1980 for controlling infestations of Kariba weed Salvinia molesta *in the eastern Caprivi wetlands. After two years of research, DWA decided to use a host-specific alien weevil,* Cyrtobagous salviniae, *for biological control, given the ecological sensitivity and inaccessibility of many wetlands. The first 500 weevils were imported from CSIRO in Australia in 1983, and a second batch was imported when the first was unsuccessful. Since then, insects have been successfully bred for regular release at all infestation sites, and are regularly monitored. Kariba weed is now under control, and healthy populations of weevils exist which remain dependent on the host plant for breeding and larval development.*

— Shirley Bethune

Table 2.10 Important museums holding Namibian insect specimens

Institution	City	Namibian specimens	Notes
National Museum of Namibia	Windhoek	*ca.* 500 000	Comprehensive in-country repository
Transvaal Museum	Pretoria	*ca.* 250 000	Coleoptera, Lepidoptera
Museum für Naturkunde	Berlin	*ca.* 180 000	Comprehensive historical (1900's) & recent
National Collection of Insects	Pretoria	*ca.* 120 000	Isoptera, Orthoptera, Neuroptera, Hymenoptera
Lund University	Lund	*ca.* 20 000	Important comprehensive historical (1950's)
South African Museum	Cape Town	*ca.* 30 000	Important historical (1920-40)
Nasionale Museum	Bloemfontein	*ca.* 40 000	Important comparative collection
Natal Museum	Pietermaritzburg	*ca.* 15 000	Diptera
Medical Research Institute	Johannesburg	*ca.* 10 000	Ectoparasites & medical problem groups
Albany Museum	Grahamstown	*ca.* 15 000	Aquatic fauna
Riksmuseet	Stockholm	*ca.* 5 000	Important historical (1850-1880)
Veterinary Research Institute	Pretoria	*ca.* 5 000	Veterinary problem groups
California Academy Sciences*	San Francisco	*ca.* 40 000	Embiidina, Hymenoptera
Alexander König	Bonn	*ca.* 60 000	Reference collection in Germany
British Museum (Nat. Hist.)	London	*ca.* 60 000	Reference collection in U.K.
Los Angeles County Museum	Los Angeles	*ca.* 60 000	Value status unclear

Note: Ex situ Namibian material in the large USA collections is presently not clear. Listed institutions are known to have collected extensively in Namibia, holdings are approximated. Source: Eugéne Marais

Table 2.11 Arachnid and myriapod specimens in the National Museum of Namibia

Arachnid order	No. of specimens	Myriapod order[a]	No. of specimens
Spiders	80 000	Earth centipedes	100
Solifuges	20 000	Large centipedes	370
Scorpions	4 500	Stone centipedes	120
Pseudoscorpions	1 200	Shield centipedes	—
Opiliones	40	Pill millipedes	—
Amblypygi	40	Pincushion millipedes	110
Mites and ticks	8 000	Worm-like millipedes	—
		Keeled millipedes	—

[a]*Common names of taxa following Lawrence.*[107] *Source: Eryn Griffin*

Fig. 2.35 Mathilda Awases at the Namibian National Insect Collection. Courtesy E Marais

Vertebrates

The National Museum of Namibia houses the largest and most extensive collections of Namibian vertebrates, including *ca.* 17 000 mammal, *ca.* 10 500 bird, *ca.* 7500 reptile, 6000 fish and 900 amphibian specimens (Table 2.12). During colonial times, foreign museums gathered and exported extensive specimen collections. Chief among these are the British Museum (Natural History), Transvaal Museum, Los Angeles County Museum, Field Museum of Natural History, Carnegie

Museum, United States National Museum, Museum of Vertebrate Zoology, California Academy of Sciences, Berlin Natural History Museum of Humboldt University, Vienna Natural History Museum, and the Alexander König Museum, Bonn. Altogether about 45 foreign museums have Namibian material, and we estimate that roughly 40 000 mammal, 30 000 reptile, 2500 amphibian and 24 700 bird specimens are available worldwide for study. Table 2.14 indicates the approximate holdings of bird collections from Namibia.

Animal genetic material, chiefly blood and skin tissue, has been collected from Namibia only rather recently. Most of these fairly small collections, which are mainly from vertebrates, are listed in Table 2.13.

Table 2.12 Vertebrate specimens in the National Museum of Namibia

Order	Approx. no. of specimens
Reptiles	
Turtles	50
Snakes	1410
Lizards	6010
Crocodiles	—
Amphibians	
Amphisbaen	79
Frogs	900
Fish	
Bony fish	6000
Sharks	22
Birds	
All birds	10 500

Sources: Eryn Griffin, Chris Brown

The MET occasionally supplies red data species to adjacent countries for restocking purposes. For example, black rhinos of the subspecies *bicornis* have been supplied to South African parks elsewhere in their former range. When political stability returns to Angola, Namibia is likely to be involved in restocking animals there, as the original Angolan populations were genetically closest to Namibian stock.

Local and international NGOs can potentially play a major role in *ex situ* conservation in Namibia. As an example, the Cheetah Conservation Fund, based near Otjiwarongo, maintains a cheetah tissue sample database and keeps the international cheetah studbook (a register of zoo animals and their reproduction). It also facilitates the introduction to zoo gene pools of new genetic stock from the wild, usually in the form of 'problem animals' from Namibian commercial farms, in addition to its *in situ* conservation efforts (section 2.5).[108]

Table 2.13 Animal tissue collections from Namibia[1]

Institution	Type of material
Namibia	
National Museum	B,M,H, I
Central Veterinary Laboratory	M, Micro
MET	M, H
MAWRD	M, Invert
MFMR	F, Invert
MHSS	M (human)
Regional	
South African Museum	B, M, H
Transvaal Museum	B, M, H
University of Cape Town	B, M
University of Stellenbosch	B, M, H
University of Witwatersrand	B, M, H
University of Pretoria	M
Europe and North America	
University of Copenhagen	B, M, H, I
Université de Paris	B, M
Edinburgh University	B
Stirling University	B
Yale University	B, M
British Museum (Nat. Hist.)	B, M, I
Alexander König Museum	M, H

[1] B = birds; M = mammals; H = herpetiles (reptiles, amphibians); I = insects; Invert = other invertebrates; Micro = microorganisms. Includes only tissue collected explicitly for genetic use. Source: Joris Komen

Finally, the captive breeding of Namibian dwarf pythons *Python anchietae* (Fig. 2.36) at the Transvaal Snake Park, South Africa, is part of a cooperative programme with the MET. Its aims are to gather breeding data for this threatened species, as well as to produce progeny for reintroduction to the wild and for educational and scientific uses.

— *Mike Griffin*

Fig. 2.36 Dwarf python. Courtesy M Griffin

Table 2.14 Important museums holding Namibian bird specimens

Institution	City	Namibian specimens
National Museum of Namibia	Windhoek	10 500
Transvaal Museum	Pretoria	3 766
Durban Natural Science Museum	Durban	2 060
British Museum (Natural History)	Tring	1 832
South African Museum	Cape Town	1 295
Zoologisches Forschnungsinstitut und Museum Alexander König	Bonn	1 275
Los Angeles County Natural History Museum	Los Angeles	875
Älvsborgs Länsmuseum	Vänersborg	751
Cornell University Vertebrate Collection	Ithaca	748
Museum für Naturkunde der Humboldt-Universität	Berlin	571
Peabody Museum, Yale University	New Haven	498
Zoology Museum, University of Michigan	Ann Arbor	402
National Museum of Natural History, Smithsonian Institution	Washington	104
Albany Museum	Grahamstown	35
Koninklijk Museum voor Midden-Afrika	Tervuren	3
Florida Museum of Natural History	Gainesville	3
Total		24 718

Source: Chris Brown

Domesticated animals

The MAWRD conducts research related to the conservation of genetic material of both small and large livestock.[109] Three projects involve small stock, specifically indigenous goats, Damara sheep, and Karakul sheep.

The first two projects aim to conserve and characterise the gene pool of indigenous small stock. In the goat project, about 110 animals are kept at Uitkomst Research Station for blood typing to determine their relationships and origin. If necessary, this stock could be improved and distributed to farmers for upgrading of their herds. A Damara sheep herd has been at Omatjenne Research Station since 1951, and presently numbers about 700 animals. Research on this herd has been completed and the herd will be maintained to conserve its gene pool. The herd has been improved through selective breeding. At Gellap-Ost Research Station, about 1200 Karakul sheep are kept for the conservation of genotypes for the three different pelt colours. This is purely a conservation of genetic material to serve as 'base stud' for the Karakul industry.

Regarding large stock, the MAWRD has an ongoing genetic project on indigenous Sanga cattle (see also section 2.8). Herds are kept at four research stations: Omatjenne (about 200 head), Sandveld (about 200 head), Sonop (about 350 head) and Sachinga (about 120 head). This project aims to conserve, characterise and evaluate the available gene pool, and to supply superior genetic material to farmers for upgrading of their herds. The Northern Regions Livestock Development Project (NOLIDEP) provides a link between the scientific and farming communities. NOLIDEP has selected five villages in which to implement this project.

Gaps and problems

Ex situ conservation needs and problems in Namibia can be summarised as four points:

- a shortage of Namibian graduates interested in careers in the conservation of genetic resources, biosystematics, or curation;
- an inadequate level of collaboration between relevant persons and institutions;
- an inadequate institutional capacity to determine the genetic display of indigenous species;
- a lack of adequate legislation to protect genetic resources from exploitation.

-- Herta Kolberg

2.8 Genetic diversity knowledge and research needs in Namibia

Many people cannot really fathom the reasons for conserving genetic diversity. Even within the framework of the Convention on Biological Diversity, many national programmes operate almost exclusively at the species level. If they appear at all, safeguards for genetic variability are tacked on almost as an afterthought.

Why is genetic diversity important? Such variation can be thought of as the building blocks on which the all-important mechanism of evolution proceeds. It is the grist to the mill of natural selection. Any loss of this variation may be cause for concern, since genetic variation allows a species evolutionary options for coping with environmental change (section 2.2). Evolution is, after all, the main process by which species will survive the environmental changes and challenges that we humans throw at them.

To understand the role of genetic variation, consider the cheetah (below), a mammal with extremely low genetic variation and a high susceptibility to disease. In theory, at least, all cheetahs could be wiped out by a single epidemic, because their immune systems (designed on the 'instructions' of nearly-identical genetic codes) might all fail equally. A more variable species would probably contain individuals with some resistance to the disease, and these might survive.[70]

Of more direct concern to our own survival and livelihood is the low genetic diversity of species on which we depend for food (below). We rely on only 30 major crops, of which three (wheat, rice and maize) provide 60% of the world's food.[110] In a risky attempt to improve agricultural production, indigenous crops are being replaced with genetically uniform cultivars.[111] We are, often obliviously, engaged in a dangerous evolutionary race--a race against the rapidly evolving crop pests and diseases which can decimate these genetically similar strains of wheat or maize over wide areas, inducing famine. A key part of the Biodiversity Convention, therefore, is to safeguard the genetic diversity of domesticated species and their disease-resistant wild relatives, as critical weapons in this evolutionary 'arms race'.

Finally, in addition to these very direct benefits of genetic diversity *per se*, there is a great value in the genetic uniqueness of taxa in Namibia. Spanning much of the South West Arid Zone, Namibia holds many taxa which are genetically very different from their nearest relatives. *Welwitschia*, *Kaokochloa*, and the Herero chat *Namibornis* are a few of the

specialties of our area. These are not just of academic intrest. Often strikingly well adapted to arid environments, Namibian plants and insects may be of potential use in land reclamation and agriculture (see below). They are emblems of Namibia, with which we can identify proudly. And as representatives of unusual taxa, they contain a large chunk of unique genetic material. So genetically, not all species are 'created equally,' but some have more unique information than others. These genetic 'outliers' must be rated highly when setting conservation priorities.

— Phoebe Barnard

Genetic diversity of microorganisms

Microorganisms such as algae, bacteria, fungi, protozoa, viroids and viruses form a large proportion of the world's biomass, and the major portion of global genetic diversity. Until recently, their diversity was largely ignored, and no realistic inventory of microbial diversity exists. A recent estimate suggests that less than 5% of species are known.[112]

The genetic diversity of Namibian microbes is completely unstudied. Since microorganisms underpin the maintenance of land productivity and other critical processes, Namibia should take explicit steps to survey them. Extreme environments are considered valuable sources of microbial genetic material.[113] Microorganisms in hot, dry or saline habitats are often highly adapted to environmental extremes that other, more complex organisms cannot tolerate, and may thus be of immense ecological and economic importance.

Ex situ collections are the mechanism by which microbial diversity is conserved for study and possible exploitation.[112] Namibia has neither the manpower nor the facilities to undertake microbial genetic inventories and *ex situ* storage, which elsewhere are done by regional microbial genetic resource centres, but could benefit by inviting these and other institutes to sample in Namibia and maintain collections at their own facilities. Legislation to protect Namibia's intelllectual property rights with respect to such material needs to be developed, so that our country can potentially benefit from its own unique microbes.

— Coleen Mannheimer

Genetic diversity of wild plants

Botany in Namibia has so far focused mainly on taxonomy, ecology and to a lesser extent ethnobotany. Little is known of plant physiology, biochemistry or genetics, particularly molecular genetics. Genetic diversity studies in Namibia are not given a higher priority than research on taxonomy, phytogeography, ecology, conservation or resource utilisation. If the Namibian flora is poorly known on a higher level, genetic data may also be of little use.

In recent years the International Plant Genetic Resources Institute and Kew Gardens have collected genetic resources from numerous plant taxa in Namibia.[114-117] Extensive collecting for the pharmaceutical industry, or bioprospecting, has not taken place legally in Namibia, although there are local suspicions that material collected for academic research or without permit has served other purposes. However, there is little published literature describing Namibian genetic resources diversity.[115,117,118-120] A national workshop on plant genetic resources[111] served mainly to build awareness and plan future activities.

In situ genetic conservation of wild plants, mainly in the protected area network, is included in the mandate of the NPGRC, but has not yet been addressed. The present reserves of the country may not adequately conserve plant genetic diversity, as they were not established with genetic criteria in mind.[121] Genetic variation studies could indicate ideal sites for reserves, and should be considered before the establishment of any future parks.

Namibian plants are likely to be important in the development of traits for arid-zone agriculture and land reclamation, such as drought and salinity tolerance. Wild relatives of existing crops, and new crops developed from wild plants such as cucurbits (Box 2.9), could have immense value in arid lands.

Box 2.9 Namibian cucurbits: potential dryland crops

Southern Africa is an important centre of diversity for the family Cucurbitaceae (melons), of which 43 species in 14 genera occur in Namibia. Several endemics and near-endemics are found here, including the *!nara* melon *Acanthosicyos horridus*, which is endemic to the Namib.

Lucrative cultivated crops such as sweet melon *Cucumis melo* and watermelon *Citrullus lanatus* originated in southern Africa. Other cucurbits are traditionally used in local agriculture and subsistence gathering. Many, especially *Citrullus*, can produce large fruits in dry seasons, yielding nutritious pulp and seeds with a high oil and protein content. They therefore have excellent potential for development to supplement or replace cereal production in arid regions. Even so, the Cucurbitaceae are poorly known. The taxonomy of the group is still in doubt; basic data on many species are lacking, and the ancestral forms of cultivated species have been largely ignored in crop improvement programmes.

The National Botanical Research Institute is investigating and documenting the agricultural potential of indigenous cucurbits in a project co-funded by the MAWRD and the Danish Government. This aims to improve the yield and quality of selected species and promote agricultural use. Crop diversification will also permit the productive use of marginal lands by farmers with limited resources. Because the cucurbits already occupy a niche in traditional agroecosystems, cuisine, culture and economy in Namibia, they are in many ways preadapted for a new level of exploitation.

— Gillian Maggs

Gaps in our knowledge of the genetic diversity of wild plants are extensive, because more pressing issues take priority for the limited human and financial resources in Namibia. So much basic information remains to be collected, and it would be unrealistic to expect massive reallocation of government resources to this area. However, opportunities abound for studies funded through private, corporate or international funds to be done in association with the NPGRC. The potential for scientific and economic benefit is considerable.

Recommendations

- Prioritise species and habitats for study, including genetic diversity analysis.
- Include genetic diversity as a criterion for selecting new conservation areas.

— Herta Kolberg

Genetic diversity of indigenous food crops

Crop genetic diversity is often overlooked as it is difficult to measure at a large scale.[122] However, judging from the rest of Africa, it is safe to assume that substantial crop genetic variation exists both within and between areas in the Namibian subsistence farming sector.[123-128] This variation is likely to contain highly valuable genes for resistence to drought and salinity, especially in pearl millet.

Until recently, neither government nor private institutions gave much research or development attention to crop production. Crops in Namibia are cultivated mainly by subsistence farmers in northern regions. Since Independence, new research and development work has begun, mainly in the form of collaborative projects between Namibian and international organisations. Regionally, concern over the conservation of genetic resources was addressed in 1989 with the establishment of the SADC Plant Genetic Resources Centre Project (section 2.7) to conserve and utilise the region's resources by *ex situ* and *in situ* methods.[104]

Other than watermelon *Citrullus lanatus* (Box 2.9), none of the world's major crops have centres of diversity within Namibia or southern Africa.[129,130] Watermelons originated in Namibia and Botswana and are considered the region's most important crop genetic resource. However, unusual regional genetic variation has also been found in other taxa, such as millet.[131]

Aside from an unpublished paper[132] and short notices in various annual reports, there is no published literature on Namibian crop genetic diversity. The genetic diversity represented in the National Plant Genetic Resources Cen-

tre (NPGRC) has not yet been described, although the characterisation of this material started in 1995. From international principles and preliminary results, however, the following inferences can be cautiously made.

A great deal of genetic variability must exist in Namibian crops that have been cultivated in the country for many years.[132,133] These are mainly the traditional crops of northern Namibian subsistence farmers (Box 4.7): pearl millet *Pennisetum glaucum*, sorghum *Sorghum bicolor* var. *bicolor*, groundnut *Arachis hypogaea*, Bambara groundnut *Vigna subterranea*, cowpea *V. unguiculata*, watermelon and others. This diversity is likely for three reasons. First, these crops have been grown in Namibia long enough to have developed distinct traits. Second, a degree of cultural isolation of crop farmers in the past, both from other countries and other areas of Namibia, could have enhanced the development of distinct local landraces. Third, a lack of 'improved' cultivars and the low priority given to agronomic research and development in the recent past must have allowed any distinct local landraces to be maintained. Indeed, modern agriculture in Namibia, as elsewhere, could be a major threat to this genetic diversity if there is insufficient appreciation of its value.

Differences in ecological conditions and cultivation practices within crop growing areas in Namibia seem to have produced different ecotypes. In controlled experiments,[132-135] performance and morphological differences in Namibian landraces of pearl millet and sorghum could be linked to their areas of origin and cultivation. In general, genetic variation in crop plants is associated with their use and adaptation to habitat.[126,136] Harlan[123] suggests that on a global scale, the more marginal areas for cultivation contain less genetic variability, but study of more material from these regions is needed. For example, the cowpea is less variable in its centre of origin, southeast Africa, than in areas of more recent cultivation.[137]

Inbreeding and outbreeding also have an effect on the genetic diversity of crops. Outbreeders are usually more heterozygous and polymorphic than are inbreeders.[138] It can probably thus be assumed that pearl millet, an outbreeder, is genetically diverse because of its breeding system.

Crops grown in Namibia by commercial farmers are 'improved' varieties or cultivars.[139] These must be genetically uniform to be registered. The genetic diversity of such crops within an area is thus assumed to be very low. There may be some genetic differences between areas due to the use of different cultivars.

Wild relatives of domesticated plants are numerous and diverse in Namibia. The genetic proximity of these species to the crop has not been well studied, and their agricultural value is mostly unknown. Several wild relatives, such as *Citrullus lanatus* and *Vigna unguiculata*, are regional endemics.

Fig. 2.37 Sorghum is expected to show significant genetic variation in Namibia. Courtesy HH Kolberg

The *ex situ* conservation of domesticated plants in Namibia has been started with the establishment of the National Plant Genetic Resources Centre in 1993 (section 2.7). The pearl millet collection is fairly representative, but other crops require extensive collection (Table 2.15). It will take several more years to make the collection fairly representative. *In situ* or on-farm conservation of crop diversity has not yet been attempted in Namibia. This falls within the mandate of the NPGRC, but is so far prevented by lack of expertise and manpower.

Genetic diversity is the basis for all advancement in agronomy.[136,140,141] The adaptation of landraces of pearl millet to marginal and variable cultivation conditions has preserved genes enhancing drought tolerance. This is important nationally, regionally and globally, with droughts becoming a common occurrence. For increased food security, high yielding, locally adapted cultivars will be of vital importance. This potential is being used in the Sorghum and Millet Improvement Programme of SADC/ICRISAT. A Namibian Drought Tolerant Composite (NDTC) was formed from 400 collections in Namibia, and yielded some grain during the drought of 1991-92.[133]

Table 2.15 Namibian crop accessions in the National Plant Genetic Resources Centre

Crop	No. of accessions
Pearl millet	
Pennisetum glaucum	1010
Sorghum	
Sorghum bicolor	126
Groundnut	
Arachis hypogaea	22
Bambara groundnut	
Vigna subterranea	44
Cowpea	
Vigna unguiculata	10
Watermelon	
Citrullus lanatus	63

Gaps and problems

The few small studies of genetic diversity in Namibian crops have been done on a morphological or performance basis.[132-135] No molecular methods,[122,142] which directly compare genetic diversity and eliminate environmental effects on gene expression, have been used. The NPGRC will over the next few years characterise germplasm morphologically, and has plans to use molecular methods. The current lack of competent staff is a severe constraint on these activities.

Recommendations

The following steps must be taken to obtain a clear understanding of crop genetic diversity in Namibia and its potential uses for the advantage of all Namibians:

- Ensure conservation of existing diversity through both *ex situ* and *in situ* methods to prevent any further loss of diversity;
- Characterise and evaluate local crops with morphological and molecular methods to establish genetic diversity patterns within Namibia, and later between Namibia and other regions;
- Develop the human resources capacity to achieve these aims.

— Herta Kolberg

Fig. 2.38 Millet genetic diversity is a focus of the NPGRC. Courtesy Ministry of Information and Broadcasting (N Akukothela)

Genetic diversity of wild animals

Little information exists on the genetic diversity of any wild animal in Namibia, with several important exceptions. Most genetic work concerns red data mammals, and is already generating valuable information. Box 2.10, for example, describes current work on carnivores in Etosha National Park which will yield genetic, ecological and behavioural data on lions, *Panthera leo*. All of these forms of data can be essential for making informed management decisions, especially when conservation spending must be prioritised.

Box 2.10 Genetic variation in Etosha lions

The genetics of lions in Etosha National Park is one of the subjects of a joint carnivore research project of the Etosha Ecological Institute (EEI) and Chicago Zoological Society. This project is generating data on the genetic distance of Etosha lions from other populations in the region, levels of heterozygosity, pride lineages, paternity, and other aspects of behavioural ecology. These data will allow staff to estimate the genetic impact, if any, of management actions such as translocations. It will also help in judging the population effects of the large numbers of lions, mainly subadult males, which are shot every year just outside the park.

Early results? Etosha lions cannot be distinguished genetically from those in the Tsumkwe District, and share 99.4% of their genes (using 509 bases) with lions in South Africa's Umfolozi Reserve. Many cat species have very little genetic variation within populations, but this seems to confirm that Etosha lions are not a distinct subspecies, as is sometimes suggested.

— *Source: Venzke & Forge*[143]

Genetic diversity can be threatened by several processes, including hybridisation. Box 2.11 outlines some threats to the genetic integrity of the black-faced impala *Aepyceros melampus petersi*, an endangered antelope which is endemic to northwest Namibia and southwest Angola. This case study highlights the need for circumspect management to safeguard distinct populations. Since high species richness is valued by game farmers and tour operators, especially those catering for trophy hunters, land users may be tempted to maximise species richness at the expense of genetic integrity.[144]

Cheetahs are genetically better known than many large mammals, due to research on problems experienced in captive breeding. Southern and east African cheetahs have such low levels of **heterozygosity**, or multiple forms of a gene (see Box 2.12), that their genetic variation is no more than that of deliberately inbred lab mice.[70,146,147] Southern African populations have an average heterozygosity of 0.0004,[146] less than that for east Africa and one or two orders of magnitude less than in other cat species.

The reasons for this have been hotly debated. Low genetic diversity could reflect **population bottlenecks** (Box 2.12) since the Pleistocene era, when mammalian extinctions in Asia and the Americas were widespread.[148] It may be related to the cheetah's hunting or breeding strategy,[149,150] or may be fairly typical of carnivores.[151] So far, there is no consensus on the reasons.

Whatever its causes, what might be the effects of this extremely low genetic diversity on cheetah conservation? As the nation with probably the largest cheetah population (section 2.5), Namibia has a particular responsibility for their conservation. A national cheetah management strategy,[70] the first for any country in the cheetah's range, has been drawn up to help preserve genetically viable populations in Namibia. Low heterozygosity has been blamed for reduced evolutionary fitness in captive cheetahs, as shown by susceptibility to disease, asymmetric body development, and breeding abnormalities, but it is not clear to what extent wild populations suffer from these problems. It has been argued[152] that cheetahs suffer from **inbreeding depression** (Box 2.12), but until recently there has been no evidence that susceptibility to disease in captivity is matched in the wild. An important exception may be the vulnerability of cheetahs to anthrax *Bacillus anthracis* in Etosha National Park, where all six radio-collared cheetahs have succumbed to the disease after eating infected prey.[153] Although the authors did not link this mortality to low heterozygosity, further work is desirable to establish why cheetahs would not develop immunity to anthrax when this disease commonly afflicts their prey.[154] Finally, cheetahs in capivity suffer from breeding abnormalities linked to low heterozygosity, such as defective sperm and high cub mortality. However, wild cheetahs do not seem to suffer. The Namibian cheetah population can double every five to seven years, in the absence of limiting factors.[70,81]

More should soon be known about the genetic diversity of other Namibian mammals, as there is an increasing focus on tissue sampling for genetic study (section 2.7).

Box 2.11 Trading one threat for another: genetic pollution in the black-faced impala

The black-faced impala *Aepyceros melampus petersi* is an endangered subspecies, endemic to southwest Angola and northwest Namibia.[145] It is of conservation concern due to the risk of hybridization with, or 'genetic pollution' by, the common impala *A. melampus melampus*. Historically, its distribution was separate from that of the common impala, but the two have recently been extensively introduced onto game farms, in some cases onto the same farm. The Etosha National Park population is also at risk, as common impala, which are adept at moving through game fences, have been introduced onto numerous adjacent farms. The risk of interbreeding has been increased by economic and bio-political incentives for farmers to have both types of impala on their land. These incentives include:

- a much higher current price for black-faced (up to N$6500) than common impala (N$250), which encourages most game farm owners to stock common impala;
- the wish of many game farm owners to offer tourists and hunters a variety of mammal species, especially regional 'specialties'; and
- trophy import restrictions on black-faced impala for U.S. hunters, who are perceived as paying more than other nationalities. This removes an important economic incentive for game farmers to stock black-faced impala: U.S. hunters will not hunt for a trophy they cannot bring home.

Due to the threat of extinction in its natural range, the black-faced impala was introduced into the Etosha National Park from the former Kaokoland (now Kunene Region) in 1968-71, with a founder population of 180 impala. Introductions into the national park have been highly successful: the Etosha populations have since increased to more than 1500. Meanwhile, Kaoko populations have increased little if at all; they are fragmented, and seriously threatened by poaching and competition with livestock, despite support among ovaHimba leaders in the region for their presence and reintroduction.

Ironically, the management strategy adopted to rescue this Kaoko endemic by translocating it into public (and then private) protected areas has inadvertently jeopardised its genetic integrity. The threat of future interbreeding can be addressed through concerted management action with game farmers, the Namibian Professional Hunters' Association, and rural communities.
Source: Green & Rothstein[144]

Box 2.12 Conservation genetics terms in (fairly) plain English

Heterozygosity
A measure of the genetic diversity in a population, based on the average proportion of an individual's genes which exist in two different 'versions' (*alleles*). Populations with high heterozygosity can usually adapt better to environmental change.

Population bottleneck
A dramatic crash in number of a population. During this process, genetic diversity is often lost, and the future genetic profile of the population is shaped by those individuals which survive.

Inbreeding depression
A state of lowered survival, vigour and breeding success of individuals, due to negative genetic changes (increased *homozygosity*) caused by repeated breeding among relatives.

Fig. 2.39 Black-faced impala are at genetic risk through hybridisation. Courtesy P Tarr

Genetic diversity of domesticated animals

Almost as diverse as its people and wild biota are Namibia's livestock. Livestock production in Namibia varies from small scale, extensive subsistence farming to large scale, extensive commercial farming. Table 2.16 gives background data on livestock numbers in the different regions. The former 'Owambo' (now Oshikoto, Ohangwena, Omusati, and Oshana Regions), western Kunene, Okavango and Caprivi Regions are communal farmland.

Most well known imported cattle breeds, plus indigenous Nguni or Sanga cattle, are found in Namibia (Table 2.17). Most imported breeds entered Namibia from South Africa, but two, the Simmentaler and Brahman, were imported directly to Namibia from Germany in 1894 and the USA in 1958 respectively. Namibia has few dairies, and there are no data on the number of breeders or animals per breed. Dairy breeds in Namibia are Frieslands and Jerseys.

Conservation of indigenous livestock has a high priority in the MAWRD's National Research Policy. 'Sanga' is a collective term for all the indigenous cattle breeds of southern Africa (Afrikaner, Tuli, Shangaan, Drakensberger, Pedi, Venda, and Namibian ecotypes), but due to the lack of a suitable distinct name, indigenous Namibian breeds are also referred to as Sangas by government agriculture staff.

North of Namibia's Veterinary Cordon Fence, the 'Red Line,' most cattle are Sangas, with very small numbers of other breeds introduced over the years. Of the roughly 2.04 million head of cattle in Namibia, approximately 700 000 are Sanga cattle held by northern communal farmers. Sangas are the most numerous of all breeds.

Sanga cattle have been undervalued by government agriculture staff for many years. They are a 'low maintenance' breed, naturally selected over centuries, with an inherent parasite resistance, high fertility and excellent maternal care. Communal farmers need to have animals that can thrive under harsh conditions, as their access to production supplements (e.g. salt licks and medicine) is often less than that of commercial farmers.

Sanga cattle are used for meat and milk production as well as draught purposes. They excel in standard indices of production: they are particularly fertile, have a low intercalving period, the highest weaning mass per unit of maternal body mass of any breed in Namibia, a high growth rate and a high feed conversion ratio.[157-159] These features plus their small size, low maintenance needs and tolerance of dry environments mean that they crossbreed excellently with large bulls of introduced breeds to produce heavy offspring. There is thus now a considerable demand for Sanga cows by commercial cattle farmers. Purebred Sangas are only surpassed in terms of biomass production by crossbreeds of pure Sanga cows with large European type beef bulls. This latter fact, however, creates a strong incentive among farmers to crossbreed the indigenous and imported cattle, which may jeopardise the integrity of the Sanga genepools.

Due to the presence of stock diseases in some areas, Sanga are the only large stock found there. Recent studies in Namibia and South Africa have found that Sanga cattle generally have a high resistance to ticks and other parasites, and the Caprivi Sanga has a strong resistance to trypanosomiasis. Sanga can also tolerate conditions from the humid Caprivi to the arid Kunene Region, and can survive under conditions where exotic breeds have died from starvation and thirst.

Fig. 2.40 The indigenous Sanga cattle breed. Courtesy P Hugo

Table 2.16 Number of different livestock per region[156]

Area	Cattle	Sheep	Goats	Pigs	Poultry	Ostriches
Caprivi	95 136	44	4 302	35	16 852	0
Okavango	106 209	137	34 799	2 491	37 562	0
Otjozondjupa	308 913	90 262	131 984	2 173	76 884	518
Owambo*	339 725	18 769	172 318	2 145	50 291	0
Kunene	272 611	128 854	389 521	1 882	28 739	116
Erongo	67 911	54 072	178 912	1 576	57 670	112
Omaheke	418 786	325 664	173 498	3 170	44 065	2 513
Khomas	175 390	159 161	32 198	1 952	64 000	2 811
Hardap	92 428	942 469	228 789	1 159	79 837	14 205
Karas	32 685	900 093	292 891	1 260	17 410	2 945
Total	1 909 794	2 619 525	1 639 212	17 843	473 310	23 220

** 'Owambo' is made up of the Omusati, Oshana, Oshikoto and Ohangwena Regions.*

Table 2.17 Cattle breeds, stud breeders, registered animals and participants in the Performance Testing Scheme, PTS

Breed	No. of breeders	No. of cattle	Participants in PTS
Afrikaner	20	2 150	5
Bonsmara	31	4 615	31
Brahman	103	6 158	31
Charolais	18	692	0
Drakensberger	-	-	1
Gelbvieh	8	121	2
Hereford	-	-	0
Limousin	6	151	0
Nguni/ Sanga	11	721	7
Santa Gertrudis	-	-	6
Shorthorn	1	-	0
Simbra	10	1 350	7
Angus	4	71	0
Sussex	-	-	0
Beefmaster	2	100	2
Brown Swiss	20	991	4
Pinzgauer	2	312	2
South Devon	2	70	1
Simmentaler	40	4 000	13

Source: Namibian Stud Breeders' Association[159]*; Simbra and Simmentaler Breeders' Association.*[160]
- = no data available

The Afrikaner is a breed indigenous to South Africa and Namibia, with a relatively small distribution and a limited gene pool. Genetic material is available only in these two nations, and is periodically imported to Namibia from South Africa. Afrikaner pure- and crossbred cows are used in rangelands for meat production in the commercial farming sector. They have good maternal care and are adapted to the harsh conditions.

Sheep are more numerous in Namibia than cattle, and play an important role in livestock production in the southern commercial and communal farming systems, as well as in the northwest of the country. Eight breeds of sheep occur in Namibia: Dorper, Karakul, Damara, Black-headed Persian, Afrikaner, Dohne Merino, South African Wool Merino, and Letelle.

The Dorper, developed in South Africa, is the most numerous breed. It is bred for mutton production and is highly fertile. It grew in popularity after economic hardship in the Karakul industry.

The Karakul, originally imported at the turn of the past century, has undergone such development since then that it could almost be called an indigenous breed. From the old traditional 'pipe-curl' pelts to the modern 'water silk' types, new variants have been selectively bred. Before the slump in this industry, Namibia produced 5 million pelts per year. The MAWRD also selectively bred the brown, grey and white Karakul sheep. At present, small nucleus herds of these different types are kept at Gellap-Ost Research Station, and are the only pure herds still in the country.[157]

The Damara sheep is the only true indigenous breed in Namibia, originating from the former Kaokoland and Damaraland (now Kunene and Erongo Regions). This is a hardy, fat-tailed breed with high fertility and excellent maternal care. Multiple births are not common. Damara sheep are adapted to the arid western areas, and all have predominantly red and black wool. The MAWRD has a herd, recently acquired in Kunene for comparison trials with a herd which has been selected for fertility and growth over the past forty years. This will determine the amount of progress made in terms of growth and fertility, but also the extent to which disease resistance may have been lost. The Damara sheep is more of a browser than other breeds.[157]

Goats are very important in Namibia's livestock industry. In the commercial sector, goat farming is practised as a primary industry in the south and as a secondary industry in the central and northern regions in conjunction with cattle. Most goats on commercial farms are Improved Boer goats, a breed developed from indigenous goats in South Africa and Namibia. This breed is very fertile and long-lived, with good maternal care, milk production and meat production. There is a high incidence of multiple births.

Fig. 2.41 Damara sheep are the only truly indigenous Namibian sheep breed. Courtesy P Hugo

Fig. 2.42 Improved Boer goat. Courtesy MAWRD

In the southern communal farmlands of Karas Region, a local type of goat is often cross-bred with Improved Boer goats for increased mass. Little is known about this breed. Two and possibly three indigenous goats are found in the northern communal areas: a long legged type in the Kunene Region, a small type in northern 'Owambo' similar to one in eastern South Africa, and a possible third type in the Okavango Region. Goats from Okavango and southern 'Owambo' have often been crossed with Boer goats, and may not be genetically distinct. A mission to collect genetic material from these breeds has just taken place, and the MAWRD has recently acquired goat herds from northern 'Owambo' and Kunene. The production and reproduction of these herds will be compared with those of the Improved Boer goat at Uitkomst Research Station.[157] In the Okavango Region, a project will determine resistance to internal parasites.

Most pigs kept on farms are for domestic use, and the most numerous commercial breeds are Large Whites, Landraces, and Durocs. There are currently about ten commercial pork producers with 1500 breeding sows. Roughly 7000 indigenous pigs are found in the northern communal areas. These pigs differ from known commercial breeds by having short snouts with a pronounced dish in the forehead, short, potbellied bodies, and variable skin colours. They are much smaller and lighter than commercial pig breeds, and accumulate fat much more quickly. Very little is known of their production potential, disease resistance, or cultural role. A current joint project of the MAWRD and the Irene Animal Production Institute of South Africa aims to characterise these pigs genetically and estimate their genetic distance from a similar South African indigenous pig, the Colbrook.

Most chickens in Namibia are of commercial breeds and crosses between these breeds. In the northern communal areas, people keep chickens which appear to represent different ecotypes. Their production potential will be evaluated, and high quality chickens will then be selected and multiplied for local use.

There are no true wild horses in Africa, but a unique group of feral horses exists in the southwestern Namib Desert (Fig. 2.43). This group is probably descended from the herd of a German captain who kept about 350 horses at Duwisib Castle, 200 km distant, until World War I. Thoroughbred stallions were bred to English Warmblood mares there, and the crossbreeds were renowned as military and police horses.

The horses came to public attention in 1987 when ten were sent to a South African veterinary institute. They show unique traits fixed by years of isolation, adaptation and inbreeding, and are related to the American and Shagya strains of Arabian horses, which were present in Namibia in early German colonial times.[161] A 1994 study revealed about 124 animals, of which 54% were stallions, 46% mares, 38% immature and 62% adults, and foal survival was 60%. They had no immunity to horse diseases, and their progeny will be used to test vaccines for horse sickness and equine flu. The horses are strongly inbred, with extremely low genetic variation. Indeed this is the second lowest level of heterozygosity of any horse.[161]

— J.F. Els

Fig. 2.43 Feral horses of the southern Namib Desert. Courtesy P Tarr

2.9 Species richness and conservation summary

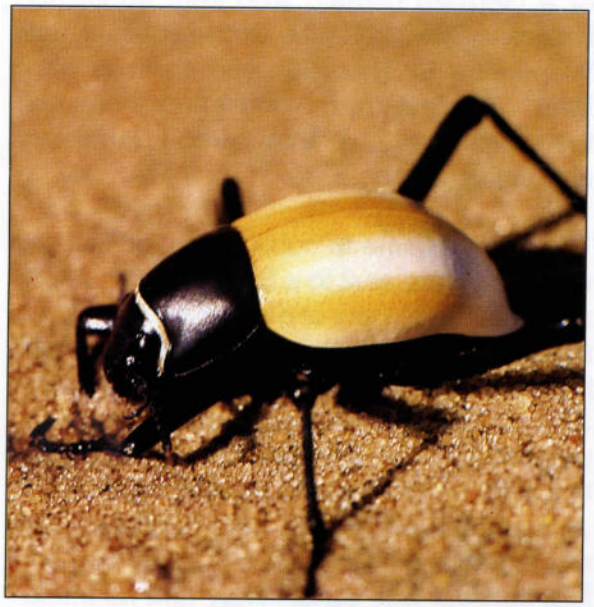


Fig. 2.44 The tenebrionid *Onymacris langi* in Hartmann's Valley. Courtesy E Marais

This section of the Biodiversity Country Study gives what might be regarded as the 'meat' of Namibia's information on the biodiversity of terrestrial and inland wetland habitats. Major species groups in these habitats are treated in taxonomic order, as this was the only feasible way of systematically addressing the issue in the necessary detail. Unfortunately, the 'patchiness' of information alluded to elsewhere in the book is nowhere more apparent than here. For some taxa we can say only that next to nothing is known; while for groups such as birds, the comparative breadth and sophistication of the database have allowed a much fuller treatment, and serve as a model for other taxa.

The essential components of this section are summaries of *species richness* (or *species diversity* where this can be assessed), *endemism*, and *conservation status*. Taxonomic summaries are preceded below by a brief numeric overview of richness and endemism. A summary of the *areas* of high species endemism was given in section 2.3 .

Overview of richness and endemism

A numerical summary of known species richness in any nation — even one with ample funding and a large, well-organised coterie of scientists — is never set in stone. Table 2.18 lists, very tentatively, the known richness and endemism of Namibian species. Still, many groups can only be labelled 'unknown.' We hope this book will prompt research into these taxa, some of them decidedly unglamorous, which keep Namibia, its environment and economy running: bacteria, soil arthropods, algae, mycorrhizal fungi, and so on.

As part of Africa's Southwest Arid Zone, Namibia is a centre of endemism for diverse groups from melons to tortoises. A summary of its endemism is complicated by gaps in taxonomic knowledge, as well as historical differences in the use of the term *endemism* by different specialists (see section 2.3). To most vertebrate zoologists, a species is 'endemic' if 75% or more (frogs, reptiles and mammals) or 90% or more (birds) of its range falls within Namibia, but for insects, arachnids, flowering plants and freshwater fish, an endemic species has strictly 100% of its range in Namibia. These awkward and, to the analyst, annoying inconsistencies reflect the past isolation and iconoclastic views of Namibia's biodiversity specialists, a situation which is belatedly but rapidly changing.

The degree of endemism in Namibian plants, invertebrates, reptiles and frogs is relatively high (Table 2.18), whereas mammals, birds and fish, many of which are highly mobile, have levels of endemism below 10%. The figures for fish need careful interpretation. Since major fish habitats are the perennial rivers bordering Angola and South Africa, even species endemic to these rivers are by definition not Namibian endemics. This is exemplified by the Orange River, where 42% of the 15 species are endemic to the river but not to Namibia alone.[162]

Figures for many taxa in Table 2.18 are very tentative, but the greatest uncertainty lies in the data for lower kingdoms and invertebrate animals. Given that invertebrates form the vast majority of species and biomass,[163] it is