Namib Sand Sea
World Heritage Nomination

Nomination dossier to UNESCO for inscription into the World Heritage List

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Namibia National Committee for World Heritage
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ACRONYMS AND ABBREVIATIONS

BP      Before Present
CBD     UN Convention on Biological Diversity
CBNRM   Community Based Natural Resource Management
CETN    Coastal Environmental Trust of Namibia
CSIRO   Council for Scientific and Industrial Research Organisation, Australia
EIA     Environmental Impact Assessment
EPLs    Exclusive Prospecting Licences
EMP     Environmental Management Plan
GDP     Gross Domestic Product
GIS     Geographic Information System
GLF     Global Land-cover Facility
GTRC    Gobabeb Training and Research Centre
ICZM    Integrated Coastal Zone Management
IBA     Important Bird Area
IPA     Important Plant Area
MAB     Man and the Biosphere Reserve
MAWF    Ministry of Agriculture, Water & Forestry
MAWRD   Ministry of Agriculture, Water and Rural Development
MET     Ministry of Environment and Tourism
MoF     Ministry of Finance
MFMR    Ministry of Fisheries and Marine Resources
MLR     Ministry of Lands and Resettlement
MME     Ministry of Mines and Energy
MPA     Marine Protected Area
MRLGHRD Ministry of Regional and Local Government, Housing and Rural Development
MTI     Ministry of Trade and Industry
MWTC    Ministry of Works, Transport and Communication
MYNSSC  Ministry of Youth, National Service, Sport and Culture
NACOMA  Namibian Coast Conservation and Management Project
NatMIRC National Marine Information and Research Centre
NBSAP   Namibia’s Biodiversity Strategy and Action Plan
NDP     National Development Plan
NNP     Namib-Naukluft Park
NPC     National Planning Commission
NTB     Namibia Tourism Board
NWR     Namibia Wildlife Resorts
OUV     Outstanding Universal Value
PoN     Polytechnic of Namibia
RDP     Regional Development Plan
SEA     Strategic Environmental Assessment
UNAM    University of Namibia
WH      World Heritage
INTRODUCTION

The Namib Sand Sea represents a well-conserved, key facet of the long but narrow coastal Namib Desert of western southern Africa. It offers a stunning landscape derived from a combination of geological, geomorphic and climatological processes in which a unique biota has evolved to take advantage of fog as a moisture source and wind-blown sand and detritus as life support media.

As the iconic heart of the Namib Desert, the Namib Sand Sea has been identified for nomination as a World Heritage Site based on all four natural criteria. Although the entire Namib Desert, extending over 2,000 km from South Africa through Namibia to south-western Angola, exemplifies elements of the natural criteria worthy of inscription, their integrity and management are not all as well developed as that of the Namib Sand Sea. As the management situation evolves, it is intended that serial additions to the Namib Sand Sea will be considered for inclusion as part of the World Heritage Site.

The contiguous Namib Sand Sea itself is more extensive than the area currently proposed for inclusion in the site. The identified site is considered to be essentially pristine dune-scapes, entirely encompassed within the Namib-Naukluft Park under the management of the Ministry of Environment and Tourism. The southern extremity of the Namib-Naukluft Park and the Namib Sand Sea were excluded from the proposed Property based on the presence of active Exclusive Prospecting Licences, the fossil aquifer which supplies water to the town of Lüderitz and the intention to leave some of the area available for potentially destructive adventure dune tourism. Establishing the western border at the high-tide line ensures that a single institution (Ministry of Environment and Tourism) is responsible for management of the Property. The northern, eastern and southern borders have been identified to provide for a variable sized buffer area within the Namib-Naukluft Park.

Moreover, the Namib also has a documented history of long human occupation from earliest man as exemplified by early palaeolithic stone tools scattered along natural travel routes in the desert to vestiges of ancestors of modern Namibians that have lived in this extreme environment. These remnants include shell middens at Sandwich Harbour and Sylvia Hill, stone circles and hunting blinds mainly along dry watercourses, and stone-capped graves at Sylvia Hill. Today some Namibians still live along the Kuiseb River valley on the northern boundary of the Namib Sand Sea and retain elements of their cultural heritage that is worthy of inscription as a cultural landscape, e.g. on the basis of their Inara harvesting and use of the landscape. Unfortunately there is currently no management system in place that would allow that landscape to be considered for inscription.

The nomination for the Namib Sand Sea put forth in this dossier is considered to be a pristine dune-scape, well managed by the Ministry of Environment and Tourism, that exemplifies all four natural criteria ensuring its worthiness as a World Heritage Site. Future serial extensions will be considered as the conservation and management situation of the greater Namib Desert evolves.
Executive Summary
A water-filled vlei on the eastern edge of the Namib Sand Sea (Paul van Schalkwyk)
EXECUTIVE SUMMARY

STATE PARTY

Namibia

REGION

Erongo, Hardap and Karas Regions

NAME OF PROPERTY

Namib Sand Sea

GEOGRAPHICAL COORDINATES TO THE NEAREST SECOND

15.183° E, 24.485° S

TEXTUAL DESCRIPTION OF THE BOUNDARY OF THE NOMINATED PROPERTY

The Namib-Naukluft Park lies on the south-western coast of Africa, in Namibia, approximately 250 km south-west of the capital Windhoek. It comprises the central portion of the hyper-arid coastal Namib Desert extending from the Olifants River in South Africa, northwards along the entire coast of Namibia, up to the Carunjamba River in Angola.

The boundaries of the identified Property designated as the Namib Sand Sea lie within the Namib-Naukluft Park south of the Kuiseb River in central Namibia. Starting from Sesriem in the centre of the eastern boundary, the envisaged site boundary extends southwards to a point where the boundary of the Namib-Naukluft meets the border of farms Kanaan and Kamaland; then west-south-west to Gibraltar on the coast before following the coastline north to the Sandwich Harbour Ramsar site. The northern boundary then heads inland (eastwards) to the Kuiseb River, skirting an area earmarked for bulk water production boreholes, from where it bends along the southern bank of the dry Kuiseb riverbed before turning south, encompassing a small extent of gramadullas with incomparable vistas over the sand sea, past the Gaub River tributary to Sesriem.
**JUSTIFICATION STATEMENT OF OUTSTANDING UNIVERSAL VALUE**

**Brief synthesis:** The boundaries of the envisaged World Heritage site, entirely within the protected Namib-Naukluft Park, encompass 3,077,700 hectares from the proximate source of sand on the coast to the final area of deposition some 100 km inland. The Namib Sand Sea along the arid African coast of the South Atlantic with its superlative, diverse, spectacular array of large, striking shifting dunes is an outstanding example of the scenic, geomorphological, ecological and evolutionary consequences of wind-driven processes interacting with geology and ecology. This Namib Sand Sea is globally unique, comprising a superimposed old and a young sand sea. The sand for both was transported by river, ocean current and wind more than 1,000 km from its source in the humid interior of eastern southern Africa. Life in the fog bathed coastal dunes of the Namib Sand Sea, and the behavioural and physiological adaptations that evolved throughout its specialist communities, are significant global examples for the evolution and development of a terrestrial ecosystem community and the resilience of life in extreme environments. The high diversity (>300 species) and endemicity (>50%) of the Namib Sand Sea biota are much greater than any other known hyper-arid, sand dune ecosystem. *In-situ* conservation of communities representing the turnover of endemic species from the cool coastal desert with frequent fog, to the hot, dry interior where more extreme aridity requires different strategies for survival, is ensured by the extensive, continuous habitat types across the full climatic gradient of the Namib Sand Sea.

**Justification for criteria:**

**vii: Outstanding natural beauty of the Namib Sand Sea**

The Namib Sand Sea encompasses vast panoramas of majestic dune-scapes, strikingly crystallised in sharply silhouetted forms continually transformed with wind and time. The striking range of spectacular dune forms and colours in an ongoing interplay of contrasting shadow and light, combined with diverse, fascinating and bizarre plant and animal life, bestows a superlative, distinct natural beauty and aesthetic charm.

**viii: Active geological processes of global significance**

The Namib Sand Sea is composed of two superimposed dune systems, one semi-consolidated as old as 21 million years, the younger unconsolidated and active for about 5 million years, neither eroded *in-situ* from the underlying substrate. Three contrasting, ongoing sedimentary ‘conveyor belt systems’, the fluvial transport of the Orange River, a coastal long-shore drift and coastal on-shore winds, finally deposited the palaeo and modern dune systems in the Namib Sand Sea – representing outstanding geological processes of global significance. The Namib Sand Sea presents a universally outstanding example of extraordinary aeolian landscapes relentlessly sculpted by the basal topography and pronounced daily and seasonal changes in dominant wind directions. Remarkable examples of ongoing desert geomorphic and physiographic features such as inselbergs isolated by encroaching dune fields, relict topography and sedimentary deposits from past climatic changes, endorheic river-end pans and exemplars of most desert geomorphic features are resplendently displayed in the Namib Sand Sea.
ix: Ongoing natural ecological dynamics that drive the evolution and interaction among Namib Sand Sea fauna and flora

The number of diverse, superbly adapted dune-inhabiting endemic species, in a hyper-arid environment with low net primary productivity, interacting through intricate food webs within a vivid environmental backdrop. In the Namib Sand Sea is unique relative to all other hyper-arid desert ecosystems. The high frequency of fog towards the coast has given rise to very rare behavioural adaptations to condense and harvest fog-water in these hyper-arid conditions. In parallel, the well-oxygenated subsurface sand offers swift escape strategies from arid extremes for ‘swimming’ and ‘diving’ invertebrates, reptiles and mammals. Myriad microhabitats of the ever-mobile dunes of the Namib Sand Sea create a plethora of ecological niches for bizarre and fascinating ways of dealing with arid, adverse extremes over small and large-scale, steep climatic gradients.

x: Extraordinary diversity of endemic species of special significance to science and environmental understanding

The Namib Sand Sea imparts an unfragmented and pristine environment along a vast range of macro- and micro-climatic and habitat conditions that sustains a vast genetic diversity of species. These rich, diverse habitats are of outstanding international importance for conservation of a variety of diverse biological creatures in their natural place of evolutionary origin with confirmed, outstanding universal scientific value. The Namib Sand Sea exemplifies one of the most extensive, spectacular protected natural habitats for in-situ conservation of hyper-arid biological diversity in the world. More than 50% endemism, in some groups over 75%, in the more than 300 species of plants, invertebrates and vertebrates is safeguarded within the sand sea that covers 84% of the Property. Well-documented results from ongoing scientific research and long-term monitoring are readily available to explain the biodiversity, ecological relationships and fluctuations in species presence and population changes. The Namib Sand Sea is wholly protected within the borders of the Namib-Naukluft Park with its long-term management programme and allocated funding.

Statement of integrity: The Namib Sand Sea is essentially a pristine environment within the borders of the Namib-Naukluft Park. The extensive dune-scapes are unspoilt and continuously refreshed and maintained by wholly natural processes. Permanent visitor and management infrastructure is non-existent within these boundaries and temporary occupation is restricted to small, temporary point locations that have no measurable effect on the well-known and well-researched geological, geomorphological, ecological, and biological processes of the Namib Sand Sea.

Requirements for protection and management necessary to maintain potential outstanding universal value: The 100-year long history of exclusionary regulations followed by conservation management interventions has informed and is available to inform future decisions about maintaining ecosystem processes not undermined by human exploitation. The Namib Sand Sea has been under conservation management for more than 50 years with well-established management and resource allocation systems, based upon a regularly revised and updated management plans and long-term budgetary planning. Key management issues today include managing the increasing demand for visitor access to pristine areas and precluding mineral exploration rights that would impact on the values and attributes of the area.
CRITERIA UNDER WHICH PROPERTY IS NOMINATED

The Namib Sand Sea along the African coast of the South Atlantic with its superlatively large, shifting dunes is an outstanding example of the scenic, geomorphological, ecological and evolutionary consequences of wind-driven processes interacting with geology and biology.

The site meets the following natural criteria:

Criterion vii: contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.

The Namib Sand Sea’s majestic dunes with their cornucopia of ever-changing shapes and interplay of shadow and light, within a setting of spectacular desert scenery and vast panoramas of undulating dune-scapes, are of compelling natural beauty. This beauty is enhanced by the exceptional visibility resulting from the virtual absence of moisture, dust and atmospheric pollution in this hyper-arid climate revealing remarkable clarity of landscape features by day and the dazzling Southern Hemisphere sky at night.

Criterion viii: is an outstanding example representing major stages of earth’s history, significant ongoing geological processes in the development of land forms, and significant geomorphic and physiographic features.

The Namib Desert results from the rare juxtaposition of cold boundary currents, such as the Benguella current of the South Atlantic, alongside hot continental interiors. The physical effects that the atmospheric conditions cause on ongoing accumulation and constant movement of dunes in the Namib Sand Sea is a renowned example of major geological processes that have formed dune and desert formations throughout earth’s history. The physiography of the sand sea includes most known types of dunes in sandy deserts (or ergs) formed through aeolian depositional processes, including associated desert land forms such as inselbergs, pediplains and playas.

Criterion ix: is an outstanding example representing significant ongoing ecological and biological processes in the evolution and development of terrestrial ecosystems and communities of plants and animals.

Life in the dunes of the Namib Sand Sea, and the behavioural and physiological adaptations that have evolved in its specialist communities, are significant global examples of the evolution and development of a terrestrial ecosystem community and the resilience of life in extreme environments.

Criterion x: contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

The number (>300) and endemicity (>50%) of species in the Namib Sand Sea, are much greater than any other known dune ecosystem. In-situ conservation of communities representing the turnover of endemic species from the cool coastal desert with frequent fog, to the hot, dry interior where more extreme aridity requires different strategies for survival, is ensured by the extensive, continuous habitat types across the full climatic gradient of the Namib Sand Sea.
NAME AND CONTACT INFORMATION OF OFFICIAL LOCAL INSTITUTION

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Identification
The Witberg is an isolated inselberg in the Namib Sand Sea (Paul van Schalkwyk)
1 Identification of the Property

1.a COUNTRY
Namibia

1.b REGIONS
Erongo, Hardap and Karas Regions

1.c NAME OF PROPERTY
Namib Sand Sea

1.d GEOGRAPHICAL COORDINATES
15.183° E, 24.485° S
1.e MAPS AND PLANS, SHOWING THE BOUNDARIES OF THE NOMINATED PROPERTY AND BUFFER ZONE (see Annex 2)

Map 1.e.1: Location of the Namib Sand Sea in Namibia and the African continent
Map 1.e.2: Boundaries of the Namib Sand Sea and Buffer Zone.
Map 1.e.3: Boundary coordinates of the Namib Sand Sea

Centre of nominated property: 15.183° E, 24.485° S
Area of nominated property: 30777 sqkm
Area buffer zone: 8995 sqkm

Map prepared by Geological Survey of Namibia
Government of Namibia 2011
Map 1.e.4: Major Substrate Habitats of the Namib Sand Sea

HABITAT
- Sand sea
- Eastern gravel plains
- Coastal flats
- Eastern rocky habitats
- Inselbergs
- Rocky coast
- Sandwich Harbour
- Pans
- Ephemeral water courses

Centre of nominated property:
15.183 E, 24.485 S
Area of nominated property:
30777 sqkm
Area buffer zone:
8965 sqkm

Based on composite Landsat 7 image
Prepared by Geological Survey of Namibia
Data provided by GlobaMap Training & Research Centre
© Government of Namibia 2011
Map 1.e.5: Important localities within the Namib Sand Sea

Places, rivers and areas within the Nominated Property

List of locations:
1. Sesriem
2. Sossus Vlei
3. Dead Vlei
4. Namib Rand
5. Great Western Escarpment
6. Avashib Mountains
7. Uhi-Hauchab
8. Springbok Vlakte
9. Farm Kamaland
10. Farm Kanaan
11. Aus
12. Gibraltar
13. Saddle Hill
14. Mercury Island
15. Sylvia Hill
16. St. Francis Bay
17. Reutersbrunn
18. Meob Bay
19. Fischersbrunn
20. Conception Bay
21. Sandwich Harbour
22. Rodibank
23. Gobabeb
24. Ganab
25. Gamsberg
26. Saagberg
27. Solitaire
28. Zais
29. Elim
Map 1.e.6: Annotated Landsat Image of the Namib Sand Sea
1.f AREA OF NOMINATED PROPERTY AND PROPOSED BUFFER ZONE

Area of nominated Property: 3,077,700 ha

Buffer zone: 899,500 ha

Total: 3,977,200 ha

Figure 1.f.1: Digital elevation model of the Namib Sand Sea on the African continent (Bowen/NASA)
Description
The iconic Deal Vlei with its 800-year-old Acacia erioloba ghost forest near Sossus Vlei (Paul van Schalkwyk)
2. Description

2.a DESCRIPTION OF PROPERTY

The Property being proposed as a World Heritage Site in this Nomination Dossier is the Namib Sand Sea (Annex 2). This Property is primarily composed of an ancient sand sea underlying a modern, active sand sea both of which are known together as the Namib Sand Sea. Components of the Property consist of the sand sea itself (84%), gravel plains and gramadullas (8%), coastal pans/flats (4%), eastern rocky hills (3%), inselbergs surrounded by the sand sea (1%), and a coastal lagoon (Sandwich Harbour), endorheic pans, ephemeral pans, and rocky shore all comprising less than 1% of the nominated Property. The superimposed ancient and modern Namib Sand Seas are the products of interactions between the atmosphere, the ocean and the land. Abundant sand, weather and climate are the key elements integrating these interactions and the spectacular dune-scapes. Of the climatic elements themselves, strong winds from various directions linked to rain and fog have overriding influence on the key attributes of the past and present Namib Sand Sea. These attributes embrace the structure, including aesthetics, dune-scapes, records of the earth’s evolution and elements of educational and scientific interest, and the ecological function, in-situ biodiversity conservation and ongoing evolution, of the Namib Sand Sea.
2.a.1 CLIMATE

The arid climate of the Namib Desert, in which the Namib Sand Sea is located, is the long-standing, overriding dynamic of the Namib Sand Sea. The aridity is exemplified by little rain, partially ameliorated by coastal fog. Strong winds, in different seasons from different directions, are the second key factor influencing attributes of the Namib Sand Sea.

Figure 2.a.2: The Namib Sand Sea within the context of Namibian climate

The extreme aridity of the Namib Sand Sea leads to exceptionally clear visibility due to a very low concentration of aerosols in the atmosphere. Conditions for atmospheric visibility have been extensively studied when the Gamsberg near the north-eastern boundary of the Namib Sand Sea was evaluated as a potential site for astronomical observations. That research proved that the eastern margin of the Namib is one of the areas with the clearest visibility in the world. The lack of...
atmospheric moisture for most of the year, especially away from the coast, combined with the virtual absence of silt and clay particles picked up by the wind and suspended as dust, provide for exceptionally clear viewing conditions over most of the Namib Sand Sea during most times of the year. That results in exceptional panoramic vistas with distant landscape features seeming to be within touching distance.

At night the clarity of the sky reveals other astounding views. The nightly spectacle exhibits myriads of stars and iconic constellations such as *inter alia* the Southern Cross, Orion the Hunter, and the Milky Way galaxy. Even when the full moon is so bright that one can distinguish topographical features and dune colours several kilometres away, the night sky simply transposes the daytime panorama for another, equally impressive. The Southern Hemisphere constellations in all their glory, undiminished by light contamination from any population centres or industrial pollution, never cease to amaze.

**Rain:** The Namib Sand Sea lies on the western, arid half of southern Africa. This situation is brought about by a combination of global air circulation, the Namib’s location on the western, rain-shadow side of the African subcontinent, and currents in the oceans surrounding the southern part of the continent, particularly the cold Benguela flowing up the west coast.

The Namib Sand Sea lies in that part of southern Africa dominated by the subtropical belt of high pressure encircling the earth. Air circulates at great height, losing its moisture over the equator, and sinks in high pressure cells or anticyclones that are centred over the tropics of Capricorn and Cancer. This subsiding air and the cool surface temperatures prevent the formation of atmospheric instability in summer that is necessary for rain to fall. In winter, however, circulation over the southern African subcontinent is dominated by a single large high pressure cell over the interior that is responsible for the clear, dry conditions experienced over the Namib Sand Sea. This high pressure cell is thought to be one of the most stable air masses on the globe.

![Figure 2.a.3: Apollo 17 photograph of anticyclone sweeping past the Namib Sand Sea (NASA Johnson Space Center, 7 December 1972)](image-url)
The latitudinal dry conditions are further enhanced by a semi-permanent high pressure cell over the cold Benguela current that suppresses evaporation over the ocean as well as the potential influx of moist air during the austral summer when the continental high pressure weakens. This effectively contributes to preventing conditions suitable for rain over the Namib Sand Sea resulting in almost permanent dry conditions. These hyper-arid atmospheric conditions are a permanent climate feature of the Namib Sand Sea only rarely interrupted by global changes in circulation that may result in rain over the Namib.

Summer rain over the Namib Sand Sea, on the rare occasion when it falls, occurs when warm, moist air is blown in from the east. Rainfall may then range from less than 20 mm in the west on the coast to more than 300 mm in the east. In winter, low pressure cells from the South Atlantic anticyclone pass over the southern tip of the continent, occasionally bringing rain to the southern, ‘winter rainfall’ part of the Namib Sand Sea. Winter rainfall, if it occurs at all, usually totals less than 30 mm.

Rain over the Namib Sand Sea is therefore exceptional as well as highly seasonal, with most coming from summer rains. Infrequent convection currents over the land initiate the thunderstorms that produce most of the rain in the interior. Occasionally, tongues of low pressure from the tropics penetrate further south than usual and, combined with the surface warming over the ocean known as the Benguela Niño, may bring widespread, soaking rains over at least the eastern portion of the Namib Sand Sea as experienced every few decades.
**Fog:** Fog, the crucial life-giving moisture source that supports the spectacular biodiversity of the Namib Sand Sea, is simply moisture in the air that reduces visibility and deposits water on any object in its path. Depending on a variety of factors including the rate of cooling of the moisture in the air, fog may materialize as minute droplets seriously obscuring visibility or as something resembling a wet drizzle almost like rain. Fog produces five times as much moisture as rain in the western sand sea and is much more predictable.

Two types of fog predominate, sometimes occurring at the same time. Within about 15 km of the coast, advective fog at less than 200 m high is borne inland on south-westerly winds, often arriving in the afternoon. Such fog forms when humid air crosses the cold Benguela upwelling and results in moderate precipitation. In contrast, high fog, which forms at about 200–600 m below a strong inversion layer, represents intercepted low status and strato-cumulus cloud. This high fog may reach inland as far as the Great Western Escarpment but most usually is intercepted by dunes at about 20–60 km inland.

Fog-water precipitation is recorded from high fogs about 60–120 days per year in the Namib Sand Sea. Using a one square metre fog collecting screen, up to 15 litres per fog day may be collected, although the long-term average is more like 1 litre per fog day. Long-term measurements indicate that the annual amount of fog precipitation can vary widely and has a distinct effect on the population dynamics of the fauna and flora of the Namib Sand Sea.

**Winds:** Potent east winds during winter bring dust, heat, organic detritus and flies. Bitingly cold northerly winds on the coast, and strong afternoon winds from the south-west in summer are part of the variable pattern. All of these features are largely explained by global circulation patterns and by local conditions of temperatures and topography.

The wind- and storm-generated long-shore drift of the Benguela Coastal Current, driven by the upwelling cells, has transported sand and marine gravels northwards along the coast since time immemorial. The peacefulness of a calm morning can be deceptive when the dominantly southerly to south-westerly winds, which are responsible for slowly transporting the sand northwards and inland, build up in the afternoon and sometimes keep blowing well into the night. During storms, the flying sand is highly abrasive.

**Summer winds:** The South Atlantic anticyclone lying offshore and to the south of the Namib Sand Sea is mainly responsible for the strong onshore winds experienced at the coast, but it is also assisted by the temperature contrast between cold ocean and warm land mass. Due to Coriolis forces, west wind is deflected to the left of its course and blows mainly from the south-west over the Namib Sand Sea. The wind blows strongest from September to November. The winds usually begin at the coast in the late morning and penetrate across the entire Namib Sand Sea by evening, dying at nightfall. There is a
trend of decreasing intensity of the south-westerly winds from the southern Namib Sand Sea northwards. The coastal area just south of the Namib Sand Sea, experiences the highest average wind velocity in southern Africa, with winds in summer varying between 30 and 80 km/h, easily transporting sand onto shore and over the dunes. Winds blowing from the northwest begin in the late afternoon and continue into the night. These dominate in summer, most especially between December and February, and often bring fog.

**Winter winds:** In winter the influence of the South Atlantic anticyclone weakens and the South African anticyclone, centred over the sub-continent, becomes more important. By far the strongest winds are the katabatic east or ‘berg’ winds, which are generated in winter when cold air from the sub-zero interior highlands flows westwards off the escarpment. The winds heat up and speed up as they cross the desert, stir up huge quantities of fine dust and have temperatures of more than 30°C and speeds of up to 80 km/hr when they reach the coast. The resulting dust plumes extend as far as 200 km out to sea. A description by Thomas Baines, explorer in southern Africa in 1861, may seem familiar to anyone who has experienced this wind at the coast: ‘Toward noon it blew very hard from the east, bringing down such clouds of sand that we could not see eighty yards in any direction. To work outside was an impossibility, and the flies, driven in for shelter, rendered the house almost untenable...’ East winds penetrate to the coast only on about 10 to 15 days a year but are very memorable and significant nonetheless for their impact on the geomorphology and ecology of the Namib Sand Sea.
The sediment-moving power of the east wind is astounding. The dust/sand plume near the Orange River mouth of 9 May 1979, south of the Namib Sand Sea, resulted from north-easterly winds averaging over 50 km/h. The plume extended about 150 km to sea, and covered an area of about 20,000 km². Assuming that this dust would settle to a thickness of one millimetre, the total quantity of sediment moved was about 50 million tonnes – the same order of magnitude as the annual input of sediments borne by the Orange River in a normal year! Clearly the Namib Sand Sea is a dynamic, variable place.

Figure 2.a.8: Sand saltation driven by wind (Hesp)

Figure 2.a.9: Dust plumes in the central Namib driven by the Southern African continental low-pressure system locally known as ‘The East Wind’ (Goddard Space Center, NASA, 13 June 2003)
2.a.2 GEOGRAPHY AND GEOLOGY

The Namib Sand Sea is actually a system of two dune seas, one on top of another. The older is semi-consolidated, and as old as 21 million years. The younger is unconsolidated and has been active for about 5 million years. It covers the older system and is still accumulating. The uniqueness of both sand seas lies in the fact that they are quite different from other large sand seas elsewhere in the world, as they have not been derived from erosion of the hard bedrock on which they lie.

Figure 2.a.10: Geological setting

Although having accumulated in the arid to hyper-arid central Namib, these dune sands originated under the humid conditions of central to eastern South Africa in the catchment area of the Orange River and its main tributary, the Vaal River. Three contrasting ‘conveyor belt systems,’ acting in unison over much longer than the 21 million years recorded by the fossils in the basal aeolianites, are the source of the Namib Sand Sea sand. These systems comprise fluvial transport by the Orange River itself, a coastal long-shore drift transporting the sediments in the marine system and the aeolian transport by coastal winds that finally deposit the sands in the central Namib Sand Sea. Thus, both central Namib Sand Seas are displaced and aeolian derivatives of the huge inland Orange/Vaal River Basin and the sandstone of the Lesotho highlands.

But the Namib Sand Sea is not just made up of shifting, unconsolidated dunes or aeolian sheet sands. The bedrock under the two sand seas forms a gradually rising peneplain studded by occasional inselbergs. Westerly flowing rivers had cut valleys into the Namib bedrock even before the first dune sands were deposited. Subsequently, rivers flowing off the Great Western Escarpment in the east during summer rains deposited fluvial gravels from time to time on the eastern dune sands. All the rivers flowing off the Great Western Escarpment just to the east of the sand sea feed fresh rainwater into the old palaeo-valleys and extensively into the older semi-consolidated sand sea. The water,

1 The geological components of the description of the nominated Property are primarily derived from: Schneider, G.I.C. 2011. The Namib Sand Sea World Heritage Site, Annex 4 of this document and publications listed in the bibliography (Section 7.e and Annex 21).
reaching the coast by this means and emerging as small springs at hidden, isolated locations, is many thousands of years old when it again attains the surface.

**Evolution of the Namib Sand Sea:** The understanding of geological processes that have led to the evolution of the present Namib Sand Sea are related to plate tectonic processes that shaped the past and present face of the earth. The geological units underlying modern Namibia were part of the huge landmass of Gondwanaland. This ancient continent broke apart some 128 million years ago, and individual pieces, including Africa, drifted apart from then on. During the Palaeogene, between 65 and 23 million years ago, Africa separated from the neighbouring parts of Gondwanaland and emerged as a continent of its own.

As a result of these plate tectonic movements, the southern African subcontinent underwent various stages of uplift, and the present interior was subject to erosion. Deep erosion from the end of the Cretaceous onwards, 65 million years ago, caused the Great Western Escarpment to migrate eastwards, leaving behind the low-lying peneplain occupied by the Namib Sand Sea today. Consequently, the geological succession in the Namib Desert consists of local Cretaceous deposits and extensive terrestrial Cenozoic to recent sediments.

**Platform underlying the Namib Sand Sea:** The bedrock, upon which the ancient and modern Namib Sand Sea dunes rest, records several major phases of crustal evolution relating to the amalgamation and breakup of the Rodinia and Gondwana Supercontinents. Outcrops occur sporadically along the coast, in a few inselbergs within the dunes and along the eastern border of the dune belt. The largest coastal outcrop area is the one between Conception Bay and Meob Bay.

Erosion by means of escarpment retreat under humid conditions produced a Namib-wide bedrock bevel or peneplain, which stretches the full north-south length of Namibia’s coast and extends from sea level in the west to an elevation of 800–1000 m at the eastern edge of the central Namib dunes. Inselbergs of Namaqua and Sinclair Formation rocks, such as the Uri-Hauchab, Hauchab and Awasib Mountains, dot this bevel in the southern half of the Namib Sand Sea dune field and along its eastern edge but are conspicuously absent in the northern half. Fossils in fluval-palustrine deposits in the northern Sperrgebiet and just south of the central Namib Sand Sea suggest that the pre-sand sea fluvial phase ended at about 21 Ma.

By the end of the Cretaceous, the Orange River was already a major drainage system and deposited vast amounts of sediments in a huge submarine offshore delta.

**The Tsondab Sandstone:** The Orange River system has been in existence since the early Cretaceous transporting sediment westwards. It built out a huge delta in the widening South Atlantic Ocean throughout the Cretaceous and the Cenozoic. The river mouth and the delta are located in an area where almost continuous and often powerful southerly winds of the South Atlantic Anticyclone drive a vigorous long-shore drift that transports gravel, diamonds and sand for hundreds of kilometres northwards and back onto the beaches of the Namibian coast. The diamondiferous gravels of the Orange River and the Namibian raised beaches contain pebbles that can be traced to very specific formations deep in the South African interior. The same powerful southerly winds blow the sands
back onshore, often along well defined sand-transport corridors, and have built up both sand seas over millions of years.

High sea levels, up to 170 m above the present sea level during the Eocene, in combination with long-shore drift, deposited marine and marginal marine sediments on the Namib bedrock bevel up to 30 km inland of the present coastline. Similarly, sea-level falls of as much as -120 m or more during the Oligocene exposed huge areas of the offshore Orange River delta and the continental shelf to its north. Thus, large areas of the Cretaceous and Cenozoic marine sediments in the delta and on the continental shelf were exposed to the strong southerly winds for long periods of time and were huge sources of sand for the two central Namib Sand Seas.

It was during the early Miocene, that the first aeolian sands of the central Namib Desert began to accumulate onshore. These eventually covered the full length and breadth of the Namib Desert from the Orange River to the Kunene River and from the coast to the valleys in the foothills of the escarpment. These consolidated to form the Tsondab Sandstone Formation. Subsequent erosion has removed most of this sandstone north of the Kuiseb River but it is still extensively preserved beneath the unconsolidated dune sands of the Sossus Sand Formation in the central Namib – the Namib Sand Sea. In the Namib Sand Sea, the Tsondab aeolian sands are interbedded with escarpment-sourced fluvial sands and gravels along the eastern edge of the sand sea.
The partial cementation of the Tsondab deposits was completed towards the end of the Miocene. During a prolonged period of relatively higher summer rainfall that followed, flood waters of the main westerly flowing rivers cut broad but rather shallow river channels into, but not through the Tsondab Sandstone and deposited westward-fining river gravels in these valleys to within 25 km of the coast. The valley gravels and the underlying sandstone gradually became cemented by calcrete that precipitated from groundwater, which continued to flow in these valleys long after gravel deposition had ceased. Some of the most spectacular outcrops of these late Miocene, calcrete-cemented gravels are in the Sesriem Canyon on the eastern boundary of the Property.

Sands of the Namib Sand Sea: The successive Plio-Pleistocene glaciations in the northern hemisphere, and the associated melting of the arctic ice sheet at the end of the glaciations, resulted in global climatic variations and sea level changes. The strong long-shore drift along the Namib coast transported much of the sediment from the offshore delta of the Orange northwards to form gravel and sandy beaches at various sea levels. The sand from these beaches has been picked up by the wind and blown inland to form the Namib Sand Sea.

The coastline is characterised by a number of south-facing embayments. These bays serve as sources of sand for the central Namib Sand Sea, and occur within one of the highest energy aeolian systems on earth. Linear valleys extending northwards from the bays are swept by winds with speeds exceeding 100 km per hour and transporting enormous amounts of sand. The aeolian sands of the unconsolidated, Pliocene to present-day Sossus Sand Formation were and are partially being fed by trains of fast-moving barchan dunes, some of which arise at beaches with north-westerly orientations as far as 100 km south of the Namib Sand Sea. That sand is gradually transported northwards and north-eastwards to contribute to the Sossus Sand Formation of the Namib Sand Sea. The heavy mineral suites in both the...
Tsondab and Sossus Formations are identical to those of the Miocene and present-day fluvial sands of the Orange River. To a limited extent, aeolian abrasion of the Tsondab Sandstone contributes to the younger Sossus Sand Formation.

The main wind directions are southerly along the coast and south-westerly further inland but there are occasional strong north-westerly and easterly winds. The overall movement of sand is consequently toward the north or north-east. The greatest rate of movement is along the coast where southerly wind blows rather strongly most afternoons and evenings. Barchan and longitudinal dunes prevail in this region. Changes in wind direction change the facing direction of the dune crests. On the eastern edge of the Namib Sand Sea near Sossus Vlei, the wind direction is more variable from day to day. Consequently, this is the region where stellate and pyramid dunes are developed.

The present Tsondab and Tsauchab Rivers have cut new channels into their old palaeovalleys and their end points are the Tsondab and Sossus Vleis, respectively. Several deposits of white, calcareous pan clays in the Sossus Vlei area occur at elevations up to 2–3 m above the present level of the Sossus Vlei clays and are underlain by unconsolidated aeolian sand. These show that the Tsauchab River has cut its channel gradually deeper with time and that the location of its end point has not always been exactly where it is today. The two rivers, the Tsondab and Tsauchab, have relatively small catchments in the escarpment region where rainfall is low. Floods in the Tsondab and Tsauchab Rivers only reach their respective end points occasionally.

Both Namib Sand Seas are, therefore, outstanding and unique examples of the interaction of a major river system draining into a highly dynamic coastal environment in which some of the most intense winds on earth drive a powerful littoral and sub-littoral long-shore drift system which transports the offshore fluvial sediments northwards and back onto beaches. The winds pick up the sands from the beaches and carry them northwards and north-eastwards to form the dunes. The average combined thickness of the two ergs together increases northwards to 24° 30’ S then decreases north of that. The maximum estimated thickness of the successive sand accumulations is 475 m.
Figure 2.a.15: Superimposed on this Landsat image are areas where these main types can be identified. The bar scale on the Landsat images of the various dune types is 2 km: 1: transverse or compound crescentic dunes, 2: longitudinal ridges or linear dunes, 3: transition forms between transverse and linear dunes, 4: branching longitudinal ridges or linear dunes, 5: network complex within the linear dune system, 6a: zibar dunes, 6b: zibar-silk dune system, 7: lace dunes, 8: honeycomb structure, 9: honeycomb structure with stellate dunes and saw-tooth dunes, 10: giant honeycomb structure, 11: warty dune ridges with stellate dunes, 12: high chaotic dunes, 13: pyramid dunes, 14: dune sand plain with craters, 15: sand sheets, 16: aeolian transport corridor with barchanoid dunes (Miller)
**Dune formations:** The sixteen recognized dune types in the Namib Sand Sea can be consolidated into three main dune types: transverse dunes in a coastal strip, linear dunes in the centre of the sand sea and star dune systems in the east. These are the sixteen wondrously varied dune types that integrate to form the spectacular dunescape with its interplay of shape, colour, movement and habitat making up the Namib Sand Sea.

**Ephemeral Rivers:** Not immediately apparent are the late Miocene to early Pliocene courses of the Kuiseb, Tsondab and Tsauchab Rivers within the Namib Sand Sea. These palaeo-rivers cut broad valleys up to 30 m deep into, but not through the Tsondab Sandstone. Continuous sheets of westward-fining river gravels of the Karpfenkliff Formation trace out these valleys. The Karpfenkliff gravels of the palaeo-Kuiseb River crop out between regularly spaced transverse dunes, but the gravels of the other two rivers are almost dune free. The valley of the palaeo-Tsondab River is the best exposed and most readily recognisable between the high valley flanks for 80 km from the eastern edge of its gravel plains, where it is 25 km wide, to 35 km northwest of Tsondab Vlei where it is only 2 km wide. A narrow strip of dunes separates the Tsondab Vlei from the exposed western 30 km of this palaeo-valley. The Karpfenkliff gravels of the Tsauchab River are totally dune free all the way down to Sossus Vlei. This palaeo-valley is not at all obvious as the high flanks of the older valley are completely covered by dunes of the Sossus Sand Formation with saw-tooth dunes down the valley flanks and onto the valley floor and stellate dunes on top of the valley flanks.

The present Tsondab and Tsauchab Rivers follow and have cut new channels into the old palaeo-valley gravels and the underlying aeolian Tsondab Sandstone, but their end points are the Tsondab and Sossus Vleis, respectively, deep inside the dune field of the Namib Sand Sea. The unconsolidated dunes of the Sossus Sand Formation further west prevent these rivers from reaching the sea, however the vleis occasionally fill up with flood waters after good rains in the interior.

**Mineral Resources:** The only minerals that have ever been mined in the nominated area are diamonds. In the early Cretaceous, the predecessor of today’s Orange River was a slow flowing, meandering river that deposited millions of tons of fine sediment into the sea. This changed when southern Africa underwent major uplift that led to the incision of river beds and fast-flowing rivers capable of transporting diamonds, together with considerable amounts of sand and gravel, all the
way to the Atlantic Ocean. Upon reaching the sea, these sediments were distributed along the southern Atlantic coastline. While the fabulously rich Namibian diamond deposits occur further south than the Namib Sand Sea, the Namib Sand Sea itself did contain smaller stones of lesser economic value that supported small-scale mining operations in the past, until the known deposits were mined out. However, extensive research into the formation of the Namibian diamond deposits contributed to the generation of knowledge about the age, formation and general geology of the central Namib Sand Sea.

The Namib Sand Sea fossil record: The strata in the Namib Sand Sea contain a rich and diverse fossil record that has proved to be useful for determining the timing of events in the desert and aspects of its palaeoclimate and palaeo-environment. The fossils comprise three major classes – trace fossils (ichnofossils such as burrows and foot prints), bioconstructions (fossilised spider webs and termite nests for example) and body fossils (remains of invertebrate shells, vertebrate skeletons and eggshells).

The Neogene strata in the Namib Sand Sea consist predominantly of aeolian sands with interbedded marine, fluvial, lacustrine, plaudal and pedogenic deposits. Near the coast there are interbeds of marine deposits up to 50 metres above present-day sea-level, and these strata often contain rich marine faunas (bivalves, gastropods). Fossils have been found at numerous points throughout the Namib, and these have permitted the age of the various deposits to be ascertained within reasonable limits, using biochronology (relative age determination of strata using fossils). The fossils also allow aspects of the palaeo-environment to be determined.

During the Early Miocene, some 21-19 million years ago, the region was semi-arid with savannah and steppe vegetation. By 16 million years the Namib Desert had become hyper-arid, with extensive deposition of aeolianites. Desert conditions have dominated ever since, although there is evidence that there were periods of greater humidity during which rivers flowed, lakes formed and calcrete crusts developed far into the desert.

Trace fossils are ubiquitous and abundant throughout the desert, particularly rich deposits being known near the coastal strip at Meob, where carnivore and ruminant footprints are well preserved and common. Elsewhere traces of termite activity, coleopteran burrows, rhizoliths and other kinds of bioturbation are widespread and attest to the fact that the desert supported a rich and diverse fauna and flora throughout its existence. Well preserved trails of the golden mole Eremitalpa and burrows of lizards and rodents are locally common in the aeolianites, especially near Awasib. Rhizoliths of various diameters reveal the former presence of grass and trees in the Namib Sand Sea.
Bioconstructions are varied and widespread in the aeolianites of the Namib Sand Sea. The commonest kind of bioconstruction comprises latrines and hives of termites, notably the sand termite *Psammotermes*, and the harvester termite (*Hodotermes*). Perhaps the most unusual bioconstructions preserved in the Namib are roof webs of the buck-spoor spider *Seothyra*, a genus that prepares a four-lobed trap door of thick web on the sand surface which has been found fossilised in various places in the desert, including Sossuvlei and the Tsoudab Flats.

Body fossils are of particular interest as they yield information about the ages and palaeo-environments of the deposits. Fossil rodents and carnivores were found at Sossus Vlei, Awasib, Tree Pan and Meob Bay. Among the mammalian fossils found in the Namib, rodents predominate, in particular Pedetidae (spring hares) and Muroids (mice and rats). The Pedetidae underwent significant evolution during the past 21 million years and are thus useful for biochronology. Rarer in the Namib are fossils of proboscideans (elephant relatives), aardvarks, bovids, (ruminants), equids (zebras) and carnivores (hyaenas, meerkats) but each occurrence yields information about palaeo-environments.

Figure 2.a.18: Succession of fossil ostrich eggshell types from the oldest (A) to the youngest (K). A. *Tsondaborinis minor*, B. *Tsondaborinis psammoides*, C. *Namornis elimensis*, D. *Namornis oshanai*, E. *Diamantornis corbetti*, F. *Diamantornis spaggiarii*, G. *Diamantornis wardi*, H. *Diamantornis laini*, I. *Struthio karingarabensis*, J. *Struthio daberasensis*, K. *Struthio camelus*.

Scale (under F fragment) 10 mm (Schneider)
and age. Thus the Kamberg Calcrete, which is widespread in the northern part of the Namib, can be dated to the Pleistocene on the basis of the equid and bovid fossils it contains, while they also indicate that there was an extended period of semi-aridity with over 250 mm of rainfall annually. The calcrete also contains stone tools, suggesting that humans were able to survive in the desert intermittently during these remote periods.

Fossil struthious (ostrich) eggshells, which are abundant in the aeolianites, are notable for the variation in shell thickness and surface morphology that they demonstrate. The fossil eggshells retain carbon and oxygen isotopes from when they were laid and this permits aspects of palaeoclimate and palaeo-ecology to be determined. Careful note of the stratigraphic context of the eggshells and their associated mammalian fossils has permitted the erection of a biostratigraphic scale based on eggshells. Some of the types of eggshells that occur in the Namib aeolianites have subsequently been reported from Malawi, Tanzania, Kenya and the United Arab Emirates and in every case the estimated age of the strata deduced in Namibia has been confirmed. The fact that the eggshells span the period 21 million years to the present is particularly useful, as they cover the entire history of the two Namib Sand Seas. Detailed mapping of the aeolianites is now possible using eggshells as a chronometric tool. Preliminary mapping reveals that the details of sedimentation are more complex than hitherto thought possible.

Thus far, little palaeontological research has been focussed on the Namib Sand Seas. The main areas studied have been Sossus Vlei, Tsondab Flats, Awasib and Meob, all of which are near the edges of the sand seas. Transects across the desert in the Uri-Hauchab area reveal that fossils probably occur throughout the desert, and it would be well worth spending more time and energy on a survey of the region because fossils hold the key for unravelling the detailed history of the Namib Desert and the Namib Sand Sea.

![Image: The Namib Sand Sea meets the southern Atlantic (van Schalkwyk)](image)
2.a.3 VEGETATION OF THE NAMIB SAND SEA

By definition, desert ecosystems have very little vegetation cover and low net primary production, while hyper-arid deserts are almost devoid of any vegetation. The Namib Sand Sea is a particularly outstanding example of that universal truth.

However, early observations, suggesting that the southern Namib Sand Sea mainly consists of sand dunes without any important vegetation are deceptive, given the exceptional adaptations of plants in the Namib Sand Sea. The attributes of the vegetation cannot be adequately described by numbers of species alone (Annex 10; Table 2.a.1) but are particularly remarkable for their adaptations and patterns of growth (Annex 6). These adaptations allow the plants to steady themselves within unstable substrates, acquire nutrients in an environment with extremely low soil fertility, obtain moisture from a substratum with very limited water holding capacity (and little moisture input) or directly from fog, and withstand extreme thermal gradients in order to reproduce successfully and persist in harsh habitats. This is not to mention the challenge of attracting pollinators and dispersers other than the wind from a limited range of faunal species found in the Namib Sand Sea. Yet, these plant communities contain highly adapted plant species with regard to environmental sensitivity, life histories and physiology while displaying among the most intriguing forms of any biome. To persist in the harsh environment of the dune fields, some plants have evolved to reduce the exposure of leaf areas to the sun and wind through rolled, water storing or exceptionally reduced leaves (xeromorphy). Belowground investments in an extensive lateral shallow root system to enable the plants to take advantage of surface moisture or, alternatively, deep taproots to enable the plants to access deep groundwater are other key adaptive strategies found in plants in the Namib Sand Sea.

Figure 2.a.20: Vegetation and soil types of Namibia

Table 2.a.1: Plant species in the sand sea compared with the entire nominated area

<table>
<thead>
<tr>
<th>Nominated area</th>
<th>Sand Sea</th>
</tr>
</thead>
<tbody>
<tr>
<td>260 species</td>
<td>15 species</td>
</tr>
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</table>
Offering habitats at the extreme end of aridity largely unaffected by climatologically drastic transformations and secluded from humans over millennia, the Namib Sand Sea shelters a variety of arid-adapted plant species. These thrive during unfavourable environmental conditions, largely unaffected by anthropogenic impacts, thus serving as a source for the restocking of affected areas upon amelioration of conditions. Moreover, the uniquely adapted flora of the Namib Sand Sea offers a rare and vast reservoir of remarkable hereditary plant traits that are potentially valuable for breeding new drought tolerant plant species and crop varieties in the face of the currently uncertain future of global warming. It is for this reason that the Namib has become a collection hotspot for the International Board for Plant Genetic Resources (IBPGR). Floristic communities on dunes and inselbergs within the Namib Sand Sea contain a matchless wealth of exclusive genetic material.

Nevertheless, the Namib dune ‘grasslands’ are quite simple compared to grasslands in moist climates where there is usually a succession involving various grasses as well as woody plants, and where subtle variations in soil chemistry and moisture can make the associations of species very complex. In contrast, in the Namib Sand Sea there is a gradient of increasing rainfall from the coast inland towards the east, and this is reflected in a gradual rise in the number of species and the abundance of grassy and other vegetation on the dunes. A separate document on vegetation in the Namib Sand Sea by Kolberg can be found in Annex 6. A comprehensive list of all flora species occurring within the nominated Property is included in Annex 10.

**Gradient west to east:** For the Namib Sand Sea ecosystems, rain is not the only important source of moisture input. It is, of course, essential for seed germination. Fog and dew are, on the other hand, of great importance, particularly for ongoing growth. Fog in the Namib stretches for tens of kilometres inland on many mornings, and is at its densest at an elevation of 200 m to 600 m above sea level and 20 km to 60 km inland. Any obstacle that may be presented by plants, rocks and soil surfaces on the landscape causes fog-water to condense and form droplets. Frequently occurring and thus more predictable fog along the Namibian coastal shores, augmented by relatively high humidity directly on

*Figure 2.a.21: Vast grasslands on the eastern boundary of the Namib Sand Sea (Fennessy)*
the coast, is the lifeline of many plant and animal species in the harsh Namib Desert and a significant causal factor in the extraordinarily high diversity of animal life in this extremely arid environment. Whereas the mean annual rainfall along the coast ranges between 2 to 20 mm and is mainly restricted to the summer months, thick fog occurs on more than 100 days of the year delivering up to 1 litre/m²/day of fresh water with low osmolarity (low salt content).

Vegetation species distribution, abundance and density in the Namib Sand Sea mirror the gradient of decreasing fog and increasing rainfall from the coast inland towards the east. This is most evidently reflected in a gradual upsurge in the biomass and number of grassy vegetation species on the dunes. Near the coast, only two plant species occur as perennial species. The succulent Trianthema hereroensis and the coarse grass Stipagrostis sabulicola are able to survive in the erg and endure drawn out rainless periods by absorbing fog-water through their leaves and shallow roots respectively. Trianthema hereroensis soaks up fog-water directly via its leaves and stems and at the same time taps into moist subsoil layers with comparatively deep roots. In contrast, the extremely extensive rooting system of Stipagrostis sabulicola is twofold. While shallow roots anchor the grass clump in the mobile sand, surface roots may cover distances of more than 20 m from the plant while extending no deeper than 5 cm. This configuration allows the grass to effectively harvest fog moisture condensing on the shallow roots. In addition, Stipagrostis sabulicola harvests fog-water on its firm upright stems and channels the droplets towards its anchoring roots just beneath the dune surface via stemflow. Nocturnal fog collecting on the grass may lead to disproportional wetting of the mound of sand around the plant, with an average-sized plant harvesting up to four litres of fog-water in one night. Moreover, heterogeneity of spatial soil water content may develop within a mound due to differential funnelling of fog drip by unevenly arranged stems and drooping V-shaped leaves.
As plants that are endemic to the Namib Sand Sea and both dependent on fog in the western dunes, \textit{T. hereroensis} and \textit{S. sabulicola} have different eastern limits to their range. While the range of \textit{T. hereroensis} extends about half way across the sand sea, \textit{S. sabulicola} grows across the entire dune field to its inland periphery. Although growing most commonly on the more stable dune base in the west, \textit{S. sabulicola} is restricted to the less stable areas near the dune crest in its eastern range. With the dune sand providing exceptional opportunities for burial of seeds and both plants regularly producing seeds, \textit{T. hereroensis} doing so all year round, a well-stocked seed bank is ensured at all times even after long dry spells. With the advent of an exceptional rain, vegetation germinates across most of the dune expanse. However, a year or so later, the zonation of different species growing at different elevations on the dune is evident. The most likely determinant of the plants’ distribution patterns and densities on the dunes is differential mortality rates related to availability of moisture over the short and longer term. Meanwhile, where \textit{T. hereroensis} drops out of the mix, several additional grass and dicot species pick up.

**Across one dune:** Vegetation growth gradient across individual dunes is relatively complex. The uppermost parts are the driest, as expected, as this part is the most exposed and gravity drains water away from it. However, the dune base is also relatively dry, probably because of the
greater compaction of the sand and consequently greater runoff and less infiltration. So the mid-dune has the highest soil moisture and the greatest standing crop.

Variation across one dune in the western, transverse dunes and adjacent linear dunes is limited. The perennials, *Trianthema hereroensis* and *Stipagrostis sabulicola*, grow mainly on the dune slopes, or plinth, but also in the sandy interdunes. In contrast, *Cladoraphis spinosa*, which germinates profusely after exceptional rains, is limited to the interdune valleys. Remnants of this spiny, shrubby grass are visible for several years after a germination event.

Midway across the dune fields, travelling from west to east, the vegetation pattern on an individual dune shows more variation. The amount of living vegetation varies greatly depending on the time since the last good rain. *Trianthema hereroensis* and *Stipagrostis sabulicola* grow on the dune slope with *T. hereroensis* more common on the lower slope and *S. sabulicola* higher up. Soon after good rains, *Cladoraphis spinosa*, which is so common on the sandy interdunes to the west, grows sparsely on the lower edge of the plinth. *Centropodia glauca* with its high protein content and often *S. leutescens* grow densely along the lower dune slope while spiny *Stipagrostis seelyae* dominates the middle part of the dune slope. The interdune, which is often composed of gravel rather than sand midway across the dunes, supports an almost uniform cover of the primarily annual *Stipagrostis gonatostachys*, with *S. ciliata* growing only on the interdune at the edge of the dunes where moisture is slightly more available. On the relatively stable coarse ripple sand of the eastern, but not the western, dune base, the leaves of *Monsonia ignorata* emerge from their corms buried 10-20 cm beneath the surface. Scattered occasionally along the dune base, individuals of the *Hexacyrtis dickiana* lily emerge and a few of them find enough moisture to produce spectacular mauve flowers. *Sesamum abbreviatum* may occasionally stand proud and flower on the lower dune.

Travelling even further east, the linear dunes and the high star dunes become more vegetated. *Trianthema hereroensis* drops out of the array but *Stipagrostis leutescens* and *S. seelyae* insert themselves on the lower and middle dune slope and the high protein, nutritious *Centropodia glauca* grows at the dune base. Interspersed among the primarily grassy flora, the dicots, *Hermannia minimifolia* and *Limeum fenestratum*, grow on the lower dune slopes as well. At a certain point the

*Figure 2.a.25: Dune grasses: Centropodia glauca, Stipagrostis leutescens and Cladoraphis spinosa (Gobabeb Centre)*
diversity peaks and then decreases as the eastern dunes are lower and perhaps two dune grass species are found with another two or three grass species on the bordering plains. At isolated spots where Tsodab Sandstone is exposed between the eastern dunes, *Stipagrostis pellytronis* is occasionally found growing on this substrate.

Five of the common dune species are strictly endemic to the Namib Sand Sea, while others extend to sand-covered areas further north or south beyond this central area. The endemic species include the grasses *Stipagrostis pellytronis* and *Stipagrostis seelyae* and the dicots *Hermannia minimifolia*, *Sesamum abbreviatum* and *Monsonia ignorata*.

**Grass as support to fauna:** Other than revealing transformations in the distribution patterns of vegetation across the erg correlated with the rainfall gradient, grass cover also patches up the uneven spread of plant cover that normally characterizes the ecosystem, allowing animals to disperse and broaden their home and foraging ranges. Being the most widely distributed and abundant vegetation type, grasses in the Namib Sand Sea, just as in grassland savannas, provide the greatest proportion of net primary production and food at the base of the ecological pyramid. Despite an almost immediate explosion in plant biomass due to the sprouting of grasses and other vegetation after significant rains, accompanied by heightened animal activities, the response varies from habitat to habitat. The remarkable jolt of available energy in the ecosystem after rains attests to the fact that plant growth in the Namib Sand Sea is very dynamic and that water is the most important limiting factor. Sufficient rainfall acts as the catalyst for *en masse* germination of countless seeds in the erg, but it takes sustained moisture input from fog to allow successful growth and establishment of plants where rainfall is limited in the western Namib Sand Sea. Additional to water, other factors such as nutrient supply, especially nitrogen and phosphorus, as well as physical stability of the sandy substrate may impose limitations on the establishment of plants in certain localities of the erg.

The two hardy iconic plants inhabiting the western dunes, *Trianthema hereroensis* and *Stipagrostis sabulicola*, although relatively sparse, are essential support for a variety of dune fauna. The succulent, *T. hereroensis*, an evergreen desert plant, flowers and produces seeds throughout the year providing shelter and food to a large diversity of animals in the Namib Sand Sea including gerbils, sparrowlarks, scale insects, ants, tenebrionid beetles, ostriches and oryx (gemsbok). An outstanding trait of this endemic plant of the Namib erg is its ability to vigorously re-grow and replace shoots eaten by oryx, the only

![Figure 2.a.26: Breeding male ostrich taking advantage of abundant grass (Gobabeb Centre)](image-url)
large herbivore commonly found in the western sand sea. The larger lush new leaves serve to continually draw the gemsbok back to the same succulent bushes. Similarly, the bushman grass *S. sabulicola* is an endemic of the Namib dunes sheltering a host of organisms such as beetles, reptiles, gerbils, ants and lizards while also being grazed by oryx when other food is limited. Both perennial plant species perform as opulent isolated islands supporting a myriad of diverse invertebrates and vertebrates in the otherwise sparsely inhabited sand sea.

The dune base may support its own distinctive flora and fauna that is discretely dissimilar from the plant assemblages and animal species found higher up on the same sand dune. The area above the dune base is slopes at about 14° relative to the horizontal plain and is known as the dune slope. The dune slope may be subdivided into a lower more vegetated section commonly referred to as the ‘plinth’ and an upper slope. As with the dune base, the dune slope including the plinth supports unique distinguishing life forms. The steepest portion of the dune that is inclined at about 34° and represents less than 1% of the total dune surface area is known as the ‘slipface’. The slipface is of essential and outstanding value to the Namib Sand Sea in that it is home to many endemic fauna (fauna only found in the Namib Sand Sea). These animals feed on windblown detritus, predominantly of plant origin, which accumulates there on a daily basis distributed by the wind. Life in the dune field is profuse on dune slipfaces inhabited by the scores of beetles, fish moths and lizards careering over the loose sand when temperatures and winds favour foraging.

*!Nara:* Although common along water courses, Inara plants (*Acanthosicyos horridus*) frequently become the keystone species in the Namib Sand Sea, often being the only plants in an area. A very long-lasting melon-bearing bush, Inara is endemic to the coastal regions of Namibia and southern Angola, essentially the Namib Desert. The Inara traps windblown sand to form giant sand hummocks of considerable height, but always manages to grow and emerge above the dunes with its knotted leafless branches. It has longitudinally ridged stems with arching branches and paired spines of 2-3 cm length, all of which are pale green to

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**Figure 2.a.27:** Distinctive substrate ecotone between dune and interdune supports different *Stipagrostis* and other sand sea grasses (Gobabeb Centre)

**Figure 2.a.28:** The endemic *Acanthoprostus diadematus* at home in the spiny leafless cucurbit Inara (Gobabeb Centre)
greyish-green in colour, thus enabling the plant stems to photosynthesise. Absence of foliar growth is a consummate water conserving adaptation to the hyper-aridity of the plant’s distribution range. The Inara plant has a thick deep taproot that can extend 40 m or more into the sandy subsoil to facilitate tapping of groundwater near ephemeral rivers and their palaeo-channels within the Namib Sand Sea. As a dioecious plant, only females bear the hard coated, spherical spiny melons that start off as green fruits before turning yellow as they ripen. The fruit reaches diameters of 15 cm and hold a copious creamy pulp surrounding numerous pips.

Inside the hard covers of Inara seeds, the protein- and oil-rich endosperm with a high content of unsaturated fatty acids has provided nutrition for desert dwellers over the millennia. Today, people eat the seeds raw or roasted as nuts or they are added to other dishes after pounding. Pulp of the Inara fruits is also consumed as dried fruit or mixed with other dishes such as porridge. Currently the Topnaar (Nama) indigenous community along the Kuiseb River harvests the fruits, mainly to market the seeds in nearby towns. They are turned into Inara-seed oil or sold as roasted, salted snacks to be enjoyed far beyond their source in the Namib Sand Sea.

Other than humans, the Inara plant also supports a number of animals by providing them with moisture and nutrition and even shelter for the small-sized ones. The hardened barbed mature stems of the Inara, aided by its entwined growth form, offer effectual security against herbivory. However, young, tender and succulent shoots and buds form an important source of moisture and sustenance for ostriches and lizards, whereas the fruits are opened up and eaten by gemsbok and black-backed jackals. The seeds, once the harder outer shell of the melon is broken, are eaten by a number of smaller mammals such as gerbils and mice.

Inselbergs: Isolated peaks are a global feature of all desert landscapes and these mountain islands or inselbergs are universally known to be havens for uncommon, often endemic species of plants and animals in a particular area. The morphological features of the constituent granite rocks forming inselbergs in the southern part of the Namib Sand Sea give rise to various habitat types on the outcrops in the crevices, depressions, cracks and at the foot of the hills. Within the Namib Sand Sea, the isolated inselbergs integrate two facets, namely the exceedingly long time of disconnection from the Great Western Escarpment to the east and the physical blockade from comparable habitats by mobile sand dunes.
The Hauchab chain of mountains within the Namib Sand Sea (25°20'S; 15°15'E) at 50 km from the lowest hills of the Great Western Escarpment and 30 km from the nearest comparable habitats within the erg are possibly the most isolated inselbergs in the entire Namib Sand Sea contributing to preserving their unspoiled natural character. Moreover, the locality of the Hauchab group of inselbergs, flanked by tropical and temperate vegetation zones in southern Africa, position them as potential refugia for flora from contrasting bioregions.

Inselbergs occur within the same rainfall range as the rest of the Namib Sand Sea but may receive relatively higher precipitation than the lower lying sand dunes surrounding them. This is thought to be due to the transfer of heat when warm air is forced to ascend the hills, leading to condensation and cloud formation. Other than convective rainfall mainly during summer, protuberance of the inselbergs from the erg landscape place them directly in the path of inland-swept fog from the ocean. As fog occurs all year round, the inselbergs consequently intercept some of this moisture, even though the frequency of fog diminishes further east.

By receiving more rainfall and catching additional fog, inselbergs have a comparatively wetter local climate than the rest of the Namib Sand Sea. This moisture is further augmented by a degree of influence from a winter rainfall climate characterised by high air humidity and mild ambient temperatures. The result is relatively abundant and diverse vegetation species composition and far greater net primary productivity in some micro-habitats of the inselbergs than on sand dunes. For an example of the diversity, the Hauchab series of inselbergs hosts a combination of species from both the palaeotropical Nama Karoo (72%) and temperate Succulent Karoo (26%) of the Greater Cape Flora. They thus feature taxonomic characteristics of the Namib Sand Sea as well as a wide range of southern Namib rocky habitats.

Increased runoff from the smooth rock surface channels water to the foothills of inselbergs and thus supports more plant species around the bases.

No endemic plant species are found specifically in the Hauchab inselbergs. This is probably due to efficient and long-range dispersal by the strong easterly, southerly and westerly winds in the Namib.
Sand Sea. In fact close to two-thirds of plant species found in the Hauchab archipelago are dispersed by wind, compared to only two-fifths of species found nearby on the Great Western Escarpment.

Seeds of 80% of the species, for which the area constitutes a distributional limit, are mainly wind dispersed. It is a particularly outstanding aspect that the inselbergs constitute the most extreme distributional range and disjointed occurrence for a high percentage of the species in the area. This is best demonstrated by *Hoodia ruschii* with the nearest population of this species 150 km away from the Hauchab area.

The most abundant plant species, mainly succulents, on and around foothills of inselbergs include among others: *Mesembryanthemum quereichianum* and *Sarcocaulon marlothii*. Some other succulent plant species, *Aloe asperifolia, Hereroa puttkamerana, Trichocaulon pedicellatum* and *Sesuvium sesuvioides*, are exclusively found in the crevices and cracks on the mountains.

**Riparian vegetation:** The ephemeral water courses flowing into the erg form oases sparsely marked by trees that nevertheless support a diversity of vegetation types within and on the edge of the Namib Sand Sea. Large quantities of pods, fruits and seeds are washed down the rivers from the interior of the country towards the Namib Sand Sea where they germinate to augment the floristic composition of river valleys within the erg. The flow of subsurface water in both the active and palaeo-channels of the watercourses recharges the...
water supply and supports the riparian vegetation. However, the force of flood water does not allow the establishment of vegetation within active river channels as trees and perennials are frequently uprooted and washed away.

Deterministic factors of species composition for plants in a specific segment of the riverbed include the points of flood origin and termination. This relates to where the seeds were picked up in the upper catchment and redeposited by floodwater as well as the duration of floods, which governs the volume and depth of moisture recharge in the soil. The roots of seedlings germinating and establishing in the riverbed need sufficient availability and access to moisture to develop fully into saplings. In this regard, the presence of suitable niches for germinating seedlings and water holding capacity of the soil in which they germinate along with the herbivory pressure from game all may exert a very strong selective force on the successful recruitment of plant species into the riparian community along ephemeral water courses flowing into the Namib Sand Sea.

The number of plant species growing along the ephemeral rivers ending in the Namib Sand Sea decreases towards the west, reflecting diminishing flood volumes, and varies from river to river and year to year. Most common is the camelthorn, *Acacia erioloba*, Namibia’s national tree. Other tree species may include, amongst others, *Maerua schinzii*, *Euclea pseudebenus*, *Ficus sycomorus*, Tamarix usneoides and *Salvadora persica*. Vegetation communities on the banks of river channels directly over the high water mark, commonly include *inter alia*, the shrubs *Adenolobus pechuelii* and *garipensis* with an understorey comprising the devil’s thorn weed *Tribulus terrestris* and *zeyheri* and aliens, wild tobacco *Nicotiana glauca*, castor bean *Ricinus communis*, thorn apple *Datura stramonium* and the Mexican poppy *Argemone ochroleuca*. Within the endpoints of the rivers, *Salsola tuberculata* is common, particularly at Tsondab Vlei. The herbaceous layer on the banks of ephemeral rivers may also include *Sesuvium sesuvoides*, *Zygophyllum simplex*, *Indigofera auricoma*, *Mesembryanthemum guerichianum* (ice plant), the spiny *Cladoraphis spinosa* (ostrich grass), and dense stands of the bitter bush *Pechuel-Loeschea leubnitziae*. 

**Figure 2.a.34:** Spiky *Blepharis obmitrata* releases its seeds slowly over several seasons (Gobabeb Centre)

**Figure 2.a.35:** Inhabiting dry water courses, *Orthanthera albida*, is pollinated by moths and the wind disperses its seeds bit by bit (Gobabeb Centre)
Riverine trees and shrubs growing in ephemeral rivers represent a ‘linear oasis’ through the Namib Sand Sea. Their role as a linear oasis varies widely depending on the lushness of the riparian vegetation they support. Larger trees provide nesting sites for vultures, birds of prey and other species. Smaller trees and shrubs harbour the smaller nesting birds. These smaller trees and shrubs tend to accumulate sand around their base and this provides a habitat for numerous small mammals, either digging into the ground or simply hiding in the shade and shelter provided. Invertebrates are also attracted to the vegetation of the linear oases. A study of the insect fauna of the lower Kuiseb River on the northern boundary of the Namib Sand Sea revealed 15 orders of 161 families and 719 species. In contrast to the sand sea, the fauna of the linear oases is almost totally non-endemic and widely distributed.

*Acacia erioloba*, a slow-growing hardwood tree renowned for its hardiness and longevity that occurs along river courses and pans and as ‘islands’ in the dune landscape, is a key element of the ecology along the eastern parts of the Property. It is the major nesting habitat for birds, from tiny pearled spotted owls *Glaucidium perlatum* occupying knot-holes, to the large nests of raptors and vultures. The communal nests of sociable weavers, *Philetarius socius*, resembling suspended haystacks, are a particularly spectacular example of bird nesting. These nests are habitats in themselves, hosting raptors, bats, large snakes, specialised nidicoles, and a whole host of invertebrates.

During the midday heat the spreading tree canopies offer welcome refuge to almost all fauna,
with herds of springbok, oryx or ostrich congregating under their shade. These animals contribute to the relative importance of *A. erioloba* trees by concentrating nutrient-rich dung patches under the trees. These visitors are also host to swarming multitudes of the near-endemic tampan species *Ornithodorus savignyi*. These soft-bodied ticks are adapted to feed only briefly, injecting salivary compounds that inhibit blood coagulation which may be fatal to non-native species. They soon drop off and bury themselves again between all the other soil fauna inhabiting the permanent shade under the trees. Of course, camelthorns also provides abundant browse, leaf litter, and nutritious seedpods that sustain complex consumer foodwebs, thus its recognition as providing extraordinary biodiverse habitat islands in the eastern Namib Sand Sea.

An unexpected consequence of these hardy trees growing at the pans and end-points of ephemeral rivers deep in the Namib Sand Sea, combined with the almost total absence of organisms with the ability to destroy hardwood, e.g. bacteria, fungi, and wood-feeding insects, is the skeletal remains of long-dead trees in areas where they were able to germinate and flourish in the past. Fossil stands of trees occur at the popular tourist destination at Dead Vlei, adjacent to the current Sossus Vlei, and at scattered locations elsewhere, e.g. abandoned end-points of the Tsondab River at Tsondabvlei. These dead trees are mute testimony to the dynamic changes imposed on rivers by the encroaching dunes. Apart from providing opportunities for spectacular photographs by amateurs and professional artists alike, they also provide information about past discharge volumes and changes in river courses.

Carbon dating of some fossil tree stands indicated that camelthorns may grow for more than 250 years, while recharge to the sites where they occur was abruptly abandoned some 600 years and 300 years ago at Dead Vlei (Tsauchab River) and Tsondabvlei (Tsondab River) respectively. The results confirm the potential of camelthorns to contribute to more detailed palaeoclimatic reconstruction in the Namib Sand Sea.

*Figure 2.a.38: Sparse *Stipagrostis sabulicola* in a dry decade (Gobabeb Centre)*
2.a.4 NAMIB SAND SEA FAUNA

Under a microscope, the dynamic windblown sand particles of the slipfaces and elsewhere in the Namib Sand Sea look like magnificent coloured marbles: hard, brilliant, irregular spheres with air trapped between them. Because the sparkling particles are so small, roundish, and hard, the sand flows like a liquid. The texture of the Namib sand, almost devoid of silt and clay particles, is believed to be one of the ecological determinants that resulted in the extraordinary endemcity of the Namib Sand Sea fauna. Despite popular belief, the overall diversity of organisms in the entire Namib Desert is comparable to that of any other desert. However, what distinguishes the Namib Sand Sea is the diversity of hyper and ultra psammophilous species as well as the level of endemicity (Table 2.a.2).

Animals in the Namib Sand Sea, unlike similar animal species in other dune deserts that have to dig burrows, can literally swim smoothly through the sand. Because they can rapidly dive into the sand and immediately disappear, the animals have access to a thermal haven wherever they are on slipface or dune slope surface. By swimming down to a depth of about 300 mm, they can reach a comfortable temperature, which does not vary between day and night, and varies only about 10°C between summer and winter. So slipface-dwelling animals can stay active on the surface during the day until the last moment, and then swiftly escape the hot sand and burning sun. A similar mechanism can be used on the dune slopes, although the sand is more compacted there and the ‘swimming’ takes a bit more effort and time. On the other hand, nocturnal animals can use the warmth of the sand to escape the cold nights too, and both diurnal and nocturnal animals can dive to avoid predators.

The animals could not use these amazing thermal havens, or the refugia safe from predators beneath the sand, if they could not breathe below the surface. The air trapped between the particles of small, roundish, hard sand grains, even half a metre below the surface, is almost as pure as surface air. No one knows how long it has taken the air to diffuse down into the sand. It is not replaced quickly if used up. However, by moving around even slightly amongst the granules under the sand surface, which the ‘swimmers’ can do by lateral
swimming, the animals can find a sufficient supply of pure, life-sustaining air wherever they are in their sandy habitat.

The animals which seem to benefit most from the spectacularly unique properties of the Namib sand particles are invertebrates. Many species of beetle can forage for long periods on the sand surface during the day because they can escape so easily if and when they get hot – or predators appear. However, much larger animals can use sand swimming locomotion too. Lizards can fold their forelegs against their bodies and writhe through the sand using powerful abdominal muscles and their tails. As reptiles, lizards have low metabolic rates, so their sub-surface swimming and ability to live below the sand is not as surprising as that of an insectivorous mammal, the Namib golden mole *Eremitalpa granti namibensis*. This blind voracious ball of fluff, except for nocturnal surface sorties, spends its life below the surface of the Namib Sand Sea. The mouse-size mole uses its spade-like forelimbs, extraordinarily powerful for an animal of its size, to paddle through the sand, down to a depth of 1 m. Unlike most ordinary mammal species, it is a poikilotherm – its temperature varies with its environment just like a reptile – which helps it match its metabolic rate to the oxygen levels in the unique, well oxygenated Namib sand.

The extraordinary conditions supporting life beneath the dunes, combined with the frequent fogs bringing moisture to the fauna and flora, represent much of the foundation of the astonishing environment afforded by the Namib Sand Sea. As a consequence, animals living in the Namib Dune Sea have adapted to all the various habitats presented by this diverse landscape (Table 2.a.2). Although some take advantage of the surface, a vast majority has found some way to live part or all of the time in the extraordinary conditions available beneath the sand surface.

<table>
<thead>
<tr>
<th>Plants</th>
<th>Arachnids</th>
<th>Insects</th>
<th>Reptiles</th>
<th>Mammals</th>
<th>Birds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand sea spp.</td>
<td>15</td>
<td>44</td>
<td>207</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Endemic spp.</td>
<td>8</td>
<td>37</td>
<td>108</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>% Endemism</td>
<td>53%</td>
<td>84%</td>
<td>52%</td>
<td>44%</td>
<td>17%</td>
</tr>
</tbody>
</table>

As this document only focuses on some of the fauna occurring in and/or frequenting the Namib Sand Sea, full animal species lists known to occur in the Property have been included in Annex 11 to 18 respectively: invertebrates and protista (Annex 11); arachnids (Annex 12); insects (Annex 13); fish, amphibians and reptiles (Annex 14); mammals (Annex 15), birds (Annex 16), Sandwich Harbour
Evolution, endemism and sand: The large number of sand sea endemics with their specialised adaptations to live in sand, which does not allow them to successfully colonise any other habitat except unconsolidated sand, are labelled ‘ultrapsammophilous’ and ‘hyperpsammophilous’. This refers to the fact that they are restricted to sand primarily through their evolution of morphological and behavioural attributes such as specialised structures for movement (feet, musculature, external features of feet and other extremities, body shape, and resistance to abrasion). These species, which include spiders, scorpions, diverse insects, reptiles and mammals colonise new habitats by migrating within fast moving barchan dunes along windswept corridors or stretches of unconsolidated hummock dunes where slipfaces are common. This distinguishes the Namib endemics from other species that merely inhabit and prefer sandy substrates (psammophiles). Ultrapsammophilous species are unable to live in any other habitat other than unconsolidated sand of slipfaces. Hyperpsammophilous species only occur in habitats where unconsolidated sand is a feature of the sandy substrate and grass-covered dunes. A more detailed overview of the ecology and evolutionary processes of the Namib Sand Sea can be found in Annex 5.

Two suites of Namib Sand Sea fauna can be biogeographically distinguished – a coastal suite and an inland or eastern component. However, separations between the distribution limits of closely related endemics are relatively fluid and often have considerable overlap. Range limits also vary considerably between different sets of species, mostly within evolutionary lineages, where coastal and inland representatives can be distinguished. This biogeographical attribute became apparent when inventorying showed that endemics from the inland parts of the Namib Sand Sea are always absent from the coast. The opposite, however, is not true as

Figure 2.a.42: *Trianthema hereroensis* distribution is closely linked to the inland boundary of coastal fog. Endemic fauna are more mobile, but in various groups closely related coastal and inland species or subspecies have evolved (Gobabeb Centre)
predominantly coastal species may range far into the interior on dune crests and slipfaces, often occurring sympatrically with their habitat equivalents towards the east. Generalized zoogeographical zonation of the Namib Sand Sea is therefore not feasible.

A small number of Namib Sand Sea endemics are only found towards the north in the fog-dominated coastal zone, but do not occur in the seemingly similar sand sea habitat in the south. They probably reflect evolutionary processes, though the past genetic barriers that may have resulted in speciation, or the factors that prevent those species from migrating south is not yet clear. It has been shown that some Namib endemics migrate within fast-moving barchan dunes, i.e. their habitat migrates while they remain stationary, which suggests that the dominant onshore wind may have a biogeographic effect. Along the eastern Namib Sand Sea, which historically has been more accessible for research, the sand sea habitat is relatively homogenous with no latitudinal gradients in Namib Sand Sea endemics. Some species occurring only in the southernmost part of the Namib Sand Sea are, however, endemic to dune habitats in the winter-rainfall Succulent Karoo Biome further south.

![Figure 2.a.43: Hadogenes scorpions that live in narrow cracks, are some of the ‘living fossil’ populations that survive on inselbergs surrounded by dunes (Gobabeb Centre)](image)

The inselbergs and eastern rocky habitats of the Namib Sand Sea have a biogeographic role as both phylogenetic and geographical relict species have been recorded from those isolated habitats. In the case of phylogenetic relics, or ‘living fossils’, the lineages they represent are extinct elsewhere in southern Africa or the continent. Although not endemic to the Namib Sand Sea, relict species at refugia within the nominated Property are an important component, as the relative isolation of these habitats shields them from more successful competitors. Similar to the phylogenetic relics, geographic relics occurring on the inselbergs and eastern rocky habitats are also not endemic to the Namib Sand Sea, but more widely distributed in mountainous habitat towards the north and along the Western Escarpment. The known populations of these species represent geographic isolation resulting from regional climatic changes. Molecular phylogeographic research on relict populations of several species that became geographically isolated in the past, now living immediately adjacent to the Namib Sand Sea, have proved their importance for understanding how populations that became isolated through climatic changes may survive.

The evolutionary adaptations that resulted in the endemcity and specialised diversity of the Namib Sand Sea are exceptionally clear. The range of Namib Sand Sea endemics furthermore offers some of the clearest known examples of progressive evolution in very different lineages of closely related species. Natural selection of specific attributes that would clearly benefit populations under the specific environmental attributes of the Namib Sand Sea, which demonstrably has led to speciation,
can be readily identified. The evolutionary ancestors of the Namib Sand Sea endemic lineages are still present in the region, which allows reconstruction of likely evolutionary pathways. Phylogenetic reconstruction of evolutionary relationships between endemic species in such diverse groups as reptiles, fishmoths, *Comicus* dune crickets, flightless *Scarabaeus* dung beetles, and a range of tenebrionid beetle genera (e.g. *Brinckia*, *Lepidochora*, *Onymacris*, *Zophosis*) has repeatedly shown similar results.

There are clear south to north evolutionary trends in specialist species inhabiting the dune fields of the greater Namib Desert, and specifically the Namib Sand Sea. This confirms the biogeographical and evolutionary consequence of the dominant unidirectional wind regime, though the particular attributes differentiated are not related to wind itself. Within the Namib Sand Sea, from south to north, the more plesiomorphic (or ancestral) species of endemic lineages occur in the southern coastal areas towards Lüderitz, with more derived (or apomorphic) species occurring further north towards the Conception Bay and Sandwich Harbour areas. Similarly, from west to east, multiple evolutionary terminations are derived from coastal species (or subspecies) leading to close derivatives towards the interior. This latter pattern also indicates the significance of reduced access to fog moisture in the evolution of Namib Sand Sea endemics and the subsequent distribution of species.

Most of the evolutionary phylogenetic reconstructions to date have been based on comparative morphology, though exploratory molecular analysis has confirmed very similar trends. As can be expected, speciation trends based upon morphological comparison cannot explain the exceptional physiological and behavioural adaptations of the Namib Sand Sea endemics. Morphology also does not show possible northwards speciation trends in dunes along the eastern margin of the sand sea. Unpublished molecular analyses indicate, however, that the observed trend for populations of coastal species to range far into the interior may relate to the genetic diversity of those species, while distinct differences may occur between different populations in species of the interior. Similarly, the exploratory research indicates that molecular genetics may explain the evolutionary ancestry of some of the behavioural and physiological characteristics in Namib Sand Sea endemics. Molecular research methodologies have yet to be applied more widely to evolutionary and biogeographical analysis of the Namib Sand Sea although they hold promise to explain how the Namib Sand Sea’s extraordinary degree of endemcity, which is so different from most other deserts, has evolved.
Overall, the fauna of the dune system is typically desertic and is composed almost entirely of insects (Table 2.a.3), arachnids and reptiles with only a few unique birds and mammals venturing into this inhospitable landscape for any length of time. Similar to the vegetation, the fauna of the Namib Sand Sea cannot be described by numbers of species alone – although these are not inconsiderable. Instead, it is a matter of astonishing adaptations to the array of habitats and their extraordinary characteristics. Although certain important morphological adaptations are exhibited by some of these animals, particularly to locomotion and life in a sandy medium, the more remarkable adaptations are of a behavioural and physiological nature. The descriptions below highlight just a few of the astonishing animals inhabiting the Namib Sand Sea and their amazing characteristics.

Table 2.a.3: Insect species richness in the Namib Sand Sea (from Annex 13)

<table>
<thead>
<tr>
<th>Nominated area</th>
<th>Exotics (aliens)</th>
<th>Desert endemics (excluding dunes)</th>
<th>Sand sea species</th>
<th>Sand sea endemics</th>
<th>% Sand sea endemicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1388</td>
<td>8</td>
<td>92</td>
<td>207</td>
<td>108</td>
<td>52%</td>
</tr>
</tbody>
</table>

Detritivores: Yet another remarkable aspect of the Namib Sand Sea is the number of animals that consume wind-blown detritus – seeds, bits of dry plants, fragments of dead invertebrates - as their main or only source of energy. Their contribution to the ecological dynamics of the Namib Sand Sea is truly amazing. In essence, the animals involved in eating wind-blown detritus – beetles, termites, lizards – are largely catalysts of decomposition. They control the rate at which this dried organic matter is eaten and fragment it into smaller pieces. However, it is actually the micro-organisms in the detritivores’ guts that truly do the decomposing, and it is they that direct the flow of energy and nutrients through this arid, wind-swept, dry fluvial ecosystem.

Gut microbes live in and maintain a relatively stable environment of regulated temperature, pH and moisture. Therefore while it is true that decomposition by free-living microbes in desert sand and litter is probably limited and extremely erratic, there is fairly continuous decomposition going on in the guts of detritivorous insects. The ‘gut ecosystem’ helps to process compounds that are typically difficult to break down because of their chemical complexity, such as cellulose (the tough part of most plant tissue) in the remains of desert plants swirling around the dune habitats.

Tenebrionid beetles: The high diversity of endemic tenebrionid beetles has always been one of the spectacular attributes specific to the Namib Sand Sea within the broader desert environment (Table

Figure 2.a.45: The endemic tenebrionid beetle *Calognathus chevrolati* is an unusual global example of a detritivore that evolved into a predator (Gobabeb Centre)
2.a.4). Over 90 species of endemic tenebrionid beetles are to be found in the Namib, with at least half of them restricted to the matchless habitat provided by the sand dunes. They are almost all detritivores – consuming wind-blown detritus – in some way gaining their moisture from the Namib fog. The remarkable exception to the rule is Calognathus chevrolati, an endemic tenebrionid beetle that has evolved into a predator. These ubiquitous beetles are joined by a variety of other endemic invertebrates ranging from dung beetles, solifuges and fishmoths to termites, spiders and weevils.

Table 2.a.4: Tenebrionidae (Coleoptera) species richness in the Namib Sand Sea (from Annex 13)

<table>
<thead>
<tr>
<th>Nominated area</th>
<th>Exotics (aliens)</th>
<th>Desert endemics (excluding dunes)</th>
<th>Sand sea species</th>
<th>Sand sea endemics</th>
<th>% Sand sea endemicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>131</td>
<td>0</td>
<td>44</td>
<td>61</td>
<td>50</td>
<td>82%</td>
</tr>
</tbody>
</table>

Tenebrionid beetles are a diverse group of insects characterised by being flightless with fused elytra. Most in the Namib Sand Sea are active during the daytime although avoiding the hot midday sun; a few are crepuscular to nocturnal. Some are fast runners, e.g. the endemic Onymacris plana, moving at more than 85 cm per second and, at the same time, experiencing exercise-induced cooling under high radiation in the Namib. Others emerge from beneath the sand surface to take advantage, in various ways, of the moisture bearing fog winds of early morning. One species, the endemic Onymacris unguicularis, may take up to 40% of its body weight in one foggy event. Many actively forage on the slipfaces in the afternoon as wind-blown detritus swirls over the steeply inclined sand surface. A few, e.g. the endemic Onymacris laeviceps, climb up onto the flowering grass stems to feed on pollen and fresh seeds. Other adaptations to the Namib Sand Sea include production of a waxy bloom on the cuticle, e.g. the endemic Zophosis mnizechi, Z. fairmairei, and Onymcaris rugatipennis rugatipennis, either to reduce water loss or to reflect incident radiation.

The abundant tenebrionid beetles track their food availability and hence the very variable rainfall of the Namib Sand Sea. Females, on average, lay an egg every second day. The vast majority of these eggs soon desiccate in the dry sand where they are laid. But, if they are laid at the base of a Stipagrostis sabulicola grass clump or Trianthema hereroensis plant where fog water accumulates, or if they are laid during an exceptional rainy season, the eggs will hatch and development will continue. Depending on the time of year the eggs are laid – influenced by temperature experienced as well as food and water availability – they may hatch as quickly as 8 weeks or require 10 months to reach maturity.

Figure 2.a.46: Only a few sand sea endemics such as Onymacris plana tenebrionid beetles have adapted to being active towards the middle of the day when surface temperatures are lethally hot (Gobabeb Centre)
Figure 2.a.47: Physiological adaptation to conserve moisture and reduce desiccation includes the evolution of protective layers such as wax blooms. Wax filaments exuded by special glands cover the surface and reflect heat. The more arid, the more wax is extruded (electron micrograph after McClain, Gobabeb Centre)
**Onymacris unguicularis**, the shiny black head-standing, fog-basking beetle is a unique inhabitant of the coastal reaches of the Namib Sand Sea. Usually active in the afternoon when the wind is blowing fresh detritus onto the dune slipface, it also emerges on foggy mornings while it is still dark to slowly make its way to the dune crest. There it faces into the fog-bearing wind, its body serving as a fog condensation unit. This species, and its close northern relative, the black-and-white *Onymacris bicolor*, have evolved a fog-capturing technique unknown in other deserts of the world.

The genus *Lepidochora*, with at least four species endemic to the Namib Sand Sea, can be called a ‘fog-collecting construction-engineer’ of unusual habits. All these species have a disc-shaped body that allows them to rapidly dive into and swim under the loose sand. It too normally feeds in the afternoon or evening as wind swirls across the dunes and slipfaces bringing fresh detritus. However, early on foggy mornings before it gets light, when the fog arrives in the desert and the surface grains are wet, these beetles emerge from beneath the sand and start constructing a trench through the wet surface grains. The raised edges of the trench stand out above the smooth sand surface and capture moisture blowing past.
After constructing such a fog collector, the beetles then return along the walls of the trench and drink the captured water from between the sand grains. These beetles, active in the evening and at night, and more sensitive to light than some of the other species, have yet to be filmed undertaking their engineering feats.

Termites: Termites are the under-recognised consumers of plant material in African savannas, and have been described as ‘keystone species’ and ‘ecosystem engineers’ that actively contribute to ecosystem functioning. They play a similar role in the Namib Sand Sea. It is surprising to learn that termites of several families and living in different habitats are found in the sand sea. Termites are generally soft-bodied insects that lack adaptations to desiccation that usually exclude them from extreme aridity such as found in the Namib. These species are predominantly the widely distributed harvester termite *Hodotermes mossambicus*, which is common in the interdunes of the sand sea and whose tracks are commonly found in the ancient Tsondab Sandstone underlying the active dune sea, and a subterranean sand dune specialist species *Psammotermes allocerus*.

Termites are particularly important in nutrient turn-over and decomposition processes in the Namib Sand Sea. First estimations suggest that *Psammotermes allocerus* could probably be the most significant consumer of detritus in the Namib dunes. Its burrows are visible as eroded tubular galleries projecting just above the sand surface, at any place on a dune. They live underground within the sand sea, not as swimmers but as tunnel constructors. Contorted, prickly hedgehog - looking cemented sand structures found at the base of some dunes are the products of these termites forming their ‘carton’ around clumps of detritus or dead plants. Their brood chambers, constructed of sand grains glued together forming a smooth-surfaced oval compartment about 100 mm in diameter, can also be found eroded out at the edges of dunes. Generally their nests are metres below the sand surface and the only evidence of their presence is their foraging tunnels projecting above the sand. The great depth of moisture in the sand dunes is what causes the termites to locate their nests so far below the sand surface and to frequently forage in the slightly moist sand surrounding plant roots.

Termites are underground detritivores while adult tenebrionid beetles and fishmoths are their aboveground counterparts. While foraging on the surface, the beetles and fishmoths select the richer elements of the detritus such as the seeds and broken bits of insect matter. In contrast, the termites forage on the cellulose of the plant leaves and roots leaving the more nutritious morsels behind. This selective feeding behaviour tends to sequentially concentrate components of the detritus that are covered and then uncovered by the wind-blown sand.
**Fishmoths:** A group that falls firmly in the detritivore pigeonhole is fish moths or silver fish, particularly the lepismatid family, of which there are at least fifteen species in the Namib Sand Sea, thirteen endemic to the central Namib dunes (Table 2.a.5). Their differing shapes and sizes reflect the specific microhabitats they occupy: spines on the legs become longer, stronger, more numerous and more like a comb structure in parallel with their preference for loose sand, and their bodies become more ‘fish-shaped’ in the sand-swimming forms.

<table>
<thead>
<tr>
<th>Nominated area</th>
<th>Exotics (aliens)</th>
<th>Desert endemics (excluding dunes)</th>
<th>Sand sea species</th>
<th>Sand sea endemics</th>
<th>% Sand sea endemicity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>13</td>
</tr>
</tbody>
</table>

*Table 2.a.5: Fishmoth (Order Thysanura) species richness in the Namib Sand Sea (from Annex 13)*

*Ctenolepisma terebrans*, with its long slender shape, lives on stable, vegetated parts of the dunes and in interdune gravel plains and is most common in the Namib Sand Sea. *C. pauliani*, similarly shaped but with leg spines arranged in a comb, is common in vegetation hummocks but is also found on compacted bare sand. Two species that are active on the surface of the slipface and dune crest are *Mormisma wygodzinskyi* and *Sabulepisma multiformis*. They have short, rounded bodies and the hind legs are long for running rapidly over the unconsolidated sand. They dive under the sand surface when requiring shelter. Two species that are active mostly under the surface are *Namibmormisma muricaudata* and *Hyperlepisma australis*. They both have a hydro-dynamic shape, broad at the head, a tapered, humpbacked body and short appendages, apparently for sand swimming. Finally, *Swalepisma mirabilis* also lives on the slipface but it is active during cold, calm early morning fogs. Although common and apparently more numerous than in other dune deserts, much remains to be found out about these unique, important detritivores and the role they play in nutrient cycling in the Namib Sand Sea.

The autecology of the whole constellation of other endemic species, such as, *inter alia*, the *Comicus* crickets, the *Julodis* jewel beetles, *Leptostethus* weevils, *Scarabaeus* flightless dung beetles, *Apterogyna* wingless wasps, scale insects, *Pamores* antlions, and many others is largely unknown.

*Figure 2.a.51: A fishmoth Ctenolepisma terebrans* digging a shelter. Other closely related species are highly adapted to swim into loose sand of slipfaces (Gobabeb Centre)
**Predatory invertebrates:** Small predators of the Namib Sand Sea take advantage of the special conditions in which they live – such as short windows of time during which it is possible to forage every day, the bare fluid-like substrate they can swim through or the loose surface across which they must move (Table 2.a.6). They display a variety of behavioural, morphological and physiological adaptations that enable them to cope in this habitat with its completely unique characteristics.

**Spiders:** All of the conditions that typify desert sand dunes – sparse vegetation, loose substrate, strong winds and a dry and thermally fluctuating surface climate – do not favour aerial web-building spiders. In this habitat, nocturnal wandering spiders predominate, and they have specialised behavioural and morphological traits that enable them to burrow in and hunt on sand. Twenty species of endemic sand-dwelling spiders are known from the Namib dunes (Table 2.a.6). A further twelve species also live in the dunefield but are not truly sand-loving; instead, they live on and under plants and stones. Of the dune-living species, the most well-known is the ‘dancing white lady spider’, *Leucorchestris arenicola*, an endemic sparassid or huntsman spider.

**Table 2.a.6: Arachnid species richness in the Namib Sand Sea (from Annex 12)**

<table>
<thead>
<tr>
<th>Nominated area</th>
<th>Exotics (aliens)</th>
<th>Desert endemics (excluding dunes)</th>
<th>Sand sea species</th>
<th>Sand sea endemics</th>
<th>% Sand sea endemicity</th>
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<tbody>
<tr>
<td>138</td>
<td>4</td>
<td>15</td>
<td>44</td>
<td>37</td>
<td>84%</td>
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</tbody>
</table>

A striking feature of spiders found in the Namib Sand Sea is their large size and robust appearance. *Leucorchestris arenicola* measures up to 14 cm across with its legs outstretched, and weighs up to 5 g. This is the largest of the dune spiders, but three-quarters of adult Namib dune spiders are larger than 5 mm, a higher proportion than in most other habitats. Of particular note is the armament of strong spines on the legs and pedipalps, as well as the brushes of modified hairs on the legs. These appear to be an adaptation to walking on loose sand and burrowing into it, and they may function in communication by picking up vibrations in the ground. Strong setae, spines and claws on the legs and pedipalps also help in digging.

**Figure 2.a.52:** The white lady spider *Leucorchestris arenicola* is renowned for its ‘dancing’ behaviour when threatened by a predator (Gobabeb Centre)

Most of the sand-dwellers live in burrows with some kind of a silken door or screen over the entrance. This allows them to penetrate below the top 6 cm of sand that gets dangerously hot in midsummer, and in fact more than half of all Namib spiders dig deeper than 20 cm, where daily temperature fluctuations are minimal. For this, their silk-producing spinnerets have long spigots (‘fingers’) that are pushed into the sand to interweave the grains, forming little nodules that,
repeated in rings along the length of the burrow, stabilise the sand and keep the burrow open. This works even in the very loose, unconsolidated sand on a slipface, which is the preferred burrowing site of the wheel spider Carparachne.

Leucorchestris arenicola, the dancing white lady spider, is confined to the Namib Sand Sea, but is absent within about 20 km of the coast probably due to the windy and foggy conditions there. It constructs a silk-lined burrow in the sand, the top of which is covered over with a mat of silk and sand that serves as a trapdoor. The obliquely descending burrow provides refuge from the temperature extremes on the surface, but is primarily designed as an ambush site. The spider positions itself upside-down in the tunnel, ‘listening’ with its feet for vibrations on the sand surface that will trigger it to rush out and grab its prey. It seizes its victim and bites immediately, the strong fangs penetrating even the tough external covering of beetles. As soon as the prey stops moving, it is dragged into the burrow and consumed.

Leucorchestris is a big animal and makes a conspicuous imprint on the sandy surface of its habitat. The most conspicuous of these is made when it ‘drums’ by rapidly tapping all 8 feet in quick succession, leaving a print of each of the tarsi and of its own body in the centre, with the head and body portions easily identifiable. These tracks have been very useful in recreating and mapping out the movements of individual spiders.

From seeing such tracks on the dunes, early spider researchers in the Namib discovered that the white lady spider devours the delicate and defenceless web-footed gecko, Palmatogecko rangei. While this has been confirmed by more detailed work, in fact beetles form the bulk of its diet, followed by moths and spiders of its own kind. On average, prey items are about one-third of their own mass, but they do occasionally take prey that is larger than they are.

Cannibalism is not uncommon in spiders and scorpions. In Leucorchestris, young spiders eat their siblings or, if conditions are bad, the mother eats her own offspring. In Seothyra, the offspring eventually eat their mother as they grow in the maternal nest.

The spiders generally stay indoors, so to speak, on cold nights (ambient temperature less than 15°C), in foggy conditions that make the trapdoor clammy, on nights with a bright moon or with a strong wind. They become quiescent in cold weather, even torpid, and eat less in the winter. In windy conditions it is probably difficult for them to detect prey on the surface against the background noise.
of moving sand grains, and they probably also get battered or risk the trapdoor being damaged if they venture onto the surface. Being white they are conspicuous on the sand surface and activity is less on brightly lit nights probably to avoid predation. Surface activity is noticeably less in the nights of each week on either side of a full moon. The morning inspection of tracks after these nights shows that the spider usually walks less than 20 cm from the burrow and then returns – a kind of ‘check-up’ of conditions before returning to safety.

White lady spiders generally occupy the lower, more stable dune slopes in preference to higher up on the dunes. They are territorial, defending an area with a radius of about 3 m from the burrow. With burrows sometimes less than 2 m from each other, it is obvious that a spider venturing out onto the surface is taking a great risk by entering the territories of its neighbours. Not surprising, then, that they confine themselves to the area within about one metre of their burrow most of the time.

Males, however, undertake long journeys far from their burrows in search of mating opportunities. Males may walk more than 300 m in an outward, wandering path that takes them up to 50 m from their burrow in a straight line distance. The males move cautiously and deliberately advertise their presence by drumming every so often on the desert floor. It may be a means of communicating to other males in their burrows or it could be an advertisement call to females, notifying his availability for mating. Such precise orientation over long distances is exceptional and is facilitated by the unique characteristics of the Namib Sand Sea.

At about 70 days old the white lady spiderlings move out of the maternal nest and build their own burrows close by. They must survive great risks posed by other spiders of their own kind and predators such as gerbils and owls. From a clutch of about 80 eggs, about 8 spiderlings will emerge and disperse, and of these, one will probably make it to adulthood at about 24 months of age. Thereafter, males survive for another one or two months, and females usually for more than another 6 months. Compared to other spiders, this is considered slow development and a long lifespan.

Carparachne aureoflava: Another huntsman spider, the golden wheel spider, is so named from its ability to roll its legs into a ball, take on the shape of a disk, and cartwheel freely down a slope. This it does when it is exposed by the digging actions of its main predator, a pompilid wasp. Although there are other animals that can roll into a ball, such as hedgehogs and pangolins, this is the first confirmed use of the wheel by an animal. A burrow situated near the top of a slope offers a better chance of escaping from a wasp this way, as the spider can roll further and can quickly get out of the

Figure 2.a.54: Carparachne aureoflava exploits gravity to cartwheel down a dune slope by contracting its legs and launching itself sideways (Gobabeb Centre)
visual and olfactory range of the wasp. A spider that opts to wheel away can almost always escape from a wasp, but one that resorts to running – which it cannot do for longer than a few seconds – is doomed to become the wasp’s prey.

**Seothyra:** Wandering and hunting on the surface might appear to be the only way for a spider to live in a habitat of loose shifting sand. But there is a kind of web-building spider that is locally abundant in the Namib dunes. Its web is embedded firmly in the sand. This is the only web spider of the central Namib that is obligatorily psammophilous (forced to live only in sand), and it can reach densities of up to 50 webs per square metre in favourable places in the dunes.

*Seothyra henscheli* makes a sticky capture web in loose, shifting sand. On the surface, the trap is visible only as four shallow depressions, which give the owner its common name of buck-spoor spider. This masks an elaborate silk-lined roof, chamber and tunnel in which the spider hides. The lobes are lined with sticky silk and form a capture web. As initially described: ‘When a hot-footing ant stumbles into the trap, the spider erupts into action. It rushes up to the edge of the mat, grabs the ant by a leg, and pulls it down onto the mat. There the ant becomes enmeshed in very fine, sticky silk that hooks its fur like velcro. A few seconds later, the spider vanishes down the cool burrow, leaving the ant to fry on top. Twenty seconds or so later the ant succumbs and the spider reappears to retrieve it.’ Yet another unique adaptation taking advantage of unique characteristics of the Namib Sand Sea.

In this windy habitat, the web needs to be maintained to stay functional. In the morning the spider flicks the edge of the capture lobes to dislodge sand that has collected there, and occasionally adds new sticky silk to the lobes. When the spider outgrows its tunnel, it builds a new one contiguous with the old but still keeps the original chamber and surface mat. This avoids the necessity of going onto the sand surface, and reduces the amount of rebuilding it must do. Storm winds do sometimes inundate the webs altogether or scour them out, from which the spiders may not recover.

Male *Seothyra* are brightly coloured and, during the mating season, walk around on the sand surface during the day. In the vicinity of Gobabeb they resemble the dune ant *Camponotus detritus*, while elsewhere they resemble the ant *Camponotus fulvipolus* or the mutillid wasp *Dasylabris*. All of these are aggressive species that are either not preferred prey items or actively avoided by other predators, and it is likely that males probably derive protection by mimicking these noxious insects.

*Seothyra* is a ‘sit-and-wait’ predator which enables it to continue foraging when conditions on the sand surface are extreme. While its ambush site is ready and sand surface temperatures reach up to
75°C, the spider is ‘sitting and waiting’ in its thermal refuge where, at the bottom of the burrow, the temperature rarely exceeds 35°C. Even though it avoids the hot surface, Seothyra has possibly the highest thermal tolerance of any spider species. It needs it because, with a body mass less than 300 mg, it heats up very quickly when it goes out onto the surface to handle prey that has become entrapped. When doing so, it occasionally has to shuttle back into its burrow to cool off. The high thermal tolerance enables the spider to forage efficiently at high ambient temperatures. Conversely, when ambient temperatures are low, the burrow is relatively warmer, enabling Seothyra to keep active and vigilant during cool conditions too.

Webs are constructed on gentle dune slopes, and characteristically occur in ‘colonies’ or high-density patches. When spiderlings disperse from their maternal nest they simply remain near their mother’s site. This may explain why, even though densely populated sites are characterised by abundant ants, there are also spiders living in poor sites when good sites are vacant nearby. When food is abundant, spiders put on weight and reduce their activity. In contrast, when food is limited, hungry spiders increase their foraging effort by increasing the trapping area of the web, but they rarely relocate.

*Camponotus detritus:* Take a walk anywhere in the dunes of the central Namib and you will be met by an aggressive ant, antennae and body in full alert, lunging forward at you with jaws wide open. Its abdomen is tucked under its body and projected forward to squirt formic acid while setting off all its neighbours to join the offensive. This is the endemic *Camponotus detritus*, the only ant species in the western dunes of the Namib Sand Sea and the dominant one in the east, where it shares the habitat with other species. Despite, or maybe because of, being so conspicuous on the bare sand, predators are deterred from eating these ants owing to the unpalatability of the formic acid they contain and readily spray on their enemies. Minor workers, usually encountered on the dune surface, are fairly large (8-14 mm).

Each colony has a few nests but only one queen. When the mother nest becomes too small, workers excavate a daughter nest nearby and carry the brood across the sand to the new nest. The nests are simple affairs, just tunnels and chambers constructed among the roots of perennial plants on the dunes, most usually under *Trianthema* or *Stipagrostis* tussocks. Sand under the plants is usually firm and the roots provide a framework for the interconnecting passages. A colony consists of up to five separate nests that may be close together or up to 100 m apart. But they all make up the territory of a colony and any individual venturing into the territory of a neighbour is likely to be attacked and dismembered very quickly.

![Figure 2.a.56: A worker of the endemic ant *Camponotus detritus* foraging (Gobabeb Centre)](image-url)
Ant nests excavated at any time of the year contain eggs and winged reproductives, as they breed all year round. They can do this because of their ever-present source of food, honeydew, which is excreted from endemic plant-sucking scale insects and endemic aphids on dune plants. This is a largely untapped food resource in the dunes, and a liquid one, so the ants are never short of moisture. While these ants concentrate most of their foraging activity on gathering honeydew, they also take other foods opportunistically. Workers are sometimes seen eating pollen and nectar from *Trianthema* flowers, and they readily take dead and defenceless animals found on their meanderings.

The critical factor limiting the number and distribution of *Camponotus* colonies remains the availability of honeydew. *Camponotus* are least abundant in the dunes near the coast, most abundant in the central dunes, and of intermediate abundance inland. This density pattern closely parallels the distribution of scale insects.

*Camponotus detritus* is an extremely successful ant species in the dunes of the Namib Sand Sea. Although sand surface temperature gets very high, the ant’s legs can lift it about 5 mm above the surface so it experiences a temperature about 10°C lower than the surface. On top of this, it takes in mostly liquids, and frequently shares this food through trophallaxis, a kind of mouth-to-mouth contact during which food is passed from one individual to another. Groups of *Camponotus* have lower rates of desiccation than solitary individuals. So in short, this species is well adapted to the Namib Sand Sea with plentiful year-round food supply, temperatures it can handle and, over most of its range, few other ants to compete with.

Figure 2.a.57: Voracious predation in the Namib Sand Sea: an asilid robber fly feeding on an endemic *Leptostethus* weevil (Gobabeb Centre)
Reptiles

For the eight different types of endemic, dune-dwelling reptiles, the ability to quickly submerge and swim through the loose, aerated sand is critical. They need to swiftly escape from predators or from heat in a wind-swept, sun-baked habitat where cover is sparse and sand surface temperatures climb uncomfortably high. The two options are sand-swimming and sand-burrowing. Sand-swimmers either dive head-first into the sand or use low-amplitude, high-frequency, lateral undulations to disappear into it. Moreover, they usually show modifications for under-sand breathing. In comparison, sand-burrowers usually have short bodies poorly constructed for lateral undulations but their feet are modified for digging. These are usually active at night. Others such as the legless lizards live their entire lives beneath the surface moving through the fluid sand. Species richness of reptiles in the sand sea is summarised in Table 2.a.7.

Table 2.a.7: Reptile species richness in the Namib Sand Sea (from Annex 14)

<table>
<thead>
<tr>
<th>Nominated area</th>
<th>Exotics (aliens)</th>
<th>Desert endemics (excluding dunes)</th>
<th>Sand sea species</th>
<th>Sand sea endemics</th>
<th>% Sand sea endemicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>0</td>
<td>6</td>
<td>17</td>
<td>7</td>
<td>41%</td>
</tr>
</tbody>
</table>

Among desert geckos worldwide, the most highly specialised and structurally modified species are those that live largely (hyperpsammophilous) or entirely (ultrapsammophilous) on sand dunes. This habitat is not uniform and their adaptations must cope with slipfaces, windward and leeward slopes, all surfaces that differ in terms of sand compaction, as well as the sandy interdune valleys. Modifications for walking on sand include fringes on toes, spinous, swollen soles, and webbed feet. Extensions of the scales to form comb-like fringes along the sides of the toes act like snow-shoes, increasing the surface area of the foot and preventing the animal from sinking into the sand. There is a direct relationship between fringe size and soil softness in the barking geckos, *Ptenopus*. The longest fringes are found in *Ptenopus kochi*, which inhabits riverbeds and interdune areas with very fine sand and silt. The common barking gecko, *P. garrulus*, has shorter toe-fringes.
Toe-fringes are taken to the extreme in the Namib obligate dune dweller, *Meroles anchietae*, in which the fringes in adjacent toes are in contact and even overlap. For *Meroles* (formerly *Aporosaura*), exclusion of fine sand particles is probably improved with the exaggerated fringes, making it more efficient in underground movements.

webs between the toes perform the same function as toe fringes, by increasing the surface area that presses against the sand while propelling the animal forward. This was originally used to explain the webbed feet of *Palmatogecko rangei*. Although the *Palmatogecko*’s webbed feet no doubt assist its movement on a sandy surface, it is more likely that the webbing and associated bone, cartilage and muscle structure evolved for the feet to function as sand shovels. The sand at the dune base and on windward slopes is compacted and has considerable bearing capacity, enough to support the weight of a person, even a car. *Palmatogecko* is able to dig tunnels into the hard sand in this habitat thanks to the well-supported webs between its toes.

*Meroles anchietae*: In terms of biomass, the conspicuous, sand-coloured *Meroles* is a small though dominant vertebrate in the central Namib dunes, and holds a key position in the food web. These lizards are omnivorous, eating seeds found among detritus as well as insects and any other small arthropods they can catch. They forage mostly on the upper vegetationless parts of the dunes, but will also venture towards grass and *Trianthema* hummocks at the foot, and even into the interdunes for a short distance on low dunes. They take whatever is available, and have been recorded eating mostly kelp flies in the dunes close to the coast, small beetles, ants, solifuges, fishmoths and even scorpions around Gobabeb, and weevils in the dunes of the northern Namib. Beetle larvae are also commonly eaten and are presumably shovelled out from just beneath the surface where they are active on cool, humid mornings.

Figure 2.a.60: Note the feet of endemic *Palmatogecko rangei* (Gobabeb Centre)

Figure 2.a.61: A vigilant *Meroles anchietae* lizard watching for unwary prey (Gobabeb Centre)

The lizards are capable of great speed on soft sand, and display considerable agility chasing and leaping up to catch flying insects. They have excellent vision, and will sprint away from the first sign of danger. When further pursued, they are quick to dive into the sand with what looks like a mere flick of the tail. For this their shovel-shaped snout is appropriate, and the nostrils face backwards and have a cartilagenous flap to prevent the entry of sand.
These lizards have been well studied and provide an ideal species for monitoring population variations. The number of individuals on a single dune may vary several-fold depending on the recent rainfall and vegetation cover in the Namib Sand Sea.

The reproductive cycle of *Meroles anchietae* is also well adapted to the unique constellation of habitat characteristics of the Namib Sand Sea. Surprisingly, the cycle is typical of tropical lizards as reproductive activity can be continuous for more than one year. Similar continuous reproductive strategies have also been reported for other sand sea endemics, contrasting sharply with the boom or bust reproductive strategy usual for arid environments world wide. A possible explanation of the continuous reproductive pattern relates to its omnivorous diet that includes arthropods as well as seeds that are picked out of detritus on the slipface. When insect abundance is low, they can still fulfil their energy needs from seeds, allowing them to continue year-round egg production. Their response to an abundant supply of insect prey is to accumulate large quantities of fat. The fat bodies are used by females to maintain egg production through the dry period, although at a lower rate. Territorial males use their fat reserves to defend their territories and to secure copulations with females. Moreover, in addition to the usual abdominal fat bodies found in these lizards, *Meroles anchietae* also stores fat in large deposits under the skin in the pectoral region – a phenomenon not known in any other lizard.

**Figure 2.a.62: A well camouflaged endemic sand lizard *Meroles cuneirostris* (Gobabeb Centre)**

This is in contrast to *Meroles cuneirostris* which also inhabits the dunes of the Namib Sand Sea but more the dune slope and interdune valleys rather than the slipfaces. They are fully insectivorous. Due to the seasonal fluctuations in their food, *Meroles cuneirostris* has a distinct seasonal breeding cycle.

Another remarkable feature of *Meroles anchietae* is the exceptionally large size of their hatchlings. At hatching, the babies are about 60% of the length of an adult female, and about 20% of her weight. This is advantageous in the extreme desert environment, since the surface-to-volume ratio is reduced in a larger body, and therefore the young are less susceptible to dehydration. Their large size probably also makes them capable of taking a wide diversity of prey, and it reduces the time to reach maturity, all of which presumably are factors in their favour for successful adaptation to the Namib Sand Sea.
**Sidewinding Adder:** The endemic dune-dwelling adder, *Bitis peringueyi*, is active during any time of the day or night in the Namib Sand Sea. They are most commonly encountered in the daytime, however, since they tend to follow the activity patterns of their main prey species, *Meroles* lizards. They remain stationary, concealed under the sand surface in their ambush position, usually on a dune slipface or at the base of a clump of vegetation. They submerge their body beneath the fluid sand by shuffling their coils to and fro, shifting sand to the side and so lowering themselves beneath the surface. Only the eyes, situated on the top of the head, are exposed, and the body colouration matches the sand grains closely. As the snake warms up it simply digs its entire body to cooler depths. The characteristic side-winding movements recorded by unique tracks on the sand surface take place mainly at night as they move between ambush sites on the dune slipface or under vegetation.

These snakes drink condensed fog-water from their body surface. The sidewinder flattens its body, increasing the surface area exposed, moves its head back and forth over the body to take up the water droplets, and every now and then raises its head, apparently to assist the flow of water into the digestive tract. Individuals can gain as much as 14% of their body weight from this practice. Like *Meroles anchietae*, the distribution of the species is limited to the Namib fog belt, suggesting that they cannot survive without this water source.
Birds

Well over 100 species of birds have been recorded over the dunes of the Namib Sand Sea – but few of them live permanently in this hyper-arid habitat. Most are dependent on habitats adjacent to the dunes while using the dunes as foraging areas, for example owls or pale chanting goshawks, or are simply passing by. Ostriches may live permanently in the Namib Sand Sea but are not endemic. Only one lark is endemic to the Namib Sand Sea (Table 2.a.8). A brief overview document on birds is included in Annex 7 as well as complete bird lists in Annexes 16 and 17.

Table 2.a.8: Bird species richness in the Namib Sand Sea (from Annex 16 and 17)

<table>
<thead>
<tr>
<th>Nominated area</th>
<th>Sandwich Harbour</th>
<th>Exotics (aliens)</th>
<th>Desert endemics (excluding dunes)</th>
<th>Sand sea species</th>
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</tr>
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<tbody>
<tr>
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<td>117</td>
<td>3</td>
<td>4</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>

Larks: The endemic dune lark is the only bird permanently resident in the Namib Sand Sea. It lives entirely on the dunes, venturing only a short distance into the interdune valley adjacent to the lower slope of a dune. Like many other larks in desert areas, the dune lark, *Certhilauda erythrochlamys*, drinks no water and relies solely on its food to supply its metabolic water. It feeds on seeds of plants found on the dunes (*Stipagrostis* grasses and the dune shrub *Trianthema hereroensis*) as well as insects that live in and close to these plants – ants, locusts, beetles, caterpillars and termites. The larks have a characteristic method of finding seeds and insects that takes advantage of the array of micro-habitats on a single sand dune. On the lower dunes, they drill a small cone into the sand with a short probe and waggle of the bill, ‘bill cratering’, which unearths seeds hidden under the surface. Higher up on the dune slope, they forage near the only two plants that remain green throughout the year which, while providing seeds, also attract a range of insects. Thus the birds tend to concentrate on insects in the upper zones of the dune. They have a clear pattern of movement from morning till midday, starting where they roost in the upper parts of the dune, gradually moving down the slope to the dune base and then returning to the upper portion as midday approaches, where they stay until the pattern is repeated later in the afternoon. While they are resting in the shade of grass and *Trianthema* clumps at midday, they glean insects from the leaves and make short dashes away from the plant to pick up others on the sand. Several dune larks have been recorded as living for more than five years, an unusual length of time for these small birds but a time period that allows them to skip breeding for a year or two if conditions are particularly poor. One female was ringed twelve years before its most recent recapture.

Figure 2.a.65: The endemic *Certhilauda erythrochlamys* (©Trevor and Margaret Hardaker http://www.hardaker.co.za)
Larks are highly successful in arid habitats. Nine species altogether are found occasionally in the dunes. Of these, all but the dune lark are nomadic to some extent. Some gather in flocks where there is abundant food (seeds or small insects or both) in grassy areas after rain. The most impressive bird irruptions are of greybacked sparrowlarks, which can suddenly appear in their thousands in the interdunes, and disappear again after a few weeks.

**Lappet-faced vultures:** Lappet-faced vultures, *Torgos tracheliotus*, are a spectacular part of the fauna of the Namib Sand Sea breeding in trees in the ephemeral rivers that penetrate the dunes. These large vultures, with a wingspan of 2.8 m, nest on the tops of trees. With large nests from one to three metres in diameter they raise a single chick each year. Like other vultures, they are conspicuous if poorly understood.

**Ludwig’s bustards:** Ludwig’s bustards, *Neotis ludwigii*, are amongst the largest bustards in existence. These spectacular birds move widely across the landscape but, after a good rain and emergence of numerous tenebrionid beetles and other insects on the dunes, are frequently found in the Namib Sand Sea.

**Sandwich Harbour:** Sandwich Harbour, although no longer a functioning harbour, is a spectacular coastal lagoon designated as a Ramsar site. The Sandwich Harbour lagoon on the northwestern coast of the Namib Sand Sea was a palaeomouth of the Kuiseb River. Fresh water still seeps out from the palaeochannels resulting in dense reed beds and brackish water in the lagoon that supports a wide diversity of aquatic invertebrates. This phenomenon attracts unusually large numbers of Palaearctic and African migrating birds.

Most waterbirds that are found at this Ramsar site migrate from their Palearctic breeding grounds in the northern hemisphere at the end of summer. They spend the austral summer feeding and resting. These include thousands of curlew sandpipers *Calidris ferruginea*, sanderlings *Calidris alba* and little stints *Calidris minuta*. Red-necked phalarope *Phalaropus lobatus* and terek sandpipers *Xenus cinereus* as well as Eurasian oystercatchers *Haematopus ostralegus* are also found there. Ringed *Charadrius hiaticula* and grey plovers *Pluvialis squatarola* appear in their hundreds.

During the annual summer census in January 2008, 45,000 lesser *Phoenicopterus minor* and 10,000 greater *Phoenicopterus ruber* flamingos were counted at Sandwich Harbour. The terns are well represented with

![Figure 2.a.66: Ludwig’s bustard *Neotis ludwigii* (Demasius)](image)

![Figure 2.a.67: Damara tern *Sterna balaenarum* nesting on the coastal plains (Gobabeb Center)](image)
at least seven species and some summer counts have recorded 60,000 birds. Common terns *Sterna hirundo* are the most prolific (± 40,000). In January 1998, at Sandwich, an exceptionally large congregation of 170,000 of these terns was recorded. Others seen are Caspian tern *Sterna caspia*, swift tern *Sterna bergii*, white-winged tern *Chlidonias leucopterus* and the small Damara tern *Sterna balaenarum*. The Sandwich tern *Sterna sandvicensis*, a common visitor to the coast, was first described in 1787 from a specimen found at another Sandwich Harbour in Kent, England.

The Sandwich Harbour Ramsar Site, included in the Namib Sand Sea Property for nomination, is well qualified for the designation. It supports an average of 75,000 waterbirds and on one occasion rising to 400,000. Sandwich Harbour also supports over 1% of the world’s population of more than 12 species, including white pelican, avocet and little stint.

Figure 2.a.68: Migratory and resident bird numbers are regularly monitored at Sandwich Harbour

Figure 2.a.69: Flamingos circling above Sandwich Harbour (Gobabeb Centre)
Namib Sand Sea
Mammals

Only two small mammals are endemic to the Namib Sand Sea: the golden mole *Eremitalpa granti namibensis* and dune gerbil *Gerbillurus paeba* (Table 2.a.9). Other gerbil species frequent this habitat but are not confined to it. A variety of larger mammals enter the Namib Sand Sea for shorter or longer periods. These include the gemsbok, *Oryx gazella*, springbok, *Antidorcas marsupialis*, and Cape hare, *Lepus capensis*, which may remain for months or even a lifetime. Common short-term visitors include predators such as the black-backed jackal, *Canis mesomelas*, brown hyena, *Hyaena brunnea*, Cape fox, *Vulpes chama* and spotted hyaena, *Crocuta crocuta*. A greater variety of desert animals may follow an ephemeral river into the dune sea but not travel far into the Namib Sand Sea itself. See Annex 8 for more information on mammals in the Namib Sand Sea and Annex 15 for a detailed list of mammals.

<table>
<thead>
<tr>
<th>Nominated area</th>
<th>Exotics (aliens)</th>
<th>Desert endemics (excluding dunes)</th>
<th>Sand sea species</th>
<th>Sand sea endemics</th>
<th>% Sand sea endemicity</th>
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<td>76</td>
<td>9</td>
<td>4</td>
<td>13</td>
<td>2</td>
<td>15%</td>
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The Namib golden mole: This small, blind, subterranean insectivore, *Eremitalpa granti namibensis* measures about 8 cm long, and possesses a silky greyish-yellow coat with a silvery sheen. The first living specimens were found in the dunes near the Gobabeb Training and Research Centre in the late 1950s. The species was previously known only from scattered remains in owl pellets. The claws on the front feet are broad and hollowed out to serve as modified shovels for digging through loose sand. Unlike other subterranean animals, the Namib golden mole lacks an underground burrow system, but ‘swims’ through the fluid, oxygenated sand of the Namib Sand Sea and emerges onto the surface to forage for its prey. This
comprises mostly invertebrates such as termites and insect larvae, but includes anything it can catch and overpower, the web-footed gecko _Palmatogecko rangei_ being the largest prey item known. Crickets, moths, spiders and legless lizards are also included in the diet.

The animals are solitary and move randomly within their home range of about 7 ha for males and 3 ha for females. These figures are much larger than comparative values for other subterranean insectivores, probably because of the relative scarcity of invertebrate prey to satisfy their energy needs. Food resources are not only sparse but also patchily distributed, so that moles must move considerable distances (up to 1,200 m per night) to find their fill. In doing so they move about the home range in a circumscribed but nomadic fashion, resting by day, and continuing by night within their ‘one-day territories’. The home ranges of neighbours overlap somewhat, but encounters between neighbours are rare since each mole forages in a different area of its home range each day. Some form of mutual avoidance, possibly based on scent, might be involved in maintaining the distance between neighbours.

Golden moles search for their prey on the surface, ‘dipping’ into the sand, probably to help in detecting vibrations underground, but maybe also to check moisture content, or the presence of organic matter or termite casts. They move in a more-or-less straight line very rarely covering ground that has already been searched that night. They switch to sand-swimming when encountering a concentrated food patch such as a cluster of termites, which is usually under a hummock of vegetation. Then their moves are short with frequent turns, ensuring that they keep within the bounds of the patch to cover it intensively.

While running on the surface exposes the Namib golden mole to owls and other predators, continual swimming would quickly tire them out. The energy cost of sand-swimming is about 80 times higher than that of running on the surface. Fortunately the cost of sand-swimming is much lower than burrowing through solid ground. It is unlikely that the Namib golden mole could exist in areas with such low abundance of food if the substrate was more compacted than that of the fluid sand of the Namib Sand Sea.

Moles in the eastern Namib dunes, where rainfall is higher and vegetation is more concentrated, move shorter distances than those in the west where their abundance may vary from one mole per 4.5 ha to one per 70 ha. These large differences in track length and mole density reflect the differences in prey abundance and hence rainfall, as well as the adaptability of this small mammal.
Namib golden moles are physiologically unusual in their ability to abandon thermoregulation during daily rest, allowing their body temperature to drop to ambient and thus depressing their metabolic rate. Resting metabolic rate is about a fifth of that predicted for a normal insectivorous mammal.

Such a low metabolic rate is advantageous as it allows slow breathing which, combined with the relatively higher humidity underground, results in lower rates of water loss. Perhaps the only ‘reptile-like-mammal’ known in the world lives in the Namib Sand Sea.

The fauna of the Namib Sand Sea, with its morphological, physiological and behavioural adaptations is one of the outstanding characteristics of this spectacular environment. Animals that swim through oxygenated sand, animals with high thermal tolerance that know how to effectively evade extremes, animals that build structures to capture fog-water – all contribute to the wonders of the Namib Sand Sea. When combined with very long-lived but small birds and invertebrates, organisms with almost continuous breeding outputs, and creatures that harbour gut micro-organisms that recycle nutrients through this extreme environment, the Namib Sand Sea has no counterpart in the other dunes of the world.
2.b HISTORY AND DEVELOPMENT

The human history of the area mainly plays out around and not inside the Namib Sand Sea. It highlights the reality of the Namib Sand Sea acting as a shield between the interior and the coast. The massive dunes and extensive stretches of waterless desert prevented desert crossings while river courses north and south of the sand mass provided natural travel routes. The lack of water and other resources made permanent settlement by large communities impossible. It was only through strenuous effort, e.g. when costs were offset by high-value resources and technological progress that people temporarily settled in the Namib Sand Sea.

Archaeology: Interpretation of archaeological evidence suggests that humans occupied the area intermittently during exceptionally productive periods during the Late Pleistocene and Holocene epochs. Surprisingly, human presence in the Namib Sand Sea dates back several hundred thousand years to the early ancestors of modern people. Artefacts from the Namib Sand Sea show that the ‘Out of Africa’ migration of early hominins into Eurasia was contemporaneous with other populations settling in decidedly marginal environments such as the Namib Sand Sea. Early Paleolithic (or Early Stone Age) tools are found at a number of locations within the sand sea. The known sites are concentrated along western extensions of some of the ephemeral rivers that now terminate within the Namib Sand Sea. One site is accompanied by *Elephas recki* fossils, dated to between 700,000 and 400,000 years before present (BP) from its geological setting. It is suggested that the elephants were slaughtered at the site. The *Elephas recki* fossils themselves are of interest as they represent a disjunct record of that extinct elephant well known from early hominin and other fossil sites in Eastern Africa. The little research that has been carried out on the sand sea’s Early Stone Age occurrences indicates that early hominins may be much more widespread.

Anatomically modern humans apparently arrived much more recently. Middle Stone Age (Middle to Late Paleolithic) artefacts are known, but these are rare and inadequately researched. Most sites from that period (200,000 to 21,000 years BP) are well outside the Namib Sand Sea, which does not allow for informed deductions to explain the few artefacts recovered from within the area. More recent Neolithic (or Later Stone Age) materials are mostly found along the coast in the vicinity of small seeps, springs and at inselbergs. These sites, representing renewed occupation after a long period without people, are presumed to reflect either a break in occupation or the inundation of coastal sites with a rapid sea level rise of more than 100 m after the ice sheets of the Last Glacial Maximum melted between 16,000–10,000 years BP.

*Figure 2.b.1: Freshwater seepage at Francis Bay has been used by many people over the last 10,000 years, including those who built the stone circles and other structures on the Sylvia Hill outcrop (Schneider)*
The archaeological history resumes around 12,000 years BP, represented by only a few sites along the margins of the Property near Gobabeb, along the Kuiseb River and in the vicinity of Sossus Vlei. Sites from within the last 5,000 years BP are more abundant, but still rare. Three human burials were found under cairns at coastal Sylvia Hill, two of which were dated to around 1,000 and 500 years BP respectively. An extensive stone circle complex at Sylvia Hill, and a number of other stone circle occupation sites both within and immediately adjacent to the Namib Sand Sea indicate that family groups, or ‘band’ societies, stayed for considerable periods in the desert. Stone circle sites were dated from around 1,000 years BP to recent (20th century) times, but it is not clear which people may have occupied them as no historical or oral evidence has yet been found to explain their construction. It is presumed that those stone circles either served as windbreaks for resident groups, or were constructed as hut foundations or supports. Similarly, middens with pottery and marine molluscs are frequently found within walking distance of fresh water seeps along the coast, dating from around 2,000 years BP to 19th century times. Fresh-water springs or shallow seeps occur at Reutersbrunn, Fischersbrunn, Conception Bay and Sandwich Harbour, all of which supported people from the remote past to the present. Other Later Stone Age materials have been found along the courses of the ephemeral river beds.

The more recent archaeological evidence was interpreted as proof of increasingly intensive hunter-gatherer subsistence strategies with specialised techniques for gathering food (marine shellfish and other resources, Inara melon harvesting), hunting (hunting blinds to ambush zebra, hunting drives, killing of seals and seabirds, spearing sharks and fish), food processing and storage (processing by cooking, drying excess meat and fish), and trading with people in the interior. These specialised techniques would have ensured greater food security in a marginal human environment such as the desert. However, all archaeologists stress that linking these disparate lines of evidence with the ethnographic present is tenuous. No clear historiographical evidence, whether oral, subsistence practice, or historical records, links modern Namibian peoples with those past practices. People were found living along the coast and along the course of the ephemeral Kuiseb River by early explorers from Europe, but they were not the direct ancestors of the modern inhabitants.

Geopolitical history: The Portuguese explorers that pioneered the maritime route between Europe and Asia were likely to be the first non-African visitors to the Namib Sand Sea. In 1486 the navigator Diogo Cão sailed along the Angolan and Namibian coastline to reach Cape Cross to the north where he erected a padrão (stone pillar). The next year (1487) Bartolomeu Dias made landfall somewhere along the Namibian coast in the north. From there he continued Cão’s first mapping of the coast in such great detail, including the Namib Sand Sea coastline, e.g. Conception Bay coast was originally Golfo da Concepção, that his information was used for three centuries. Diaz successfully rounded the southern tip of Africa into the Indian Ocean before returning to Portugal, erecting a padrão at Angra Pequena (today Lüderitz) on his return journey. Diaz’s route was only repeated ten years later, in 1497, by Vasco da Gama, who successfully continued on to India.

Numerous Portuguese merchant fleets would follow the Diaz-da Gama route over the next century. The Portuguese retained their monopoly on the seaborne trade between Europe and India by keeping the route secret and fortifying numerous strategic harbours, many of which have been inscribed as World Heritage. Their grip on that lucrative trade was broken by Dutch seafarers in 1596,
Ocean trade was an additional cause of concern. Attempts by the Dutch in 1793 and English in 1795 and alarm, while the emergent French dominance in Europe and possible interdiction of the Indian where possible. Both the Dutch and the Royal Navy viewed that development with some animosity rapidly as whale catches elsewhere decreased. They resupplied by trading with indigenous people elsewhere.

A century later the American Revolution and political changes in Europe resulted in much greater interest in the Namibian coast and adjacent interior. England lost most of her colonies in North America and was engaged in a struggle for dominance with other nations. Thus, before sending their first ‘convict’ fleet to Botany Bay in Australia in 1787, the British government wished to investigate strategically more promising locations for a penal settlement. The HMS Nautilus was dispatched to investigate possible sites along the African coast in Ghana and near the Orange River mouth (the southernmost tip was still Dutch) during 1786. Finding those locations unfavourable, the Nautilus’s captain sailed northwards from the Orange River along the Namibian coast to investigate various locations such as Lüderitz (Angra Pequena), Spencer Bay, Sandwich Harbour and Walvis Bay. The report was unfavourable regarding a penal settlement, but resulted in the first systematic account of people and resources along the Namib Sand Sea coast. A small group of people were encountered at Lüderitz, with a large settled community at Walvis Bay. The latter were fishing in the lagoon, harvesting Inara, and herding cattle. Other signs of people were found much further north in Angola.

American whalers started visiting the Namibian coast during the 1770s. Their numbers increased rapidly as whale catches elsewhere decreased. They resupplied by trading with indigenous people where possible. Both the Dutch and the Royal Navy viewed that development with some animosity and alarm, while the emergent French dominance in Europe and possible interdiction of the Indian Ocean trade was an additional cause of concern. Attempts by the Dutch in 1793 and English in 1795
to curb outside interest by annexing Walvis Bay did not meet international law. Royal Navy ships subsequently visited the Namib coast frequently, most of which made detailed notes that are available in archives. Strategic information such as where indigenous people were found (which fresh food can be obtained by trade), woody debris on shore (required as fuel for ships’ stoves), water sources (to replenish water casks) shipping hazards and navigation information were noted where feasible. It is of interest that during the next century no permanent inhabitants were noted at regularly visited places such as Lüderitz, Spencer Bay, Sylvia Hill, or Sandwich Harbour. The reports suggest a sparse and transient human occupation along most of the coast. The exception was Walvis Bay, from where an established community frequently travelled to Sandwich Harbour and carried out a brisk trade supplying beef and mutton to visiting ships.

The potential economic importance of the offshore islands where seabird guano was harvested as fertilizer for sugar-producing colonies, and Walvis Bay for replenishing food and water, led to the formal annexation of Walvis Bay and Namibia’s offshore islands in 1878 by the Cape Colony. The rest of Namibia was claimed by Imperial Germany during the ‘Scramble for Africa’ in 1884.

Local history: Sandwich Harbour with its fresh water seepage (named after the English whaling ship Sandwich) was long a focus of human habitation and resource use. Archaeological evidence shows that people exploited the plentiful marine resources there since the fourth century (1,600 years BP). Settlements were established in the Kuiseb River delta at Walvis Bay after pastoralism became established in the Namib Desert during the last millennium. Groups of itinerant visitors from those settlements continued harvesting resources at Sandwich Harbour, occasionally even bringing cattle to graze on the dune vegetation and lush reeds. Sandwich Harbour was furthermore well known as a source for fresh water along the maritime trade route to India. British and Cape Town merchants began commercial exploitation of fish at Sandwich Harbour from 1853 to 1891. The entrance of the harbour then closed and the fishing industry ceased to operate. The indigenous people concomitantly continued gathering Inara melons and marine resources from there, opportunistically also supplying labour for the fishing operations and trading with visiting ships.

The history of Walvis Bay immediately to the north of Sandwich Harbour is probably much more complex because of more water, resources, and ease of access from the interior. The rich cultural history from more than 150 sites in the Kuiseb Delta attests to a long settlement history of the area. Today the indigenous inhabitants at Walvis Bay and along the Kuiseb River (the northern boundary of the Property) are the ≠Aoni Nama tribe or Topnaar people. They were traditionally herders and
gatherers of Inara melons, the pulp of which they cook and dry to last for more than a year. That tradition of Inara harvesting is estimated to be at least 800 years old, which is almost contemporaneous with the start of livestock herding along the lower Kuiseb. Today, the Nama-speaking Topnaar or ≠Aonin Nama-speaking people still maintain small, mainly ‘weekend’ farms along the lower Kuiseb River valley just outside the northern border of the nominated Property.

The Topnaars were most likely the people who first made contact and traded with European visitors. At one time, the main supply of meat for the British colony on St. Helena Island was sourced from Walvis Bay with ships purchasing 200–300 cattle at a time. Trade with visiting ships burgeoned during the late 18th and 19th century when American and other whaling ships needed fresh supplies to counter scurvy. Whalers regularly visited Walvis Bay while decimating the whale population along the Namibian coast. The whalers then moved on to other hunting grounds, but a brief guano rush to the islands southwards brought thousands of new ships. At the height of the guano rush hundreds of ships anchored every month at Ichabo and Mercury Islands. For example, during February 1845 it was recorded that 451 ships were anchored in the two-mile wide channel between Ichabo Island and the mainland alone. The situation was similar on Mercury Island off Spencer Bay. During the guano rush, hundreds of sailors were clearing the dried seabird excrement that accumulated over millennia for export to Europe and various colonies requiring fertilizer, e.g. the sugarcane fields of Mauritius and the Caribbean. During this period an indigenous group also briefly settled at the water near Saddle Hill to exploit the opportunity for trade.

Beef, wood and water were in considerable demand by visiting ships. Livestock was exchanged for glass trade beads, porcelain, and a variety of other goods. Near Walvis Bay the missionary Archbell reported a number of settlements in 1822, some of them with over 300 households. The Nama-speaking people at Walvis Bay were at the centre of the local trading network that extended as far as Botswana to the east. Expansion of settler influence in the Cape to the south, however, caused various Nama-speaking groups, called Oorlam Nama, to emigrate from the Cape at the beginning of the 19th century. These Oorlam Nama had absorbed considerable cultural information from their European neighbours, including the use of guns, horses and wagons that rapidly resulted in them dominating the interior of Namibia as far as Angola through their superiority in having firearms and horses.

One of the Oorlam Nama groups settled at Bethanie in the Karas Region in 1814. A local entrepreneur, Vleermuis, lost no time in establishing a trading route to Lüderitz Bay. Though the trade briefly collapsed in 1822 and Bethanie was abandoned, it resumed again in the mid 1830s. That
trade was possibly one of the reasons for the disparate Nama families at Bethanie to coalesce as a tribe under chiefs Frederiks and Vleermuis. Other Oorlam groups that also immigrated early in the 19th century raided livestock throughout the interior of Namibia to supply their overland trade with the Cape for ammunition and more guns and horses. Thus in the early 1830s, the #Aonin were thoroughly defeated and dispossessed of almost all their livestock to become vassals of the Afrikaner Oorlam Nama. When the explorer James Alexander reached the middle Kuiseb and #Aonin homesteads in 1837, they had very little livestock of their own. Alexander was also the first European explorer along the interior margin of the Namib Sand Sea, travelling down the Tsondab River and then along the interior margin of the dunes to the Kuiseb River. The number of missionaries, explorers and traders continued to grow from the 1840s, contributing to a decline of the coastal trading routes in preference for overland trade with the Cape Colony in South Africa. The Witbooi Oorlam tribe, which settled in 1863 at Gibeon in the Hardap Region, replaced the Afrikaner tribe as the dominant Nama group in the southern interior of Namibia. They continued the tradition of large-scale livestock raiding to feed the demand for guns, ammunition and horses. That period of emergent African politics came to an end in 1882 when Chief Frederiks in Bethanie inadvisably leased Lüderitz and the adjacent coast, most of which consisted of ‘worthless’ sand dunes, to a German trader. That opened the door for Germany to join the rush of European nations claiming overseas colonies.

The occupation of Namibia by Germany in 1884 resulted in a steady decline in the economic self-sufficiency of all indigenous Namibian people. The new colonial masters first usurped and subverted intertribal trading mechanisms before totally disenfranchising and decimating local societies through a series of devastating colonial wars. Walvis Bay, a British possession, became marginalised as the German colonial authorities developed harbours at Swakopmund to the north and Lüderitz in the south. The #Aonin subsisted through an impoverished lifestyle on the periphery of the new economic reality. Those further away up the Kuiseb were able to continue farming with livestock and kept up some degree of seasonal exploitation of different resources along the Kuiseb, while those still living at Walvis Bay became more sedentary and subsisted on the Inara harvest, fishing and scavenging. This internal inequality resulted in the livestock herders becoming known as the !Khuisenin, or Kuiseb people, and the coastal group in the vicinity of Walvis Bay as the Hurinin or sea people.

During World War I, the German colonial period was brought to a close in 1915 when South African troops invaded the territory through Lüderitz and Walvis Bay and forced the surrender of the German forces. During the Treaty of Versailles and the establishment of the League of Nations, a mandate to administer the ex-German colony passed to South Africa. After long years of a bitter independence struggle, Namibia eventually gained its independence in 1990. However, Walvis Bay and the offshore islands, some only some hundreds of meters from the Namib Sand Sea coast, remained in South African hands. The colonial chapter was finally closed in 1994 when Walvis Bay and the islands off the Namibian coast were reintegrated into the Republic of Namibia.

**Industrial history:** An enduring myth of the Namib Sand Sea is of fabulously rich diamond fields. This dates to 1908 when the first diamond was found to the east of Lüderitz. Anybody who could afford to buy a prospecting license flocked to the desert south of the town. The pegging of claims was chaotic. In response, the German government proclaimed the area between 26° south and the Orange River, and from the coast to 100 km inland, off limits for diamond prospecting (the so-called Sperrgebiet).
The sole rights were consolidated under a single company rather than continuing with the haphazard pegging of thousands of claims by different individuals. This also gave the German government an opportunity to exploit the newly discovered riches.

The outraged prospectors turned their attention to the Namib Sand Sea north of Lüderitz. Within three months after the Sperrgebiet was proclaimed, some prospectors discovered the first few diamonds at Spencer Bay. By 1910, more than 5,000 claims had been registered to virtually cover the entire Spencer Bay area. Access to the ‘northern fields’ was by foot, ox wagon, mules, horses and camels. A few springs provided some water, later supplemented in 1913 by four drilled wells and a windmill to the east of Conception Bay. Large quantities of fodder and all food, fuel, construction materials, and household necessities had to be imported. Labour to work the claims was an additional challenge. Initially workers were recruited from adjacent areas, but these labourers returned home during the !nara harvesting period and to tend their farms during the rainy season. Workers were then recruited from northern Namibia to live under atrocious conditions. Their meagre rations were mostly eaten half raw for lack of firewood, which made it more difficult to digest and not very nutritious. Minimal medical supplies, the hard work and the lack of a balanced diet resulted in extremely high mortalities for man and beast on the northern diamond fields.

Prospectors in search of food eliminated most game, if not all, that occurred along the coast. Some species such as oryx and ostrich eventually recovered, but the springbok that were exterminated along the coast never returned. Following the pattern set by mariners, the prospectors and miners used any kind of wood they could find to construct shacks or to burn as fuel. Shipwreck remains were particularly useful, but also the

claim beacons of fellow prospectors. Particularly notorious accounts of the wreck of a sailing ship that was blasted into tinder with dynamite, a shipwreck at Meob Bay dismantled by workers to build shacks, and boards from shipwrecks used to stabilize the sandy walls of wells dug at Fischersbrunn illustrate the demand for wood. Even the masts and wood panelling of the cabins of the steamer Eduard Bohlen that stranded at Conception Bay in 1909 while transporting mining equipment were used as fuel. Today the wreck of the Eduard Bohlen lies hundreds of metres inland from the beach and is a major tourist attraction as a manifestestation of the constantly changing shoreline. This demand for wood virtually cleared the beaches north of Lüderitz of shipwreck remains that may have been useful to reconstruct the maritime trade history.
At the outbreak of World War I in 1914, the diamond fields ceased operations. Approximately 30,000 carats had been recovered by then. Vast areas between Conception Bay and Meob Bay were systematically prospected and mined when production re-started in April 1921. The diamondiferous gravels of these deposits resulted from past sea level changes and therefore occurred in isolated patches in shallow depressions. Mining concentrated on surface workings and the thin surface deposits were quickly exhausted with very little potential of diamond-bearing sediment remaining today. Operations by the Consolidated Diamond Mines (CDM) were abandoned at the end of 1930 and Namaqua Diamonds in 1931. At that point total output from the northern fields amounted to some 579,734 carats from the Conception Bay fields and 14,763 carats from the Meob Bay fields. The South African government already had problems controlling this vast region, therefore it proclaimed the area as Diamond Area No. 2 and closed it for prospecting and mining, though claims at Saddle Hill that were registered just days before the closure were still honoured.

The Great Depression of 1929 and the global economic crisis constrained mining at Saddle Hill until 1941 when World War II caused diamond prices to soar. The area quickly developed into a hive of mining activities using massive equipment. The large demand and excellent prices for diamonds enabled the ‘Industrial Diamonds of South Africa’ company to operate despite the expense of mining in such a remote area. The deposit was eventually mined out in 1963 after more than 300,000 carats were produced between 1931 and 1963. Extensive prospecting along the coast from 1951–1957, 1962–1969, and 1975 through intensive mapping, geophysical studies, sampling and drilling exercises proved that only very small potential deposits remain. The area was eventually included in the Namib-Naukluft Park during the late 1980s.

During these mining years, sprawling encampments with stores, workshops and rudimentary shacks developed at the ‘Grillenberger’, ‘Charlottenfelder’, ‘Holsatia’ and ‘Fischersbrunn’ fields. Cutlery, crockery, tools and other debris of daily life still clutters these old settlements. The crumbling structures, abandoned transport and disintegrating industrial debris such as sieves and jigs are gradually succumbing to the encroaching sands. Visiting these abandoned infrastructure and industrial waste dumps has become a key attraction for the burgeoning adventure tourism concession industry.

**Namib-Naukluft Park**: The Namib Sand Sea occupies a major part of the Namib Naukluft Park. Since the park’s early proclamation on 22 March 1907, sand dunes immediately south of the Kuiseb River were included but Sandwich Harbour was only integrated into more precisely delineated park boundaries in 1941. The eastern frontier of the then Namib Desert Park was extended to the boundaries of commercial farmland as well as southward to north-west of Solitaire in 1962. A third expansion on 1 August 1979 amalgamated the conservation areas of the Namib Desert Park, Naukluft Mountain Zebra Park and uninhabited state land into the 23,340 km² Namib-Naukluft Park. The park was expanded again in 1986 when fragments of State Land, all of Diamond Area No. 2 and parts of Diamond Area No. 1 north of the Aus-Lüderitz road were also included. With these additions of extensive conservation area the Namib-Naukluft Park reached its current size of approximately 50,000 km² of which 30,777 km² comprise the nominated Property.
A striking display of the two Namib Sand Seas, with the Sossus Sand Formation superimposed on the Tsondab Sandstone Formation (Paul van Schalkwyk)
Justification for Inscription

The Namib Sand Sea stretches along the central Namibian coastline at the heart of the Namib Desert, a cool coastal desert extending for more than 2,000 km along the waterless South Atlantic coast of Africa. The Namib Sand Sea, exemplifying exceptional stark beauty and magnificent dune-scapes, is a notable and striking global feature. The incredible contrast between the Namib Sand Sea, the ephemeral Kuiseb River and the northern gravel plains inspired one of the first hand-held photos of earth to be taken from space. The complex and dynamic mosaic of distinctive and spectacular dune-scapes representing the Namib Sand Sea is being forever modified by strong winds that continually shift and mould the loose sand into dunes of myriad sizes and morphologies. The relatively narrow Namib Sand Sea extends for almost 300 km along the desolate coastline, while the eastern boundary is roughly located at 100 km inland, along the 100 mm rainfall isohyet, 1,000 metres above mean sea level. Rainfall increases from virtually nothing on the coast to further inland and from south to the north across the Namib Sand Sea. Seasonality shifts from winter in the south to summer in the north – if any rain falls at all. The life-supporting fog moisture decreases away from the coast. The ragged inland border of the Namib Sand Sea runs parallel to the Great Western Escarpment from whence ephemeral watercourses originate. This eastern frontier of the Namib Sand Sea presents an outstanding example of rich integrated geological and biological desert habitats.

The Namib Sand Sea’s desert scenery and natural beauty, as well as its large dunes, are the result of on-going geological processes. The extreme aridity imposed by the cold Benguela upwelling and the constant supply of beach sand it delivers, which is then mobilized and transported inland by wind, is an outstanding example of the interaction between some of earth’s major processes. These encompass atmospheric, marine, and terrestrial forces and the resultant geo-morphological, ecological and evolutionary processes that are shaped by those primary determinants. Moreover, the exceptional visibility resulting from the virtual absence of moisture, dust and atmospheric pollution in its hyper-arid climate contributes to remarkable clarity of landscape features by day and the dazzling Southern Hemisphere sky at night.
The diversity of endemic life forms that have evolved and adapted to the Namib Sand Sea is unique in the world as sustained by the ecological and biological processes within the hyper-arid terrestrial ecosystem. Investigations into this diversity, particularly the outstanding behavioural and physiological adaptations needed to sustain life under extreme conditions, have advanced and inspired theoretical and applied science globally. These studies, and the fascinating community dynamics of Namib Sand Sea endemics, have made an unrivalled contribution to the universal understanding of desert ecosystems and evolutionary processes, not only for scholars, but also in households by attracting the attention of the world’s print and electronic media. The in-situ conservation of this array of endemic communities within their natural habitat of the Namib Sand Sea has been ensured and improved over more than a century of protection and conservation management of one of the world’s outstanding desert environments.

Figure 3.1: The vast extent of the Namib Sand Sea along the west coast of southern Africa lying between the southern Atlantic Ocean and the Great Western Escarpment (Bowen/NASA)
3.a CRITERIA UNDER WHICH INSCRIPTION IS PROPOSED

This proposed inscription addresses four criteria for natural properties: Criteria vii, viii, ix and x. All are important in the realisation of the Outstanding Universal Value.

**Criterion vii:** contain superlative natural phenomena and areas of exceptional natural beauty and aesthetic importance.

The Namib Sand Sea embodies vast panoramas of majestic dunes in a pristine environment, providing extraordinary natural desert vistas. Countless photographs and paintings by professionals and amateurs alike, adorning calendars, coffee table books, travel magazines and panoramic wall hangings, complemented by creative innovations ranging from jewellery to crafts to films of all descriptions, attest to the Namib Sand Sea’s exceptional natural beauty, inspirational stimuli and aesthetic appeal (Table 3.a.1).

![Figure 3.a.1: The interplay of light and shadow on the dunes inspires the artistic soul in all of us (van Schalkwyk)](image)

The Namib Sand Sea boasts gigantic dunes and, while it may forever be disputed where the highest active dunes in the world occur, the Namib dunes are without doubt the largest most accessible dunes on earth. There is nowhere else in the world where dunes of this magnitude are in such easy reach of people, within a leisurely morning drive in a family sedan car. Other comparably large dunes are located in the centre of vast deserts, requiring lengthy and strenuous desert expeditions, thus limiting access to a very few privileged visitors or local residents.

The spectacular desert scenery and incomparable natural beauty of the large dunes of the Namib Sand Sea provide for extraordinary desert panoramas, complemented by the aesthetic charm of its striking colours and fascinating animal life. The interplay of shadow and light in a variety of shapes, from the detail of individual sand grains and bizarre life forms to the plethora of dune types and vast picturesque views of majestic dunes, is an endless source of fascination as the time of day, the season, the weather conditions, and the perspective of the observer compel ever-changing spectacles. This natural beauty is further enhanced by the remarkable clarity of landscape features by day and the dazzling Southern Hemisphere sky at night.

Astonishing desert vistas, profusely crystallised in silhouetted forms with fascinating kaleidoscopic sceneries continually transformed with time, make the landscape of the Namib Sand Sea a sight to behold. Its striking colours range from black to garnet to red to deep orange to light yellow in an interplay of contrasting shadow and light. The colours together with diverse, fascinating plant and animal life, bestow a distinct natural beauty and aesthetic charm. The visual splendour of the Namib Sand Sea is enhanced by the sinuous curves and shapes constantly being remodelled by wind.

The ever-changing wind directions and forces in the Namib Sand Sea create a continuously evolving landscape. Depending on the time of day, fog may cover this surprisingly variable dunescape in a chilly white-grey blanket, allowing for diverse life in unexpected forms to survive in this barren and seemingly hostile environment. This ever-returning, life-giving phenomenon of fog is one of the wonders of the Namib Sand Sea. The seemingly endless undulating dunes of the Namib Sand Sea are brought to an abrupt termination in the north by intermittent flow of the ephemeral Kuiseb River. Its occasional violent floods following on high rainfall further inland, far from the Namib Sand Sea, will forever thwart the dunes from crossing its course and penetrating the Namib gravel plains beyond.

However, the Namib Sand Sea is not limited to magnificent dunes, where winds continually drift and mould the loose sand into dunes of innumerable scales and forms. Another manifestation of its stark beauty is in the startling contrast of habitats that can be found directly adjacent to each other within the Namib Sand Sea. These create an extraordinary juxtaposition of natural living environments with their associated multitudes of life forms on its sand dunes, dry riverbeds, interdune valleys and inselbergs.
Table 3.a.1: Books and films portraying the Namib Sand Sea

<table>
<thead>
<tr>
<th>Prominent examples of print media and film portraying the Namib Sand Sea</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International and local photographers:</strong> Tony Bannister, Gerd Behrens, Joh Henschel, Peter Johnson, Richard Muller, Paul van Schalkwyk, Helmut zur Strassen, numerous amateurs.</td>
</tr>
<tr>
<td><strong>Natural history books:</strong> Henschel, Dausab, Moser, Pallett - !Nara: fruit for development of the !Kuiseb Topnaar; Lovegrove – Living Deserts of Southern African; Schneider – Roadside geology of Namibia; Seely – Natural History of an Ancient Desert; Seely – Deserts: illustrated library of the earth.</td>
</tr>
<tr>
<td><strong>Coffee table books:</strong> Coulson – Namib; Johnson, Bannister – Africa’s harsh paradise; Levinson – Diamonds in the desert; McClain, Brain – Leonard the landrover; Mertens – Namib; Rothmann – More than grains of sand; Schneider – Treasures of the diamond coast; Seely, Pallett – The Namib: secrets of a desert revealed; Swart – Landscapes of Namibia; Sycholt – Journey across the thirstland; zur Strassen – Land between two deserts; zur Strassen – Namib: portrait of a desert.</td>
</tr>
<tr>
<td><strong>International and locally generated calendars:</strong> Gerd Behrens, Dirk Heinrich, Richard Muller, Heinz Pulon; numerous wall hangings and carpets with sand dune theme woven of local karakul wool.</td>
</tr>
<tr>
<td><strong>Travel books and magazines with the Namib Sand Sea frequently on the cover:</strong> Flamingo (NamibAir) - monthly; Lonely Planet; Travel Namibia; Namibia Holiday &amp; Travel; monthly supplement Allgemeine Zeitung, Windhoek.</td>
</tr>
<tr>
<td><strong>Natural history films:</strong> Anglia Television – Strange Creatures of the Skeleton Coast; BBC – Dune; BBC – Earth Enchanted Kingdom (3D); David Attenborough – Deserts of the world; National Geographic/Discovery Channel – Shifting Sands of Namib; numerous films by Japanese and other international film makers.</td>
</tr>
<tr>
<td><strong>Feature films:</strong> 10,000 BC; Flight of the Phoenix; Space Odyssey 2001; The Cell 1; Julius Cæsar; numerous product promotion films.</td>
</tr>
<tr>
<td><strong>Traditional knowledge records:</strong> film record by Botelle, Kowalski - Living on the edge; Kinahan – By command of their lordships; Kinahan – Pastoral nomads of the Namib Desert; van den Eynden, Vernemmen, van Damme – Ethnobotany of the Topnaar.</td>
</tr>
</tbody>
</table>
**Criterion viii: is an outstanding example representing major stages of earth’s history, significant on-going geological processes in the development of land forms, and significant geomorphic and physiographic features.**

Two dune systems are present in the Namib Sand Sea. The older is semi-consolidated and as old as 21 million years. The younger is unconsolidated and has been active for about 5 million years. It covers the older system and is still accumulating. However, neither erg has been derived from the underlying hard rock basement. Although having accumulated in the arid to hyper-arid central Namib, these dune sands originated under the humid conditions of central to eastern South Africa in the catchment area of the Orange River and its main tributary, the Vaal River. Three contrasting “conveyor belt systems,” acting in unison over much longer than the 21 million years recorded by the fossils in the basal aeolianites, namely the fluvial transport of the Orange River itself, a coastal long-shore drift and the coastal on-shore winds, finally deposited the sands in the central Namib. Thus, both the palaeo and the extant Namib Sand Seas are displaced aeolian derivatives of the huge inland Orange/Vaal River Basin.

**Figure 3.a.2: Two superimposed dune systems transposed over thousands of kilometres by river, sea and wind (van Schalkwyk)**

The Namib Desert is one of the oldest deserts on earth. The question of desert antiquity in various parts of the world is continuously debated as new evidence is discovered and new methodologies are applied. What is known is that the area occupied by the Namib Sand Sea, and its underlying precursor dunes known as the Tsondab Sandstone, apparently has not been any wetter than semi-arid for approximately 130 million years. Initially the present locality of the Namib Desert occupied the centre of Gondwanaland, where it formed part of the largest inland desert in the middle of a large
continental drift then split this ancient desert in two and the eastern portion became firmly established as the contemporary Namib Desert at least 32 million years ago. The post-Gondwana erosion surface joined the late Precambrian bedrock at an angle to form an extensive platform known as the Namib unconformity surface on which the Cenozoic deposits later accumulated. Presently, the original Namib peneplain enfolds the large sand sea at the verge of the African continent. The area’s aridity is caused by its location under the atmospheric high-pressure zone (latitude 30°S), amplified and intensified by the Benguela upwelling system along the western coast. Thus the terrestrial Namib Sand Sea represents an uncommon interaction between the hot desert and cold oceanic conditions. In an endless interplay between upwelling cold waters and strong winds blowing onto the coast, aridity is perpetually preserved.

One of the illuminating aspects of the Tsondab Sandstone underlying the Namib Sand Sea, elucidating the evolution of these land forms, is the presence of trace fossils with direct parallels in the modern Namib Sand Sea. These include passageways and chambers of termites, root casts resembling present day grasses and other iconic dune plants as well as back-filled, burrow-like tracks that resemble those of the present day golden mole. Of major importance explicitly revealing the history of the sandstone layers is an evolutionary sequence of distinctive and readily identifiable eggshell fragments of ostrich-like birds. The oldest fragments at the bottom of the Tsondab Sandstone represent an emu-like bird not unlike the giant Aepyornis that occurred on Madagascar. This sequence is overlain by sequences indicated by eggshell fragments from eight different ostrich species assigned to three different genera and covering 16 million years. Not only are these varied shells interesting from an evolutionary perspective, they provide a unique series of well-preserved fossil remnants exceptionally useful to date and interpret terrestrial deposits underlying the modern Namib Sand Sea.

The ancient and modern desert dune-scapes have been and continue to be sustained by sand delivered through an amazing natural conveyor belt system. This system transports sand for almost 1,000 km from the central interior of southern Africa to the Namib Sand Sea. Sand is first washed from the Lesotho Highlands down the Orange River into the Atlantic Ocean and onto what should be the Orange River delta. The long-shore drift augmented by the Benguela Current then takes over, however, and sweeps the sands northwards and onto shore. Strong winds transport the sand inland and further north, first forming barchans and small transverse dunes then transforming them into larger transverse and longitudinal dunes to the north and east that morph into star dunes further inland.

Within the Namib Sand Sea, several inselbergs crop out of their sandy surroundings, providing a harsh contrast in ecosystems and fascinating but crucial habitats within the dunescape. These inselbergs (literally meaning ‘island mountains’) divert the flow of sand and create diverse, unexpected dune-scapes. Rocky outcrops such as the Hauchab and Guinasib Mountains impede prevailing southerly winds, causing sand deposition and thus dune formations to curve around these obstacles. At the same time the inselbergs intercept fog and rainwater which flow off the bare expanses of rock to accumulate in cracks and crevices and support a richer fauna and flora than the surrounding dunes and desert plains. Similarly the gramadulla landscape towards the north-eastern extremity of the
identified Property provides incredible habitats and spectacular views augmenting the core area of the sand sea.

The complex dune systems of the Namib Sand Sea have been developing since the late Pliocene with incredible variations in colour of the dune sands. These range from pale yellow coastal dunes, often crowned by crests of deep red coarse garnet sand or black heavy minerals, to strongly coloured, pure red dunes on the Namib Sand Sea’s eastern margin. These amazing colour variations are mainly caused by progressively higher inland concentrations of iron oxide coatings on the quartz sand grains. This colour transition serves as an additional phenomenon to interpret the evolutionary history of contemporary and ancient Namib Sand Sea landscapes.

The Namib Sand Sea is responsible for the termination of two ephemeral watercourses, the Tsondab and Tsauchab, originating in the Great Western Escarpment. In contrast, a third, mightier ephemeral river, the Kuiseb, keeps the dunes at bay on the northern perimeter of the dune field. Thus sand thwarts floodwaters of the two lesser rivers flowing westward towards the Atlantic Ocean while intermittent Kuiseb floods impede the dunes of the Namib Sand Sea from extending northward onto the Namib peneplain. This ancient and continual interface of river and dune sands is repeatedly captured and well preserved within the primal as well as contemporary deposits in the lower reaches of the Kuiseb. There the Namib Sand Sea has relentlessly pushed the river northwards leaving behind fossil channels now deeply buried beneath seemingly immaculate sand dunes.

The Namib Sand Sea thus offers a universally outstanding example of aeolian landscapes created by the basal topography and pronounced seasonal changes in wind direction. Where sand is scarce and wind forces unidirectional, barchans form. Rapidly moving barchans gradually merge into massive yellow coloured, transverse dunes which further morph into orange linear, deep red star and other spectacularly shaped dunes. The moving and morphing dunes set the scene for interplay between the geomorphology and biology of the Namib Sand Sea ecosystem. As the dunes move forward across the desert surface, beetles, lizards and other small animals move along with the dunes while vegetation selectively establishes, grows, is covered and emerges again above the sand. This continues the dynamic interplay of wind, sand and life in the Namib Sand Sea.

**Criterion ix:** is an outstanding example representing significant on-going ecological and biological processes in the evolution and development of terrestrial ecosystems and communities of plants and animals.

The Namib Sand Sea is one of the most striking global demonstrations of the evolution and development of an arid terrestrial ecosystem. The number of diverse, superbly adapted dune-inhabiting endemic species, interacting through intricate food webs within a vivid environmental backdrop is unique relative to all other hyper-arid desert ecosystems. At first glance, the Namib may seem barren or even hostile, not readily revealing its extensive secrets. Though seemingly devoid of animal and plant life, the desert is inhabited by a surprisingly diverse and resilient biota, energized and regulated by interactions between various forces peculiar to arid zones. Not only is it composed of three different contrasting habitats (the dunes, dry riverbeds and gravel-covered interdune valleys)
but its inimitable ecosystems support all classes of living organisms. These range from plants and fungi to insects, arachnids, reptiles, birds and mammals thus allowing natural ecological interactions and processes to continue functioning in all their complexity.

Figure 3.a.3: The extreme aridity of the Namib Sand Sea is ameliorated by coastal fog and episodic rainfall events (van Schalkwyk)

Adaptation to the extremely harsh desert conditions dictates the evolution, speciation and specialisation of organisms. The fine, windblown dune sands of the Namib Sand Sea support very hot temperatures on the surface during the day with strong, direct incident radiation. Thus most of the Namib sand dune inhabitants are active in the morning or evening when surface microclimates are temporally moderate. Nevertheless, some species in the erg show exceptional physiological and behavioural adaptations to survive even the hottest conditions during the day. In addition, the high frequency of fog towards the coast has resulted in very rare behavioural adaptations to condense and harvest fog-water in these hyper-arid conditions. The abundant life in the dunes shows fascinating interactions to illustrate the relative importance of biotic constraints such as predation and competition in desert communities.

Wind blowing in the Namib Sand Sea is a daily occurrence, forever changing the landscape in an interplay of sand, wind and moisture, which sustains significant on-going ecological processes and interactions. Mobile barchan dunes carry beetles, lizards and other small animals with them over distances of tens of meters each year as they are gradually shifted around by winds. Patterns of alternating dunes, dry riverbeds and interdune valleys also have an effect on the distribution and speciation of plants and animals. Thus the Namib Sand Sea shows an amazing diversity in plant and animal life, some of which are geographically confined to relatively isolated parts of their sandy
homes. Dune movement has been on-going for millions of years and will continue indefinitely, therefore evolution and speciation in the Namib will never be a story of the past, but rather as contemporary as diurnal and seasonal changes evident in the erg.

In an undisturbed environment such as the Namib Sand Sea, structures, shapes and roles are not only conserved but also rejuvenated on a regular basis, creating new and breaking down old dune frameworks representing all stages of dune succession. The fascinating morphological, behavioural and physiological adaptations that enable a variety of endemic species to live in the Namib Sand Sea adjust continuously to the changing dunes. The astonishing specialisations, that allow for on-going ecological and biological processes in all types of dune habitats, have been studied, described and elucidated by scholars and scientists from around the world.

The Namib Sand Sea provides an outstanding study site or natural laboratory with its unique interplay of rocks, sand, wind and the cold Benguela current. This complexity makes it an internationally renowned reference area for primary examples of unravelling the evolutionary, physiological, behavioural, and ecological processes associated with desert ecosystems world-wide. Research documented in films, books, scientific papers and unpublished reports has been carried out in the Namib Desert for a century by a global array of researchers. The Namib Desert is undisputedly one of the prime locations in the world to study such contrasting habitats immediately juxtaposed to each other (sand dunes, interdune valleys, rocky outcrops, riverbeds and gravel plains). For an environment that is generally considered to be lifeless, the Namib Sand Sea always amazes those that have come to study and understand it. An anthology of research interests, topics and outputs by scientists from diverse professional fields and expertise from all different corners of the world attest to the lure of the Namib Sand Sea and its superlative array of organisms with highly specialised behavioural and physiological adaptations to the extreme desert climate. The gathered information has been broadcast globally by the world media to inform and educate the public at large about the resilience of biological communities and evolutionary processes that allow survival in extreme environments. This knowledge gained in the Namib Sand Sea also contributes significantly to understanding the threats of desertification and to developing appropriate responses to ameliorate the potential impacts of climate change. The Namib Sand Sea therefore provides insight into how humans, who are rapidly changing their own landscapes into less productive environments, could approach the future.

The inhabitants of the Namib Sand Sea have found unique and fascinating ways of dealing with arid, adverse conditions over small and large-scale, steep climatic gradients. In order to escape extremely hot or cold conditions on the sand surface, animals such as lizards, beetles and even the golden mole have evolved to quickly ‘dive’ or ‘swim’ into the loose, oxygenated sand of the Namib Sand Sea. Without having to excavate burrows, as is the case in other deserts, this swimming behaviour allows them swift escape strategies. Various microhabitats of the ever-mobile dunes in the sand sea create a plethora of ecological niches providing suitable conditions for avoidance of desert extremes. These variations contribute to the increase in number and diversity of fauna and flora of the Namib Sand Sea.

Plants have developed their own mechanisms to escape or tolerate the harsh conditions of the sand sea. Many plants adapted to the erg by becoming ephemeral or simply evolving very fleeting life
Dunes of the Namib Sand Sea offer a variety of habitats for plants and animals. The total amount of vegetated riverine oases and hard-surfaced interdunal plains offering life to rare and exotic animal species. The Namib Sand Sea is not only home to numerous animals but also an important, secure although dynamic seed bank for plants.

**Criterion X:** contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

The Namib Sand Sea stretches along the coast of Namibia to form one of the most spectacular natural habitats for in-situ conservation of biological diversity in the world. Despite its extreme aridity, a remarkable number of endemic plants and animals have evolved in this habitat, displaying ancient adaptations to life in soft sand. The Namib Sand Sea is wholly within the borders of the Namib Naukluft Park. This park protects other areas of the Namib Desert, one of the most pristine environments in the world, first proclaimed as a conservation area in 1907 and thus counting among the oldest conservation areas in the world. The Namib Sand Sea contains many different habitats that form the basis for ecological specialisation under extreme conditions along an environmental gradient. The rich, diverse habitats are of outstanding international importance for conservation of a variety of biological creatures in their natural place of evolutionary origin with outstanding universal scientific value.

The Namib is inhabited by a surprisingly diverse and resilient biota. A large and highly diverse segment of this biota is composed of more than 250 invertebrate species, more than 80% of them endemic to either the Namib Desert as a whole or the Namib Sand Sea in particular. Many of the highly adapted endemic dune species have evolved extraordinary tolerance and responses to acute climatic and substrate variability in the shifting mobile sand of the Namib Sand Sea. The Namib dunes harbour a high proportion of plant and animal life with important and unusual characteristics linked to a climate that is typically dry, sometimes foggy, highly variable and extremely harsh.

The extraordinary endemcity of living organisms in the Namib erg, as well as the outstanding and universal value that the study of their unique physiological and behavioural adaptations has contributed to science, are protected in the Namib-Naukluft Park. This park encompasses all habitats of the wind-swept dune field, from cool coastal desert to the hot, dry interior. The unbroken landscape of undulating dunes to the pediplains, of desert inselbergs and playas and of the windswept coastal plains to the stable dunes on the eastern desert margin are all well and truly represented within the nominated Property for in-situ biological conservation.

The Namib Sand Sea is an area of extraordinary beauty with three habitats (undulating dunes, vegetated riverine oases and hard-surfaced interdunal plains) offering life to rare and exotic animal species. Extensive and almost unbroken sandscapes stretch for a distance of approximately 300 km along the coast, and up to 120 km into the interior. Shaped by wind, sand and moisture dynamics, dunes of the Namib Sand Sea offer a variety of habitats for plants and animals. The total amount of
standing vegetation biomass able to establish and potentially fortify the structures of dunes is, in turn, determined by moisture availability. Varying degrees of dune sand stability from the base to the crest then offers a diversity of microhabitats able to support distinct fauna and flora. The end result is a complex multitude of niches exploited by an astonishing number of plant and animal organisms and thus significant natural habitats for in-situ conservation of biological diversity.

Figure 3.a.4: Diverse magnificent desert land forms populate the Namib Sand Sea (van Schalkwyk)
3.b PROPOSED STATEMENT OF OUTSTANDING UNIVERSAL VALUE

Brief synthesis: The boundaries of the envisaged World Heritage site, entirely within the protected Namib-Naukluft Park, encompass 3,077,700 hectares from the proximate source of sand on the coast to the final area of deposition some 100 km inland. The Namib Sand Sea along the arid African coast of the South Atlantic with its superlative, diverse, spectacular array of large, striking shifting dunes is an outstanding example of the scenic, geomorphological, ecological and evolutionary consequences of wind-driven processes interacting with geology and ecology. This Namib Sand Sea is globally unique, comprising a superimposed old and a young sand sea. The sand for both was transported by river, ocean current and wind more than 1,000 km from its source in the humid interior of eastern southern Africa. Life in the fog bathed coastal dunes of the Namib Sand Sea, and the behavioural and physiological adaptations that evolved throughout its specialist communities, are significant global examples for the evolution and development of a terrestrial ecosystem community and the resilience of life in extreme environments. The high diversity (>300 species) and endemicity (>50%) of the Namib Sand Sea biota are much greater than any other known hyper-arid, sand dune ecosystem. In-situ conservation of communities representing the turnover of endemic species from the cool coastal desert with frequent fog, to the hot, dry interior where more extreme aridity requires different strategies for survival, is ensured by the extensive, continuous habitat types across the full climatic gradient of the Namib Sand Sea.

Justification for criteria:

vii: Outstanding natural beauty of the Namib Sand Sea

The Namib Sand Sea encompasses vast panoramas of majestic dune-scapes, strikingly crystallised in sharply silhouetted forms continually transformed with wind and time. The striking range of spectacular dune forms and colours in an on-going interplay of contrasting shadow and light, combined with diverse, fascinating and bizarre plant and animal life, bestows a superlative, distinct natural beauty and aesthetic charm.

viii: Active geological processes of global significance

The Namib Sand Sea is composed of two superimposed dune systems, one semi-consolidated as old as 21 million years, the younger unconsolidated and active for about 5 million years, neither eroded in situ from the underlying substrate. Three contrasting, on-going sedimentary ‘conveyor belt systems’, the fluvial transport of the Orange River, a coastal long-shore drift and coastal on-shore winds, finally deposited the palaeo and modern dune systems in the Namib Sand Sea – representing outstanding geological processes of global significance. The Namib Sand Sea presents a universally outstanding example of extraordinary aeolian landscapes relentlessly sculpted by the basal topography and pronounced daily and seasonal changes in dominant wind directions. Remarkable examples of on-going desert geomorphic and physiographic features such as inselbergs isolated by encroaching dune fields, relict topography and sedimentary deposits from past climatic changes, endorhaeic river-end pans and exemplars of most desert geomorphic features are resplendently displayed in the Namib Sand Sea.
ix: On-going natural ecological dynamics that drive the evolution and interaction among Namib Sand Sea fauna and flora

The number of diverse, superbly adapted dune-inhabiting endemic species, in a hyper-arid environment with low net primary productivity, interacting through intricate food webs within a vivid environmental backdrop In the Namib Sand Sea is unique relative to all other hyper-arid desert ecosystems. The high frequency of fog towards the coast has given rise to very rare behavioural adaptations to condense and harvest fog-water in these hyper-arid conditions. In parallel, the well-oxygenated subsurface sand offers swift escape strategies from arid extremes for ‘swimming’ and ‘diving’ invertebrates, reptiles and mammals. Myriad microhabitats of the ever-mobile dunes of the Namib Sand Sea create a plethora of ecological niches for bizarre and fascinating ways of dealing with arid, adverse extremes over small and large-scale, steep climatic gradients.

x: Extraordinary diversity of endemic species of special significance to science and environmental understanding

The Namib Sand Sea imparts an unfragmented and pristine environment along a vast range of macro- and micro-climatic and habitat conditions that sustains a vast genetic diversity of species. These rich, diverse habitats are of outstanding international importance for conservation of a variety of diverse biological creatures in their natural place of evolutionary origin with confirmed, outstanding universal scientific value. The Namib Sand Sea exemplifies one of the most extensive, spectacular protected natural habitats for in-situ conservation of hyper-arid biological diversity in the world. More than 50% endemism, in some groups over 75%, in the more than 300 species of plants, invertebrates and vertebrates is safeguarded within the sand sea that covers 84% of the Property. Well-documented results from on-going scientific research and long-term monitoring are readily available to explain the biodiversity, ecological relationships and fluctuations in species presence and population changes. The Namib Sand Sea is wholly protected within the borders of the Namib-Naukluft Park with its long-term management programme and allocated funding.

Statement of integrity: The Namib Sand Sea is essentially a pristine environment within the borders of the Namib-Naukluft Park. The extensive dune-scapes are unspoilt and continuously refreshed and maintained by wholly natural processes. Permanent visitor and management infrastructure is non-existent within these boundaries and temporary occupation is restricted to small, temporary point locations that have no measurable effect on the well-known and well-researched geological, geomorphological, ecological, and biological processes of the Namib Sand Sea.

Requirements for protection and management necessary to maintain potential outstanding universal value: The 100-year long history of exclusionary regulations followed by conservation management interventions has informed and is available to inform future decisions about maintaining ecosystem processes not undermined by human exploitation. The Namib Sand Sea has been under conservation management for more than 50 years with well-established management and resource allocation systems, based upon a regularly revised and updated management plans and long-term budgetary planning. Key management issues today include managing the increasing demand for visitor access to pristine areas and precluding mineral exploration rights that would impact on the values and attributes of the area.
3.c COMPARATIVE ANALYSIS (INCLUDING STATE OF CONSERVATION OF SIMILAR PROPERTIES)

As an ancient, fog-dominated coastal desert environment, the Namib Sand Sea has no corresponding natural system on earth. The environment is produced and regulated by a cold ocean current and associated climatic conditions, is primarily characterised by hyper-aridity and is host to all major dune types and to some of the highest sand dunes in the world. The dominant wind conveyance system is disrupted by only sparsely occurring inselbergs and dry ephemeral river courses. Partly as a result of these climatic and geomorphological characteristics, the biodiversity of the Namib Sand Sea is greater than in any other dune deserts. A comprehensive analysis by Goudie and Seely\(^1\) mentioned some but not all of the comparative areas. A more recent document entitled Namib Sand Sea Comparison by Goudie is attached as Annex 3.

Coastal fog deserts are found on five continents, namely Africa, Asia, Australia, North America and South America. However, only one of these fog deserts, the Namib, contains sand dunes of any great extent influenced by the fog. Most of the other fog deserts have coastal dunes but not a major erg within the coastal desert. The exceptions are the coastal dunes in Mauritania and Oman, both of which represent extensions of larger dune fields, the Sahara and the Arabian desert.

Table 3.c.1: Coastal fog deserts of the world bordering on cold currents or oceanic upwelling systems

<table>
<thead>
<tr>
<th>Country</th>
<th>Fog desert</th>
<th>Oceanic current</th>
<th>Dunes*</th>
<th>Biota</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Australia</td>
<td>East Indian Ocean</td>
<td>+</td>
<td>Variable states of conservation</td>
</tr>
<tr>
<td>Chile &amp; Peru</td>
<td>Atacama</td>
<td>Humboldt Current</td>
<td>+</td>
<td>Lomas vegetation; algae, lichens, cactus; not well conserved; no management plans</td>
</tr>
<tr>
<td>Mauritania, Banc d’Arguin National Park, Ramsar, WHS</td>
<td>Sahara</td>
<td>Cape Verde upwelling</td>
<td>++</td>
<td>World’s largest concentration of wintering shorebirds; Ramsar and WHS well conserved, not further inland</td>
</tr>
<tr>
<td>Mexico</td>
<td>Baja California</td>
<td>California Current</td>
<td>+</td>
<td>Xeric shrubs; not well conserved, no management plan</td>
</tr>
<tr>
<td>Namibia (includes Ramsar Site)</td>
<td>Namib</td>
<td>Benguela Current</td>
<td>+++</td>
<td>Sparse dune vegetation, diverse endemic invertebrates; well conserved</td>
</tr>
<tr>
<td>Oman &amp; Yemen</td>
<td>Arabian Peninsula Coastal Fog Desert</td>
<td>Monsoon driven upwelling</td>
<td>+</td>
<td>Dhofar Mtns: 60 endemic plant species; large mammals &amp; predators; no management plan</td>
</tr>
</tbody>
</table>

\(^*+ = \) limited dune occurrence; \(^++ = \) extensive dune occurrence

\(^1\) Goudie and Seely 2011. World Heritage Desert Landscapes, IUCN.
The Namib Sand Dune Sea is the only coastal aeolian desert underlain by a previous desert from the same external origins and having experienced the same atmospheric, oceanic and terrestrial controls. The Atacama Desert is perhaps the closest analogue to the Namib Desert with extensive fog and great antiquity.

Comparative analysis reveals one single desert, the Atacama Desert on the Pacific Coast of South America as somewhat equivalent to the Namib Desert in terms of its situation and climate. The Atacama lies in the rain-shadow of the Andes Mountains off the Chilean coast (comparable to the Great Western Escarpment of Western Namibia) and is under the influence of an inversion layer induced by the cold offshore Humboldt Current (similar to the Benguela Current influence). It too is straddling the Tropic of Capricorn and is reputedly the driest desert on earth. However, the Atacama Desert does not display the aeolian land form features of the Namib Sand Sea. In terms of biodiversity, the Atacama Desert is comparatively devoid of life and does not compare to the Namib Sand Sea with its rich array of endemic organisms.

Smaller coastal deserts elsewhere (Arabia, Australia, India, North America) are not comparable in size or ecology to the Namib or Atacama Deserts. Similar desert ergs with vast dune landscapes occur elsewhere in the world and include the Arabian, Gobi, Sahara and TaklaMakan Deserts. However, only a few localities in middle-eastern desert landscapes of Iran, Iraq and Saudi Arabia, or the Gobi in China, boast sand dunes that may approximate those found in the Namib erg in size or height. In terms of biodiversity, the concentration of morphological, physiological and behavioural adaptation to hyper-arid dune habitats as found in the Namib erg is unmatched by any other aeolian desert systems in the world. This is coupled to the high degree of endemicity among the Namib dune field’s biotic communities and thus the ecology of the area.

The scientific contribution that has been made by scholars studying the diverse geological, geomorphological, ecological and evolutionary processes of the Namib erg is outstanding. It continues to be augmented by ongoing work at the world-renowned Gobabeb Training and Research Centre on the northern banks of the Kuiseb River that form the northern edge of the nominated Property. Most other desert research is conducted by university research groups or institutions, which do not have facilities with long-term researchers situated within the desert. The exceptions are Australia where Alice Springs and other CSIRO-affiliated institutions are situated in the interior arid areas of Australia. Similarly, Repetek in Turkmenistan is a continuously occupied research station in the MAB Biosphere Reserve of UNESCO located in the cold winter desert of the East Karakum Desert.

It is evident from this overview that there are very large gaps in the coverage of desert landscapes and geomorphological features in existing World Heritage properties. In particular it is clear that the most distinctive land forms and land forming processes of deserts - aeolian features - are not reflected in the World Heritage List. This is the case for dunes, yardangs, pans, dust sources and coastal sabkhas, and this is also true for weathering forms and various types of crust, rind and varnish not directly analogous to the Namib Sand Sea. It is also true for various Quaternary phenomena (e.g. ancient river systems and pluvial lakes) and some highly important fluvial phenomena, including alluvial fans, pediments and debris flow phenomena only secondarily represented in the identified Property (Table 3.c.2).
### Table 3.c.2: Biophysical elements of the Namib Sand Sea in comparison with other fog-bathed, dune deserts.

<table>
<thead>
<tr>
<th>Characteristics of the Namib Sand Sea</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Its fogginess, aridity and clear climatic gradient inland, which makes it an ideal dune location for testing, <em>inter alia</em>, the way in which weathering processes operate in dune deserts</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>Its antiquity, which though not unique, is substantial</td>
<td>Requires further research</td>
</tr>
<tr>
<td>The ancient aeolianite erg that underlies the modern erg</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>The three-part conveyor system which transported sand from the interior of South Africa and Lesotho to the coast and along the coast northwards and back onto land into the ancient and modern Namib Sand Seas</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>The presence of a comprehensive suite of well-developed dune forms that make it an ideal model to study dunes in the context of a whole erg</td>
<td>No other dune landscape has a comparable diversity in a relatively small area</td>
</tr>
<tr>
<td>The relationships between dunes and rivers and dunes and coastal structures</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>The pattern of colouration across the erg</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>The size of some of its dunes, which are among the highest in the world</td>
<td>Not exceptional size, but especially accessible</td>
</tr>
<tr>
<td>The utility of the Namib as a model for planetary aeolian and weathering forms on Mars and other celestial bodies</td>
<td>Accessible but not exceptional</td>
</tr>
<tr>
<td>The long term data that are available on rates of dune crest migration</td>
<td>No known comparable data set</td>
</tr>
</tbody>
</table>

The existing World Heritage List has relatively few desert properties, and those that exist are not noted for the development of their dune forms. The proposed Namib Property has been the subject of intensive research, has been mooted as a World Heritage Site and it is apparent that in global terms it is notable for a variety of characteristics.

These same fog influenced dune forms of the proposed Namib Sand Sea Property are remarkable in global terms from an ecological point of view as well (Table 3.c.3).
Table 3.c.3: Ecological elements of the Namib Sand Sea in comparison with other fog-bathed, dune deserts.

<table>
<thead>
<tr>
<th>Characteristics of the Namib Sand Sea</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Its fogginess, aridity and clear climatic gradient west to east and south to north, make it an ideal location for comparative study of desert dune adaptations and physiology under different moisture regimes</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>Its diversity of dune types, from barchans to transverse to linear to star dunes, provides a variety of habitats used differentially by elements of the dune flora and fauna</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>Its diversity of micro-habitats across one sand dune, e.g. interdune, dune base, plinth, slipface, crest makes available a variety of niches for zonation of dune flora and fauna</td>
<td>Microhabitats not exceptional but associated fauna with no known comparable examples</td>
</tr>
<tr>
<td>The apparently unique absence of very fine silt among the sand grains allows diffusion of sufficient oxygen beneath the sand surface to support the evolution of a multiplicity of ‘sand swimming’ fauna that do not use burrows</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>The juxtaposition and long-term variability of dunes, ephemeral rivers, inselbergs and underlying Tsondab Sandstone provided the basis for evolution of a highly endemic fauna and flora over aeons</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>The juxtaposition of dunes, ephemeral rivers, inselbergs and underlying Tsondab Sandstone provides further opportunity for comparative studies as well as investigations of biogeographic interactions among fauna and flora based in the different habitats</td>
<td>Exceptional opportunities with no comparably diverse examples</td>
</tr>
<tr>
<td>The presence of ancient aeolianite erg of Tsondab Sandstone underlying the sand dunes provides an almost continuous long-term record of dune biota presence and evolution in the Namib Sand Sea</td>
<td>No comparable examples</td>
</tr>
<tr>
<td>The long-term monitoring results pertaining to climate, vegetation, invertebrates, birds and mammals, and ongoing research at the Gobabeb Training and Research Centre provide a firm background for evolving research topics and applications</td>
<td>No known comparable data set</td>
</tr>
</tbody>
</table>

Paragraph 132 of the Operational Guidelines expects “A comparative analysis of the property in relation to similar properties, whether or not on the World Heritage List, both at the national and international levels, shall also be provided. The comparative analysis shall explain the importance of the nominated property in its national and international context.” This is expected to be carried out for each individual criterion. The above summary highlights the main elements of why the Namib Sand Sea is special, particularly in terms of other sites inscribed as World Heritage for each of the criteria for which the Namib Sand Sea are being nominated.

Criterion vii: The World Heritage List contained 131 properties with 6 transboundary properties inscribed under this criterion in 2011. As “exceptional natural beauty and aesthetic importance” is such a ubiquitous value for almost any site that may be considered for nomination and is a special
attribute of hyper-arid desert landscapes, it was not feasible to consider sites on the tentative lists of state parties for comparison. It is accepted that almost any desert landscape to be nominated will have attributes expressing exceptional natural beauty as is the case for the Namib Sand Sea. Particularly relevant are inscribed desert sites that include: Tassili n’Ajjer, Uluru-Kata Tjuta National Park, Wadi Rum Protected Area, Cliff of Bandiagara (Land of the Dogons), and Grand Canyon National Park. Of these, only the Grand Canyon does not include sand dunes as an attribute (Table 3.c.4). The scenic beauty of the dune morphology sites specifically inscribed for this criterion as well as areas with dunes listed in Table 3.c.1 will have many attributes similar to that of the Namib Sand Sea. The scenery resulting from superlatively sized dunes as in the Namib Sand Sea is, however, not represented in any site currently inscribed under Criterion vii.

Table 3.c.4: Comparison of the Namib Sand Sea with desert World Heritage Sites inscribed under Criterion vii

<table>
<thead>
<tr>
<th>Country</th>
<th>Name of Property</th>
<th>Dunescapes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Uluru-Kata Tjuta National Park</td>
<td>Yes</td>
</tr>
<tr>
<td>Jordan</td>
<td>Wadi Rum Protected Area</td>
<td>Yes</td>
</tr>
<tr>
<td>Mali</td>
<td>Cliff of Bandiagara (Land of the Dogons)</td>
<td>Yes</td>
</tr>
<tr>
<td>Niger</td>
<td>Air and Ténéré Natural Reserves</td>
<td>Yes</td>
</tr>
<tr>
<td>USA</td>
<td>Grand Canyon National Park</td>
<td>No</td>
</tr>
</tbody>
</table>

A popular aspect of the Namib Sand Sea used for marketing is the size of the dunes, purportedly ‘the highest dunes in the world’, but also under Criterion vii for “superlative natural phenomena”. The superlatively sized dunes of the Namib Sand Sea are not the highest dunes in absolute terms (Table 3.c.5), though their unparalleled accessibility allows visitors to fully appreciate that size. None of the sites in Table 3.c.5 has been inscribed and only the Namib Sand Sea has been nominated.

Table 3.c.5: Dune height in the Namib Sand Sea in comparison with other massive dunes

<table>
<thead>
<tr>
<th>Height (m)</th>
<th>Country</th>
<th>Desert</th>
<th>Location</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1176</td>
<td>Peru</td>
<td>Sechura Desert</td>
<td>Cerro Blanco</td>
<td>Stationary dune</td>
</tr>
<tr>
<td>500</td>
<td>China</td>
<td>Gobi Desert</td>
<td>Badain Jaran</td>
<td>Stationary dunes</td>
</tr>
<tr>
<td>470</td>
<td>Iran</td>
<td>Lut Desert</td>
<td>Rig-e Yalan Dune</td>
<td>Unstable dunes</td>
</tr>
<tr>
<td>465</td>
<td>Algeria</td>
<td>Sahara Desert</td>
<td>Tifernine Sand Sea</td>
<td>Unstable star dunes</td>
</tr>
<tr>
<td>380</td>
<td>Namibia</td>
<td>Namib Sand Sea</td>
<td>Sossus Vlei</td>
<td>Unstable star dunes</td>
</tr>
<tr>
<td>280</td>
<td>Australia</td>
<td>Namib Sand Sea</td>
<td>Mount Tempest, Moreton Island</td>
<td>Stationary coastal dune</td>
</tr>
<tr>
<td>230</td>
<td>USA</td>
<td>Great Sand Dunes National Park</td>
<td>Star Dune</td>
<td>Stationary dunes, clay rich</td>
</tr>
<tr>
<td>105</td>
<td>France</td>
<td></td>
<td>Pilat Dune</td>
<td>Stationary coastal dune</td>
</tr>
<tr>
<td>200</td>
<td>China</td>
<td>Taklamakan Desert</td>
<td>Ming-Sha Dunes</td>
<td>Stationary and unstable barchan dunes</td>
</tr>
<tr>
<td>190</td>
<td>Mongolia</td>
<td>Khongorin Els</td>
<td>Khongor</td>
<td>Stationary dunes</td>
</tr>
</tbody>
</table>
The information in Table 3.c.5 was gleaned through an internet search using a variety of search terms and search engines (carried out 29 October 2011). Dune size comparisons between different regions of the world do not feature in geomorphological literature as the size and scale of individual dunes, including height, is determined by a range of factors such as grain size, silt and clay fraction, soil moisture, wind directions and speed, sand supply, distance from source, vegetation, basement topography, and nearby land forms. No attempt has been made to analyse any of these factors as the lack of scientific studies precludes objective comparison.

**Criterion viii:** The relevancy of this criterion was discussed above. The World Heritage List in October 2011 contained 80 properties with eight transboundary properties inscribed under Criterion viii. This criterion encapsulates four distinct, although closely linked, elements as discussed by Badman et al.². It is contended that the Namib Sand Sea in any context, also outside desert environments, represents exceptionally significant examples of earth’s history, on-going geological processes in the development of land forms and geomorphic or physiographic features. The report by Dingwall et al.³ specifically did not systematically identify possible new sites for nomination as theme reports such as Goudie and Seely² envisaged. Comparison of the geomorphic features of the Namib Sand Sea with those listed in Table 3 of the latter document indicate that the Namib Sand Sea includes the majority of features (Table 3.c.6), many of which are inadequately represented in the current list of World Heritage properties. Most of the inscribed properties were listed for their fossil, erosional, or volcanic features. Only the Willandra Lakes Region in Australia has been inscribed for sedimentary deposition, in particular its pans and lunette dunes, though rather for the fossil nature of those features than as a global example or ongoing geological process. None of the inscribed sites is comparable to the Namib Sand Sea in those terms and none of the inscribed desert sites includes the range of aeolian dune types as is found in the Namib Sand Sea.

**Table 3.c.6: Geomorphic features of the Namib Sand Sea and those of other inscribed World Heritage sites (after Table 3 in Goudie and Seely)**

<table>
<thead>
<tr>
<th>Geomorphic features</th>
<th>Namib Sand Sea</th>
<th>Other inscribed sites and locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeolian features</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dunes</td>
<td>Spectacular diversity, size and extent</td>
<td>Willandra Lakes Region (Australia) (small linears and lunettes), Air and Ténéré Natural Reserves (Niger), Wadi Rum (Jordan)</td>
</tr>
<tr>
<td>Yardangs</td>
<td>Present (small)</td>
<td></td>
</tr>
<tr>
<td>Pans</td>
<td>Present (27.7 km²)</td>
<td>Willandra Lakes Region (Australia), Península Valdés (Argentina)</td>
</tr>
<tr>
<td>Dust storms and deflation surfaces</td>
<td>Frequent</td>
<td></td>
</tr>
<tr>
<td>Coastal sabkhas</td>
<td>Present</td>
<td>Banc d’Arguin (Mauritania)</td>
</tr>
</tbody>
</table>

² Badman et al. 2008. Outstanding universal value: Standards for natural world heritage. IUCN.
### Weathering forms, processes and surface materials

<table>
<thead>
<tr>
<th>Feature</th>
<th>Status</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium nitrate crusts</td>
<td>Absent</td>
<td>Humberstone and Santa Laura Saltpeter Works (Chile) (cultural property)</td>
</tr>
<tr>
<td>Gypsum crusts (gypcrete)</td>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>Calcium carbonate crusts (calcrete)</td>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>Salts and salt weathering</td>
<td>Present (insignificant)</td>
<td>Wadi Rum (Jordan)</td>
</tr>
<tr>
<td>Cavernous weathering forms (tafoni and alveoles)</td>
<td>Present (insignificant)</td>
<td>Rock-Art Sites of Tadrart Acacus (Libya), Tassili n’Ajjer (Algeria) (cultural property)</td>
</tr>
<tr>
<td>Desert varnishes and rinds</td>
<td>Present</td>
<td>Twyfelfontein or /Ui-/aes (Namibia) (cultural property)</td>
</tr>
<tr>
<td>Desert karst and tufa deposition</td>
<td>Present (insignificant)</td>
<td>Purnululu National Park (Australia) (sandstone only)</td>
</tr>
</tbody>
</table>

### Fossil lakes and other pluvial evidence

<table>
<thead>
<tr>
<th>Feature</th>
<th>Status</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relict weathering profiles</td>
<td>Present</td>
<td>Wadi Rum (Jordan)</td>
</tr>
<tr>
<td>Lake basins with palaeo shorelines</td>
<td>Absent (present around pans)</td>
<td>Lake Turkana National Parks (Kenya)</td>
</tr>
<tr>
<td>Ancient river systems</td>
<td>Present (&gt;500 km²)</td>
<td></td>
</tr>
</tbody>
</table>

### Fluvial and slope processes and forms

<table>
<thead>
<tr>
<th>Feature</th>
<th>Status</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ephemeral stream channels (wadis)</td>
<td>Present (29 km²)</td>
<td>Grand Canyon National Park (USA)</td>
</tr>
<tr>
<td>Badlands/gramadullas</td>
<td>Present (953 km²)</td>
<td>Dinosaur Provincial Park (Canada), Ischigualasto/Talampaya Natural Parks (Argentina) (natural sites listed primarily for fossil values)</td>
</tr>
<tr>
<td>Pediments</td>
<td>Present (&gt;2000 km²)</td>
<td></td>
</tr>
<tr>
<td>Sheetflood activity</td>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>Inselbergs</td>
<td>Present (270 km²)</td>
<td>Uluru-Kata Tjuta National Park (Australia)</td>
</tr>
<tr>
<td>Sand ramps</td>
<td>Present (very large)</td>
<td>Wadi Rum (Jordan)</td>
</tr>
<tr>
<td>Alluvial fans</td>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>Debris flows</td>
<td>Present</td>
<td>Wadi Rum (Jordan)</td>
</tr>
<tr>
<td>Groundwater sapping</td>
<td>Present (insignificant)</td>
<td>Grand Canyon National Park (USA), Wadi Rum (Jordan)</td>
</tr>
<tr>
<td>Natural arches</td>
<td>Absent</td>
<td>Rock-Art Sites of Tadrart Acacus (Libya) (cultural property), Wadi Rum (Jordan)</td>
</tr>
</tbody>
</table>
**Criterion ix:** The phrase “significant on-going ecological and biological processes in the evolution and development of terrestrial ... ecosystems and communities of plants and animals” could have been specially wordsmithed to describe the ecological processes of the Namib Sand Sea. The World Heritage List contained 109 properties with seven transboundary properties inscribed under Criterion ix. The Namib Sand Sea is a fogbound coastal desert, thus the delisted Arabian Oryx Sanctuary in Oman would have been the only directly comparable site. Table 3.c.3 highlights the ecological elements that resulted in the distinctive hyper-arid biota of the Namib Sand Sea. In a wider evolutionary context, the Namib Sand Sea may be considered to simply represent a desert site that should be compared with other similar sites, or that it represents an ecological ‘island’ as the only hyper-arid area in sub-Saharan Africa. Table 3.c.7 reflects other desert sites, sites dominated by sandy substrates, and sites with comparable significance in understanding evolutionary processes.

**Table 3.c.7: Comparison of the Namib Sand Sea with World Heritage Sites inscribed under Criterion ix**

<table>
<thead>
<tr>
<th>Country</th>
<th>Name of Property</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecuador</td>
<td>Galápagos Islands</td>
<td>Speciation, Island ecology</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>Saryarka – Steppe and Lakes of Northern Kazakhstan</td>
<td>Wetland ecology, Ramsar Site</td>
</tr>
<tr>
<td>Mauritania</td>
<td>Banc d’Arguin National Park</td>
<td>Wetland ecology, Ramsar Site</td>
</tr>
<tr>
<td>Mexico</td>
<td>Islands and Protected Areas of the Gulf of California</td>
<td>Speciation, Desert ecology</td>
</tr>
<tr>
<td>Niger</td>
<td>Air and Ténéré Natural Reserves</td>
<td>Refugia, Desert ecology</td>
</tr>
<tr>
<td>Spain</td>
<td>Doñana National Park</td>
<td>Wetland ecology</td>
</tr>
<tr>
<td>Seychelles</td>
<td>Aldabra Atoll</td>
<td>Speciation, Island ecology</td>
</tr>
<tr>
<td>USA</td>
<td>Grand Canyon National Park</td>
<td>Altitudinal and Desert ecology</td>
</tr>
<tr>
<td>Namibia</td>
<td>Namib Sand Sea</td>
<td>Speciation, Desert ecology, Refugia, Physiological and Behavioural ‘island’ evolution, includes Ramsar Site</td>
</tr>
</tbody>
</table>

The Air and Ténéré Natural Reserves and Banc d’Arguin National Park are Warm Desert Biome representatives in the Afrotropical Realm (after Udvardy). The Air and Ténéré Natural Reserves have been on the List of World Heritage in Danger since 1992 and their state of conservation creates grave concern over the incessant degradation of the Outstanding Universal Value (OUV) of the Property (35COM 7A.11).

The Banc d’Arguin National Park was inscribed under Criterion ix for its wetland ecology. The boundaries of the Namib Sand Sea include a Ramsar Site at Sandwich Harbour that is considered to be a secondary attribute and therefore not compared to other similar sites. It could have been argued that the Namib Sand Sea should have been considered simply as other Afrotropical desert sites with secure conservation status not represented on the World Heritage List. However, it also represents the climatic extremes of the isolated Namib Desert Biogeographic Province which was suggested in 2004 as a future priority for a credible and complete list of natural and mixed sites (WHC-04/28.COM/INF.13B).
Biogeographic considerations for the Namib Sand Sea refer simply to its geographical location and associated climate. The specific attributes to carry its OUV are, however, associated with the extraordinary morphological, physiological and behavioural adaptations of a complex biota to unconsolidated sand surfaces and reliance on fog as a moisture source. It augments a suite of extraordinary natural evolutionary laboratories such as the Galápagos Islands, the Islands and Protected Areas of the Gulf of California, Grand Canyon National Park, Aldabra Atoll, Socotra Archipelago, Lake Malawi National Park and Lake Baikal. None of those sites, as is the case with the Namib Sand Sea, can be effectively compared to any other area, as their evolutionary histories are intimately bound to the ecological elements that define them (Table 3.c.3). The ecological context of the Namib Sand Sea is therefore not representative of the entire Namib Desert Biogeographic Province even though the evolutionary responses of its biota have, as can be expected, many convergent similarities with those in other Namib ecosystems.

Criterion x: At the time of nomination, the World Heritage List contained 129 properties with five transboundary properties inscribed under Criterion x. There are 31 properties and one transboundary property inscribed from the Afrotropical Realm (after Udvardy), of which Lake Turkana National Parks, Air and Ténéré Natural Reserves, Banc d’Arguin National Park, Ichkeul National Park and

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**Figure 3.c.1:** The Namib Sand Sea in the context of Udvardy Biomes (http://www.fao.org/geonetwork/srv/en/metadata.show?id=1008)

**Figure 3.c.2:** Endemism and species richness of taxa in the Namib Sand Sea
Socotra Archipelago are in arid or desert settings. The biodiversity values of Banc d’Arguin National Park and Ichkeul National Park are essentially as stopovers and destinations for hundreds of thousands of migrating birds (as is also the case for Saryarka – Steppe and Lakes of Northern Kazakhstan and to a lesser degree Doñana National Park). None of these sites shall be considered further although they may relate to the Sandwich Harbour Ramsar Site that contributes to the overall biodiversity values of the Namib Sand Sea. Additional World Heritage sites that were considered include Ningaloo Coast, Galápagos Islands, Islands and Protected Areas of the Gulf of California, Aldabra Atoll, Grand Canyon National Park and Yellowstone National Park.

Biodiversity includes all organisms, species, and populations; the genetic variation among these; and all their complex assemblages of communities and ecosystems. It also refers to the interrelatedness of genes, species, and ecosystems and their interactions with the environment. Though biodiversity is usually discussed in terms of three levels – genetic, species, and ecosystem diversity – this comparative analysis is based on two aspects alone – species richness and endemity (Table 3.c.8). The combination of these two levels is an accepted measure reflecting biodiversity. Additional issues to consider are biogeographic coverage, the number of globally threatened species and economically important species and their wild relatives. These guidelines are deceptively simple as biogeographic coverage is the only information readily available. Species richness may also be forthcoming in some cases but may give a deceptive view of the Property. For example, 83.5% of the more than 3,077,700 hectares of the Namib Sand Sea consists of the sand dune habitat that is the core of this nomination. The high degree of endemity in most classes (Figure 3.c.2) is a prominent feature of the biodiversity, even though overall species richness is relatively low (as is also the case for the Galápagos Islands). Endemity of some Namib Sand Sea invertebrate taxa is as high as for groups in that iconic example of insular evolution.

<table>
<thead>
<tr>
<th>Group</th>
<th>Endemics</th>
<th>Sand sea habitat</th>
<th>Whole Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants</td>
<td>8</td>
<td>15</td>
<td>265</td>
</tr>
<tr>
<td>Arachnids</td>
<td>37</td>
<td>44</td>
<td>138</td>
</tr>
<tr>
<td>Insects</td>
<td>108</td>
<td>207</td>
<td>1388</td>
</tr>
<tr>
<td>Rest of invertebrates</td>
<td>0</td>
<td>5</td>
<td>54</td>
</tr>
<tr>
<td>Reptiles</td>
<td>8</td>
<td>18</td>
<td>71</td>
</tr>
<tr>
<td>Birds</td>
<td>1</td>
<td>9</td>
<td>301</td>
</tr>
<tr>
<td>Mammals</td>
<td>2</td>
<td>12</td>
<td>75</td>
</tr>
</tbody>
</table>

If the overall species richness of the Namib Sand Sea is considered, species numbers rise dramatically. It highlights that the usefulness of taxonomic checklists, as a measure for rapid assessment and broad definition of important areas for biodiversity conservation, should be augmented by more specific arguments. The overall biodiversity of the Namib Sand Sea is a secondary attribute related to the interdigitation of an array of habitats essential for the wholeness of the geological and aesthetic attributes of the Namib Sand Sea (Criteria vii and viii). They add a layer of ecological diversity that illustrates the interaction between the species complexes of the sand sea habitat with associated desert communities (Criterion ix) that is particularly important for understanding the evolutionary

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history of the high degree of endemism. Habitat complexity and the vibrant communities in functional ecosystems that are not related to arid terrestrial systems, e.g. the wetlands of the Sandwich Harbour Ramsar Site, the marine littoral of the Benguela oceanic province, savannah corridors along the ephemeral rivers, and the Succulent Karoo outliers in the south, all contribute to the overall biodiversity values of the Property.

The Namib Desert Biogeographical Province has not been considered particularly outstanding from a global biodiversity perspective in previous thematic studies⁵. Assessments from other prioritisation programmes such as WWF Global 200 Ecoregions, Conservation International’s Global Biodiversity Hotspots, Centres of Plant Diversity, Endemic Bird Areas and IUCN’s Red List of Threatened Animals recognise the significance of the Namib Desert Biogeographical Province and its species without being concerned about them. It is not an omission or disregard for its species richness and endemism, but a reflection of the security offered to the biota through a long history of conservation success and sustainable environmental exploitation. Annexes 10-17 indicate where possible the distribution status of the biota, of which all near endemics are endemic to the biogeographical province and arid-area specialists are endemic to the much larger southern African arid zone. Despite the restricted ranges of many groups, the long-term protection that ensures habitat security and shields the biota resulted in a low degree of endangered, threatened or vulnerable species.

The state of conservation of the Namib Sand Sea that shelters its biota stands in sharp contrast to the sites such as and Air and Ténéré Natural Reserves that have been on the List of World Heritage in Danger since 1992 with many of the species contributing to its OUV for inscription being extinct in the Property (35COM 7A.11) and the Arabian Oryx Sanctuary, which would have been the most comparable World Heritage site to the Namib Sand Sea. The latter was delisted in 2007 after conservation of the Property has deteriorated to the extent that it has lost its Outstanding Universal Value and integrity (31COM 7B.11). The biological systems of the other comparable site in Africa, Lake Turkana National Parks, that are the basis of its inscription on the List of World Heritage under Criterion x are in imminent danger and may be considered in future as a World Heritage site in Danger [35COM 7B.3 - Lake Turkana National Parks (Kenya) (N 801bis)]. Even though the latter is not through neglect of its obligations by the State Party, it illustrates the present security of the Namib Sand Sea’s state of conservation.

Figure 3.c.3: An Oryx gazella against a backdrop of Namib Sand Sea dunes (Gobabeb Centre)

The Namib Sand Sea is one of the better studied desert systems world-wide as reflected in the quality of ecological and biodiversity information that is available. Comparison with other areas, whether world heritage or not, requires similar levels of information that are not readily available. Annex 8 in Goudie and Seely 2011 (World Heritage Desert Landscapes. IUCN) reflects some of the knowledge about the biodiversity of desert landscapes that is available. That information was supplemented by additional information gleaned from other thematic or biodiversity studies on well-known biodiversity hotspots that are potentially comparable to the Namib Sand Sea (Table 3.c.6). It was not feasible to do a breakdown of that information to specific ecosystems within those properties to compare to the sand sea habitat, thus the overall species richness of the Namib Sand Sea was used for comparison. It was presumed that the Namib Sand Sea would not compare well. A hyper-arid desert system with only substrate and climatic dispersal barriers may be expected to be less diverse than more productive ecosystems as reflected by plant taxa. However, it compared surprisingly well to other world heritage properties inscribed for their biodiversity values.

Table 3.c.9: Comparison of biodiversity values in the Namib Sand Sea to other desert and World Heritage properties inscribed under Criterion x

<table>
<thead>
<tr>
<th>Place</th>
<th>Type of Desert</th>
<th>Vascular Plants</th>
<th>Vertebrates</th>
<th>Invertebrates</th>
<th>Endemics Plants</th>
<th>Vertebrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arches National Park</td>
<td>Plains desert</td>
<td>2556</td>
<td>489</td>
<td>?</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bodélé Depression</td>
<td>Plains desert</td>
<td>500</td>
<td>335</td>
<td>?</td>
<td>?</td>
<td>3</td>
</tr>
<tr>
<td>Death Valley</td>
<td>Plains desert</td>
<td>2490</td>
<td>498</td>
<td>?</td>
<td>?</td>
<td>3</td>
</tr>
<tr>
<td>Lut Desert</td>
<td>Plains desert</td>
<td>900</td>
<td>483</td>
<td>?</td>
<td>?</td>
<td>5</td>
</tr>
<tr>
<td>Western Desert and Bagnold Dunes</td>
<td>Plains and sand-dune desert</td>
<td>500</td>
<td>335</td>
<td>?</td>
<td>?</td>
<td>3</td>
</tr>
<tr>
<td>Galápagos Islands</td>
<td>Arid interior</td>
<td>543</td>
<td>252</td>
<td>2289</td>
<td>236</td>
<td>93</td>
</tr>
<tr>
<td>Aldabra Atoll</td>
<td>Island</td>
<td>185</td>
<td>106</td>
<td>?</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Socotra Archipelago</td>
<td>Island</td>
<td>825</td>
<td>236</td>
<td>800</td>
<td>308</td>
<td>38</td>
</tr>
<tr>
<td>Ningaloo Coast</td>
<td>Arid shrubland</td>
<td>630</td>
<td>329</td>
<td>?</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Gulf of California</td>
<td>Arid shrubland</td>
<td>238</td>
<td>295</td>
<td>?</td>
<td>50</td>
<td>23</td>
</tr>
<tr>
<td>Réserve de la Biosphère El Pinacate et le Grand désert d’Altar</td>
<td>Arid desert</td>
<td>560</td>
<td>324</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Grand Canyon National Park</td>
<td>Arid shrubland</td>
<td>1737</td>
<td>463</td>
<td>?</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Yellowstone National Park</td>
<td></td>
<td>1350</td>
<td>399</td>
<td>?</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Great Gobi Desert</td>
<td>Arid desert</td>
<td>410</td>
<td>214</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Repetek Biosphere State Reserve (Karakum Desert)</td>
<td>Arid desert</td>
<td>269</td>
<td>254</td>
<td>1343</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Namib Sand Sea</td>
<td>Hyper-arid desert</td>
<td>265</td>
<td>446</td>
<td>1580</td>
<td>8</td>
<td>11</td>
</tr>
</tbody>
</table>
Attempts to compare the biodiversity values of the Namib Sand Sea with sites on the tentative lists of other State Parties, e.g. the Grand Erg Occidental (Algeria), the San Pedro de Atacama (Chile – for cultural attributes), the Taklimakan Desert — *Populus euphratica* Forests (China), the Great Desert Landscapes (Egypt), the Desert National Park (India) in the Thar Desert, and Khor Al-Adaid Natural Reserve (Qatar) in the Arabian Desert were not feasible as the level of information that could be sourced is inadequate for comparative purposes.

Criteria vii to x – global comparison: The 936 properties on the World Heritage List in November 2011 included 183 natural and 28 mixed properties. Of these, 20 properties with two transboundary properties were inscribed under all four natural criteria. Inscribed sites considered to be of particular significance for comparison to the Namib Sand Sea include the Great Barrier Reef, Galápagos Islands, and Grand Canyon National Park, either because the combination of aesthetics and active geological processes is integral to the ecological and biodiversity values (Great Barrier Reef), or for their arid features (Galápagos Islands, Grand Canyon National Park). Other listed properties such as Volcanoes of Kamchatka, Lake Baikal and Yellowstone National Park were only briefly considered, as the geological values refer to the setting against which backdrop the ecology and biodiversity values are exhibited. The biodiversity values of Shark Bay, Western Australia and Ngorongoro Conservation Area are spectacular, but endemism is low.

The altitudinal ecological succession and associated biodiversity changes that contribute to the very high species richness of the Grand Canyon National Park is the consequence of down-cutting and erosion of the Colorado River. The steep ecological gradient from arid conditions at the bottom of the sun-baked canyon to mountain woodland vegetation on the canyon rim is very different to the Namib Sand Sea.

The extreme isolation of the Galápagos Islands and the steep ecological gradients from the coastal zone through widespread arid zones to the higher elevation humid zones are products of the volcanic origin of the islands. The humidity results from dense fog intruding over land from the adjacent ocean as is also found in the Namib Sand Sea, in both cases having a significant evolutionary effect. In the Galápagos the fog condenses on the rocky outcrops to sustain life, whereas in the Namib the sand absorbs condensation that requires exceptional adaptations in plants and animals for direct harvesting of condensed fog moisture through condensation. These are different aspects of the adaptability and resilience of life. The geologic processes at the Galápagos Islands do not have a direct effect on their ecological processes and exceptional biodiversity, which is the case in the Namib Sand Sea where geological factors are central to its biota’s evolutionary history. The interaction and close relationship between the values of all four natural criteria for World Heritage is therefore unlike any other property currently inscribed.

Criteria vii to x – national comparison: Paragraph 132 of the Operational Guidelines expects a ‘comparative analysis of the property in relation to similar properties’ on a national as well as on an international basis. In Namibia, there are three other dune deserts apart from the Namib Sand Sea. Two are closely related to the Namib Sand Sea, although extending along the coast beyond the borders of Namibia south into South Africa and north into Angola. The third is part of an interior continental ‘thirst land’, the Kalahari, lying in the centre of southern Africa with only its western portion in Namibia.
The sand dunes of the Namib Desert are usually described as the southern, central and northern dune fields. The dune sea of the Namib Desert begins at the Olifants River mouth, south of the Orange River in South Africa. The Olifants River represented the outflow of the proto-Orange River before it was captured by its current lower course. Sparse sand from the Olifants River is distributed along the coast and blown inland by the southern African anti-cyclonic system. Extensive accumulations of sand but no high dunes are found south of the Orange River. Sand blowing from the south that reaches the Orange River is carried to the sea along with that coming from further inland.

At the same time, some of the sand being transported down the Orange River is blown northward off the north bank of the river. This, together with sand blown on-shore from the coast north of the Orange River, forms extensive pale-coloured mobile sand sheets, sand plains and coastal dune hummocks throughout the Sperrgebiet National Park. A few stand-alone, red semi-stabilised dunes occur further inland such as the Obib dunes nestled between the Obibberg and the Schakalsberg immediately north of the Orange River. Other independent dunes associated with mountainous terrain include the Chammaub and Tsaus dune grasslands. The sand accumulations including some genuine dunes, extending from the Olifants River to the Aus – Lüderitz railway on the southern border of the Namib-Naukluft Park, constitute the southern ‘dune fields’.

The central dune fields encompass the contiguous Namib Sand Sea as well as a part of the Namib-Naukluft Park extending south of the sand sea and excluded from the proposed heritage nomination, and a narrow ridge of coastal dunes extending northward from the Kuiseb River to the Swakop River. Although not part of the Namib Sand Sea being proposed for World Heritage status, this narrow coastal dune belt incredibly harbours one totally endemic tenebrionid beetle restricted to its 30 km x
5 km extent. These dunes are formed of sand from the Namib Sand Sea that is washed down from the upper Kuiseb River and deposited in its lower reaches. From there the sand crosses the poorly delineated lower Kuiseb River braided courses. This narrow dune field, including all the sand from the Namib Sand Sea, is terminated by the well incised lower Swakop River to the north. From there the sand is washed out to sea and transported northwards by current and waves for over 230 km, with only small amounts of sand being deposited along the shore south of the Huab River mouth.

The northern dune field starts at approximately the Huab River mouth from where pale, almost white sand is blown inland and northward. The northern dune field consists of a series of triangular-shaped dunes with their apex at the mouth of a river from where sand is blown inland and northward until it reaches the next river and is carried once more toward the coast. These dunes intermittently occupy the Skeleton Coast Park. Such dunes form north of the Huab, Koigab, Unjab, Hoanib and Hoarusib rivers in Namibia, and north of the Kunene and Coroca Rivers in Angola. This dynamic zig-zag transport of sand, originating in the eastern highlands of southern Africa and starting at the Olifants River, terminates at the Caranjamba River in Angola.

The fourth sand dune habitat comprises the western edge of the Kalahari Basin. It consists mainly of linear, vegetated sand dunes relatively well stabilised by grassland vegetation and separated by wide interdune valleys. In Namibia this landscape is used for grazing of wildlife and livestock throughout much of the >1,000 km long eastern border of the country. The thick Kalahari sand mass extends from South Africa northwards to the Congo River and occupies parts of South Africa, Botswana, Namibia, Angola, Zimbabwe, Zambia and the Democratic Republic of the Congo.

**Criterion vii:** All four dune fields in Namibia have unusual natural phenomena and areas of exceptional natural beauty and aesthetic importance. All four have been featured in natural history books, travel books, on film and in paintings and photographs. Table 3.c.10 briefly compares some of the characteristics of these dune fields.

**Table 3.c.10: Comparison of natural phenomena and beauty**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Southern dune field</th>
<th>Central dune field (Namib Sand Sea)</th>
<th>Northern dune field</th>
<th>Kalahari</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural desert vistas</td>
<td>Spectacular</td>
<td>Spectacular</td>
<td>Spectacular</td>
<td>Modified by vegetation</td>
</tr>
<tr>
<td>Pristine environment</td>
<td>Extensive active diamond and zinc mining</td>
<td>Pristine</td>
<td>Varied active mining</td>
<td>Livestock farming and some crops</td>
</tr>
<tr>
<td>Large, active dunes</td>
<td>Active sand sheets, barchans and dunes to 30 m high</td>
<td>Gigantic active dunes to 300 m high</td>
<td>Active sand dunes &lt;100 m high</td>
<td>Active dune crests &lt;20 m high</td>
</tr>
<tr>
<td>Continuity of sand sea</td>
<td>Sand sheets connecting individual dune forms</td>
<td>Continuous sand sea</td>
<td>Partially or completely unattached dunes</td>
<td>Continuous sand-filled basin</td>
</tr>
<tr>
<td>Mobility of sand sea</td>
<td>Extremely mobile</td>
<td>Continuously mobile</td>
<td>Extremely mobile</td>
<td>Semi-stabilised by grassland</td>
</tr>
<tr>
<td>Accessible dunes</td>
<td>Controlled entry requiring 4x4 vehicles</td>
<td>Sossus Vlei controlled, accessible to sedan cars</td>
<td>Controlled entry for fishing access</td>
<td>Accessible along tarred roads and on commercial farms</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-----------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Extraordinary flora</td>
<td>Myriad of diverse succulents on sand sheets; sparse dune vegetation</td>
<td>Sparse dune vegetation</td>
<td>Sparse dune vegetation</td>
<td>Extensive vegetation cover, primarily grasslands</td>
</tr>
<tr>
<td>Extraordinary fauna</td>
<td>Few vertebrates and numerous invertebrates</td>
<td>Few vertebrates and numerous invertebrates</td>
<td>Few vertebrates and numerous invertebrates</td>
<td>Few vertebrates and numerous invertebrates</td>
</tr>
<tr>
<td>Primary moisture sources</td>
<td>Fog and some winter rain (&lt;100 mm)</td>
<td>Fog and some summer rain (&lt;100 mm)</td>
<td>Fog and some summer rain (&lt;100 mm)</td>
<td>Summer rain (&lt;100 mm in south to &gt;500 mm in north)</td>
</tr>
<tr>
<td>Evaporation</td>
<td>&lt;1,680 mm to 2,100 mm/year</td>
<td>&lt;1,680 mm to 2,100 mm/year</td>
<td>&lt;1,680 mm to 2,100 mm/year</td>
<td>1,800 mm to &gt;2,660 mm per year</td>
</tr>
<tr>
<td>Winds</td>
<td>South-westerly winds predominate</td>
<td>South-westerly winds predominate</td>
<td>South-westerly winds predominate</td>
<td>Variable winds primarily easterly</td>
</tr>
<tr>
<td>Associated landscapes</td>
<td>Ocean, rivers, escarpment, inselbergs, pans</td>
<td>Ocean, dry rivers, escarpment, inselbergs, pans</td>
<td>Ocean, rivers, escarpment, inselbergs, pans</td>
<td>Mainly flat Kalahari basin dunescape</td>
</tr>
</tbody>
</table>

**Criterion viii:** Examples of major stages of earth’s history, on-going geological processes and significant geomorphic and physiographic features are found in all four dune areas. The three coastal dunes are derived from the same three integrated, contrasting ‘conveyor belt systems’ consisting of fluvial transport, coastal long-shore drift and coastal on-shore winds. All three were underlain by a semi-consolidated dune system, known as Tsondab Sandstone, dating to 21 million years which originated from the same three-step conveyor belt system. This palaeo sand sea has been stripped from the northern dune area, is partly remaining in the south and underlies the entire central dune area.

All four dune areas are basically aeolian landscapes interacting with differing amounts of sand underlain by differing basal topography manipulated by different wind strengths and directions. A full range of dune types can be found along the Namib coast while this diversity is absent from the Kalahari. The three coastal dune fields continually evolve in situ through the interplay of fluvial sand transport by ephemeral and perennial rivers with long-shore drift and with coastal, on-shore winds dominated by the southern Atlantic anti-cyclonic system. In contrast, the Kalahari is dominated by the continental anti-cyclonic system that has been identified as the most stable high pressure system on earth, sometimes remaining steady for more than a month at a time.
Table 3.c.11: Comparison of examples of major stages of earth’s history and significant ongoing geological processes

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Southern dune field</th>
<th>Central dune field (Namib Sand Sea)</th>
<th>Northern dune field</th>
<th>Kalahari</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palaeo-dunes underlying active dunes</td>
<td>Palaeo-dunes primarily toward coast</td>
<td>Palaeo-dunes underlie entire Namib Sand Sea</td>
<td>Palaeo-dunes have been eroded away</td>
<td>Palaeo-dunes/ lunettes border dry pans</td>
</tr>
<tr>
<td>Sand source</td>
<td>Three step conveyor system originating in eastern, southern Africa</td>
<td>Three step conveyor system originating in eastern, southern Africa</td>
<td>Three step conveyor system originating in eastern, southern Africa</td>
<td>Deposits from rivers terminating in the basin and from in situ erosion</td>
</tr>
<tr>
<td>Striking sand colours</td>
<td>Pale to red sand</td>
<td>Vast range</td>
<td>Primarily white to light yellow sand</td>
<td>Dark red</td>
</tr>
<tr>
<td>Transverse rivers</td>
<td>Perennial Orange River; ephemeral rivers ending in pans; large dry valleys with small water courses; river and dune sediments interwoven</td>
<td>Several ephemeral rivers, some blocked by dunes; deeply incised water courses in larger dry valleys; river and dune sediments interwoven</td>
<td>Several ephemeral rivers and perennial Kunene River cross dune field; deeply incised water courses in larger dry valleys (some of glacial origin); river and dune sediments interwoven</td>
<td>Ephemeral rivers in larger dry valleys parallel to interdunes, not transverse – increasingly clogged by alien woody vegetation</td>
</tr>
<tr>
<td>Inter-digitating plains</td>
<td>Extensive rocky plains underlie sand sheets</td>
<td>Bordering rocky, inter-digitating plains</td>
<td>Bordering and underlying rocky, inter-digitating plains</td>
<td>Sandy plains</td>
</tr>
<tr>
<td>Outcrops and escarpment</td>
<td>Below western escarpment; Roterkamm meteor crater; rocky ranges and inselbergs</td>
<td>Below western escarpment; bordering rocky ranges and inselbergs</td>
<td>Below western escarpment; bordering rocky ranges and inselbergs</td>
<td>Little relief; occasional inselberg</td>
</tr>
<tr>
<td>Angle of coast</td>
<td>South-south east to north-north west</td>
<td>Primarily south to north</td>
<td>South-south east to north-north west</td>
<td>NA</td>
</tr>
<tr>
<td>On-shore winds</td>
<td>Strongest recorded on earth</td>
<td>Moderately strong</td>
<td>Very strong</td>
<td>NA</td>
</tr>
<tr>
<td>Dune forms</td>
<td>Primarily vegetation hummocks, dune trains, sand sheets and small dunes all moving northwards;</td>
<td>Myriad contiguous dune types – from vegetation hummocks and barchans on the coast to linear</td>
<td>Primarily independent barchan and transverse dunes with vegetation hummocks on coast; to</td>
<td>Linear dunes; less than 50 m high</td>
</tr>
</tbody>
</table>
barchans up to 30 m high racing northwards at 50–300 m per year

Criterion ix: Ecological and biological processes contributing to evolution and development of terrestrial ecosystems and communities are on going in all four dune areas. Many, diverse well-adapted dune animals, a large number of them endemic to their dune field or at least the broader Namib area, interact through intricate food webs and are adapted to extremely harsh desert conditions. Exceptional physiological and behavioural adaptations are the rule and range from bizarre mechanisms for uptake of fog-water as a primary water source, for plants and animals, to cooling by running rapidly across the sand surface or diving to cooler sand layers beneath the surface. Constantly changing structures, shapes and succession of dunes and of the plant and animal communities that live in them ensure continually evolving responses and specialisations. These ongoing ecological and biological processes have been studied, described and elucidated by scholars and scientists from around the world.

Table 3.c.12: Comparison of on going ecological and biological processes and evolution and development of communities

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Southern dune field</th>
<th>Central dune field (Namib Sand Sea)</th>
<th>Northern dune field</th>
<th>Kalahari</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uptake of moisture</td>
<td>Plant and animal adaptations to use fog-water; germination requires rain</td>
<td>Plant and animal adaptations to use fog-water; germination requires rain</td>
<td>Plant and animal adaptations to use fog-water; germination requires rain</td>
<td>Rain is primary source of water</td>
</tr>
<tr>
<td>Oxygenated sand as subsurface retreat</td>
<td>Animals can dive into or swim through fluid sand</td>
<td>Animals can dive into or swim through fluid sand</td>
<td>Animals can dive into or swim through fluid sand</td>
<td>Burrowing most common in sand habitat</td>
</tr>
<tr>
<td>Mobile barchan dunes promoting evolution and speciation of fauna</td>
<td>Very mobile barchan dunes throughout</td>
<td>Mobile barchan dunes particularly along coast</td>
<td>Mobile barchan dunes</td>
<td>Barchan dunes absent</td>
</tr>
<tr>
<td>Ever shifting dunes promoting evolution of mechanisms in biota for adaptation, escape or avoidance</td>
<td>Few dune forms constantly hammered by strong winds</td>
<td>Myriad of dune forms across the broad Namib Sand Sea from coast to 120 km inland</td>
<td>Variety of dune forms constantly changing shape across 40 km expanse</td>
<td>Linear dunes relatively stable</td>
</tr>
<tr>
<td>Examples of flagship species</td>
<td>Namaqua dune molerat; desert rain frog; Nama</td>
<td>Namib golden mole; sidewinder adder; shovel-</td>
<td>Desert plated lizard; Namaqua chameleon (also</td>
<td>Mainly widespread sand-dwelling</td>
</tr>
</tbody>
</table>
padloper; dwarf mountain adder; southern rock agama; African penguin; Barlow’s lark; Trigonephrus snail; myriad endemic succulents

snouted lizard; Brain’s blind legless skink; web-footed gecko; Koch’s barking gecko dune lark; myriad endemic tenebrionid beetles and arachnids

south & central); white tenebrionid beetles, other tenebrionids and arachnids

species – invertebrates to elephants

<table>
<thead>
<tr>
<th>Plant productivity</th>
<th>Rich succulent flora, primarily on rocky sand sheets</th>
<th>Sparse dune vegetation, varies with rainfall</th>
<th>Very sparse vegetation</th>
<th>Stabilising grass, tree and shrub cover with relatively high productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Important plant species in area (Atlas 2002)</td>
<td>Quiver tree; Inara</td>
<td>Inara, Trianthema hereroensis</td>
<td>Welwitschia; mopane; Inara</td>
<td>Quiver tree; kiaat; devil’s claw</td>
</tr>
<tr>
<td>Bush encroachment (Atlas 2002)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Acacia mellifera; Terminalia sericea</td>
</tr>
</tbody>
</table>

**Criterion x: In-situ** conservation of biological diversity over large areas is possible in all four dune habitats in Namibia, although they are currently under very different management systems. MET has various levels of responsibility in each of the four areas, although this responsibility is broadly shared in three of them.

The four dune fields have been studied to different degrees and with different foci so exact comparisons between them is not possible. Endemicity of the fauna and flora is high in the southern and central coastal dune fields and essentially absent in the Kalahari Basin encompassed within Namibia. Although there are spectacular endemic species in the northern dune Namib, their relative proportion with respect to the entire biota is not known. The study of the fauna and flora of all four dune fields has contributed outstanding universal value to science and our understanding of conservation, evolution, and physiological and behavioural adaptations of several exceptional desert biotas.
Table 3.c.13: Comparison of natural habitats for in-situ conservation of biological diversity

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Southern dune field</th>
<th>Central dune field (Namib Sand Sea)</th>
<th>Northern dune field</th>
<th>Kalahari</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size or area (823,988 km² total Namibia)</td>
<td>Sperrgebiet: 21,600 km² encompassing assorted, intermixed mountains, rocky surfaces, sand sheets and scant dunes</td>
<td>30,777 km² encompassing primarily contiguous dunes (84%), gravel plains (8%), coastal flats (4%), hills (4%)</td>
<td>Est: 16,000 km² Skeleton Coast Park encompassing intermittent gravel plains and dunes</td>
<td>Est: 40% of Namibia in Kalahari Basin with sandy substrate</td>
</tr>
<tr>
<td>Designated protection</td>
<td>Sperrgebiet National Park previously restricted as Diamond Area #1</td>
<td>Namib-Naukluft Park previously restricted as Diamond Area #2</td>
<td>Skeleton Coast Park open for prospecting and mining</td>
<td>Private property; Tsumkwe conservancy; Khaudum Game Park; Caprivi protected areas</td>
</tr>
<tr>
<td>Management authorities</td>
<td>MET; NamDeb (diamonds) and other mines</td>
<td>MET</td>
<td>MET and other bodies</td>
<td>Private sector; also conservancy and MET</td>
</tr>
<tr>
<td>Research status</td>
<td>Rich vegetation relatively well collected</td>
<td>Extensive literature on variety of topics</td>
<td>Studies of specific species and areas published</td>
<td>Studies of specific species and areas published</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Plan compiled and initiated</td>
<td>Long-term, selected fauna and flora</td>
<td>Short-term lichen monitoring; large mammals ongoing</td>
<td>Intermittent monitoring of birds and large mammals</td>
</tr>
<tr>
<td>Current development</td>
<td>Diamond and zinc mining; controlled, guided tourism; tourist accommodation in nearby towns; Oranjemund town</td>
<td>Controlled, guided tourism; limited self-drive tourism; lodges border area</td>
<td>Mining and prospecting; restricted tourism; access to fishing areas only; lodges within area; two MET stations in park</td>
<td>Commercial and communal farming and conservancies; hunting farms; national parks; lodges; towns</td>
</tr>
<tr>
<td>Biomes (from Atlas 2002)</td>
<td>Succulent Karoo; Desert; Nama Karoo</td>
<td>Desert; Nama Karoo</td>
<td>Desert</td>
<td>Nama Karoo; Acacia Tree-and-shrub Savanna; Broadleaved Tree-and-shrub Savanna (S to N)</td>
</tr>
<tr>
<td>Biodiversity recognition</td>
<td>Designated floral ‘hotspot’; Orange River mouth Ramsar Site</td>
<td>Potential hotspot designation; Sandwich Harbour Ramsar Site</td>
<td>Kunene River mouth potential Ramsar Site</td>
<td>Several ephemeral pans; diverse wildlife in parks</td>
</tr>
<tr>
<td>Endemics [Note: available]</td>
<td>Entire Sperrgebiet Est minimum:</td>
<td>Namib Sand Sea Minimum known:</td>
<td>Northern dunes Est. at least (on</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
The geologic evolution and ongoing processes of the four dune areas in Namibia have a direct effect on their ecological evolution, processes and exceptional biodiversity. These processes are central to the evolutionary history of the three coastal dune fields although less so in the Kalahari. The three additional dune fields situated in Namibia and neighbouring countries have identified, circumscribed superlative features when compared with the Namib Sand Sea. That is, in some instances individual features are even more remarkable in the three comparative sand seas than in the Namib Sand Sea, but taken as a whole, the Namib Sand Sea is comprised of a superlative composite suite of attributes. A key issue in terms of nomination of a World Heritage site, however, is the potential for management focused on in-situ conservation of biological diversity and in this regard the Namib Sand Sea is without comparison. The interactions and close relationships in the Namib Sand Sea, among the outstanding universal values of all four natural criteria for World Heritage, are therefore unlike any other similar property within Namibia.

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3.d INTEGRITY

The boundaries of the envisaged World Heritage Site Property were designed to encompass all the elements of the Namib Sand Sea that exemplify its Outstanding Universal Values. These elements are well conserved and intact and included on a scale appropriate to the ongoing dynamic processes. Its size of 30,777 km² adequately ensures that all the active dune formations including the underlying fossilised dune formations of the underlying sand sea, causative processes and ancillary habitats related to the fossil and active dune formations are included. The features, processes, relationships and dynamic functions which convey the significance of the Namib Sand Sea, past and present, are fully represented, well conserved and in an excellent, undamaged state. Because of its vast size, difficulty of access and current management by the Ministry of Environment and Tourism, the Namib Sand Sea has not suffered and is not suffering any adverse effects of neglect, use or development.

In terms of the key words related to a World Heritage Site the following conditions exist:

**Wholeness:** all the necessary attributes essential to address the four criteria are encompassed well within the identified Property.

**Intactness:** all the necessary attributes are intact. Because of its long history, first of inaccessibility, second of exclusion as part of Diamond Areas #1 and #2 and lastly under the protection of the Ministry of Environment and Tourism within the boundaries of the Namib-Naukluft Park, the identified area is essentially undisturbed.

**Absence of threats:** none of the attributes are threatened by development or neglect. Tourism is the primary development process envisaged for the Namib Sand Sea and this is well regulated and controlled by the Ministry of Environment and Tourism. Neglect, on the other hand, has been a benefit to the identified Property, as it has ensured that potential disturbance by unwarranted intrusion was not experienced.

Apart from controlled access roads and routes, ablution facilities at visitor sites, and long abandoned huts from early twentieth century mining villages near the coast, there is no other infrastructure within the envisaged boundaries of the World Heritage Site. The magnificent dune-scapes are unspoilt and the incredible scenery is maintained by natural forces. The site includes all the elements typical of extreme desert landscapes, including extensive dune systems; inselbergs and pediplains; gramadullas; deeply incised as well as shallow drainage systems, often terminating in ephemeral pans; and all the biotic zones, dune habitats, and communities of dune life forms. Visitor and management infrastructure within these boundaries is restricted to ephemeral, temporary point locations that have no effect on the well-known and well-researched geological, geomorphological, ecological, and biological processes of the Namib Erg. The very large size of the Namib Erg within the envisaged boundaries, which is in turn wholly within the proclaimed Namib-Naukluft Park, ensures that such geological, geomorphological, ecological, and biological processes shall not be influenced by future human development and economic activities. Likewise, the large size of the envisaged site, and well-established management protocols, will safeguard that the long-term stability and conservation of the highly endemic biotic communities are ensured.
Figure 3.d.1: The vast size, the century of exclusion and then protection and the current controlled adventure tourism have resulted in a state of wholeness, intactness and absence of threat to the Namib Sand Sea (b: Bowen/NASA, c: Schneider)
Endemic Damara terns and other birds at the Sandwich Harbour Ramsar Site in the Namib Sand Sea (Paul van Schalkwyk)
4 State of Conservation and Factors Affecting the Property

4.a PRESENT STATE OF CONSERVATION

The Namib Sand Sea is managed as a conservation area by the Namibian Ministry of Environment and Tourism as part of the Namib-Naukluft Park. The current state of conservation varies, however, throughout the variety of habitats within the nominated area as a number of past and current uses and proactive measures influence the habitats to different degrees. Although the sand dunes themselves constitute more than 83% of the identified Property, a brief overview of the state of conservation of all the habitats, primarily defined by substrate and geomorphology, follows. All of the habitats are relatively to well conserved despite their variable sensitivity (Table 4.a.1).

<table>
<thead>
<tr>
<th>Habitat (% of area)</th>
<th>Sensitivity*</th>
<th>State of Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand sea (84% of property)</td>
<td>3</td>
<td>Dunes resilient, sandy plains more easily scarred; tourism traffic mainly confined to dunes; supports diverse endemic fauna and flora; <strong>well conserved</strong>.</td>
</tr>
<tr>
<td>Inselbergs (surrounded by sand sea) (1%)</td>
<td>4</td>
<td>Archaeological resources and vegetation are very sensitive, surrounding pediplains are easily scarred; attractions for dune excursions; <strong>relatively well conserved</strong>.</td>
</tr>
<tr>
<td>Coastal lagoon (Sandwich Harbour) (&lt;1%)</td>
<td>3</td>
<td>Special protected status (Ramsar Site) in park, extremely dynamic habitat, tourism day visits only; semi-annual count of waterfowl; <strong>well conserved</strong>.</td>
</tr>
<tr>
<td>Rocky shore (&lt;1%)</td>
<td>4</td>
<td>Archaeological and vegetation resources vulnerable, relatively inaccessible; <strong>well conserved</strong>.</td>
</tr>
<tr>
<td>Coastal pans/ flats (4%)</td>
<td>5</td>
<td>Extensively disturbed by past diamond mining and prospecting for various minerals; focal area for uranium prospecting; now destination for historic and adventure tourism; easily scarred; <strong>relatively well conserved to date due to the long period of natural rehabilitation</strong>.</td>
</tr>
<tr>
<td>Eastern rocky hills and gramadullas (3%)</td>
<td>3</td>
<td>Archaeological resources and vegetation very sensitive; extensive past use associated with prospecting and livestock farming on gravel plains; limited destination for dune excursions; <strong>relatively well conserved</strong>.</td>
</tr>
<tr>
<td>Endorheic pans (&lt;1%)</td>
<td>5</td>
<td>Archaeological resources around edges, key megafauna and megafioral habitat; Sossus Vlei is key tourist attraction with high tourism and development pressure; Tsondab Vlei is Strict Nature Reserve but in demand for tourism; other</td>
</tr>
<tr>
<td>Habitat</td>
<td>Sensitivity</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ephemeral river courses (&lt;1%)</td>
<td>4</td>
<td>Key migration route for non-endemic fauna and flora and breeding habitat; serve as traffic corridors; occasional floods restore habitat; river banks more sensitive than watercourse; relatively well conserved.</td>
</tr>
<tr>
<td>Gravel plains (8%)</td>
<td>4</td>
<td>Easily scarred; traffic now confined to designated tracks; scars associated with previous use for prospecting and emergency grazing are disappearing; relatively well conserved.</td>
</tr>
</tbody>
</table>

*The sensitivity of the various elements of the habitat is designated from 1 (very robust) to 5 (very easily damaged).

The fauna and flora living in the various habitats outlined in the table are all well conserved. Since it is an arid area, their populations are very variable depending mainly on rainfall. The only exceptions to this state of conservation are the breeding vultures, particularly *Torgos tracheliotus*. Because of low-flying light aircraft, the breeding pairs along the Tsondab and Tsauchab rivers declined over the past decade although this trend is currently being reversed. Nevertheless, the flight levels of aircraft could be better controlled with appropriate zonation and enforcement of existing regulations. Breeding performance of vultures and other birds of prey could be easily, if slowly, improved if stronger action is taken to regulate tourism flights over the area.

A number of government agencies are responsible, to a greater or lesser extent, for the management of resources in the Namib Sand Sea (Table 4.a.2)

![Image of Namib Sand Sea](image)

*Figure 4.a.1: The pristine state of the environment has been maintained by a long history of neglect, conservation and well-managed tourism treading lightly on the landscape (van Schalkwyk)*
Table 4.a.2: Official agencies responsible for resources or management aspects outside the remit of the Namib-Naukluft Park management staff

<table>
<thead>
<tr>
<th>Authority</th>
<th>Area of influence</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Agriculture, Water and Forestry (MAWF), Department of Agriculture</td>
<td>Livestock density enforcement &amp; agronomic licencing</td>
<td>vii viii ix x</td>
</tr>
<tr>
<td>MAWF, Department of Agriculture</td>
<td>Pesticide licencing &amp; migrant pest control (locusts)</td>
<td>x x</td>
</tr>
<tr>
<td>MAWF, Department of Water Affairs and Forestry</td>
<td>Water extraction licencing &amp; pipeline construction</td>
<td>x</td>
</tr>
<tr>
<td>Ministry of Defence (MoD)</td>
<td>Marine patrols and off-shore law enforcement</td>
<td>x x</td>
</tr>
<tr>
<td>Ministry of Environment and Tourism (MET), Department of Environmental Affairs</td>
<td>Evaluating and approving environmental assessment and environmental management plans</td>
<td>x x x</td>
</tr>
<tr>
<td>MET, Department of Tourism</td>
<td>Tourism planning, licencing &amp; infrastructure maintenance</td>
<td>x x x</td>
</tr>
<tr>
<td>MET, Department of Tourism</td>
<td>Promotion &amp; awareness</td>
<td>x x x x</td>
</tr>
<tr>
<td>Ministry of Finance (MoF)</td>
<td>Fiscal planning and economic prioritisation</td>
<td>x x x</td>
</tr>
<tr>
<td>Ministry of Fisheries and Marine Resources (MFMR)</td>
<td>Commercial &amp; recreational fishing licences</td>
<td>x x x</td>
</tr>
<tr>
<td>Ministry of Mines and Energy (MME)</td>
<td>Exploration &amp; mining Licences</td>
<td>x x x x</td>
</tr>
<tr>
<td>MME</td>
<td>Power line construction</td>
<td>x</td>
</tr>
<tr>
<td>MME</td>
<td>Petroleum exploration and transport</td>
<td>x x x x</td>
</tr>
<tr>
<td>Ministry of Regional and Local and Housing and Rural Development (MRLGHRD)</td>
<td>Town &amp; industrial development</td>
<td></td>
</tr>
<tr>
<td>MRLGHRD</td>
<td>Coordination with Regional Government &amp; Traditional Authorities</td>
<td>x x x</td>
</tr>
<tr>
<td>Ministry of Trade and Industry (MTI)</td>
<td>Industrial development planning &amp; licensing</td>
<td>x x x</td>
</tr>
<tr>
<td>Ministry of Works and Transport (MWT), Department Transport</td>
<td>Civil Aviation licencing &amp; operational enforcement</td>
<td>x</td>
</tr>
<tr>
<td>MWT, Roads Construction Company</td>
<td>Road maintenance &amp; construction</td>
<td>x x x</td>
</tr>
<tr>
<td>MWT</td>
<td>Ship licencing &amp; operational enforcement</td>
<td>x x</td>
</tr>
<tr>
<td>National Planning Commission (NPC)</td>
<td>Development planning coordination</td>
<td>x x x</td>
</tr>
<tr>
<td>Regional Governments (Ergo, Hardap, Karas)</td>
<td>Regional development planning &amp; infrastructure needs assessments</td>
<td>x x x</td>
</tr>
<tr>
<td>Town Councillors (Lüderitz, Walvis Bay)</td>
<td>Local development planning</td>
<td>x x</td>
</tr>
</tbody>
</table>

A range of other official agencies also has responsibilities and authority for managing particular resources occurring in the area. Currently interaction and communication between the different agencies is poor resulting in poor control and law enforcement over sensitive resources, e.g.
archaeological resources are legally protected but, in practice, widely overlooked. A number of other stakeholders are involved in conserving the Namib Sand Sea and have been consulted in the process of preparing this dossier (Annex 24).

The one exception to adequate protection is the frequent light aircraft flights undertaken by tourism operators. While these do not land any place except their departure and arrival airports and approved landing strips, they sometimes fly below the required 1,000 m limit. A small aircraft tourism industry at Sesriem on the eastern edge of the Property mainly flies to the coast and along ephemeral river courses, while operators from Swakopmund enter and exit all along the northern boundary.

Balloon excursions are popular over the spectacular dunes. Operators skirt the eastern edge, taking off and landing outside the boundaries but still provide expansive views over the Sand Sea. Balloon excursions are strongly controlled by the weather, especially wind, and take place within the first several hours of the morning immediately after first light.

Several concessions have been granted for adventure tourists, primarily using off-road vehicles, to enter into remote areas of the Namib Sand Sea through specific entry and exit points. In addition to the experience of driving through the spectacular dunes, favourite destinations for these excursions are the remote inselbergs and coastal areas with their history of diamond mining within the Property. Although access is well regulated, it is of some concern that the sensitivity of resources such as archaeological, historical and vegetation concentrations may be overlooked by the operators and visitors. These issues have been identified and measures are being put in place to sensitise operators and visitors. In addition there is a need to develop monitoring mechanisms to evaluate the effect of off-road traffic along traffic corridors granted to concession holders. Each concession holder is granted a different corridor to minimise impact.

With the recent ‘uranium rush’ in the central Namib north of the identified Property, augmented by interest in other strategic minerals, such as the diamond placer occurrences, speculative Exclusive Prospecting Licences (EPLs) have been granted all around the borders of the Property and along portions of the coast by the Ministry of Mines and Energy (MME). These speculative EPLs currently exist on paper only, as no prospecting within the designated Property has taken place over the past four years. Currently, 17 EPLs are under consideration with four of them granted and 13 pending. All those that have been granted will expire within two years. Moreover, even with a prospecting licence, companies still require an official entry permit that is subject to environmental management procedures from the MET. The Minister of Mines and Energy has stated that these EPLs will be withdrawn by MME when the current EPLs expire, and no further EPLs will be granted. This firm approach to prospecting in the nominated area has to be approved by Cabinet.

Conservation of the area to ensure preservation of the Outstanding Universal Values of the Namib Sand Sea is considered as the area is developed. A number of tourism concessions have been granted by MET within the Property (Table 4.a.3). These are preceded by an EIA, taking into account the values of the Property, undertaken by independent consultants and approved by MET. These concessions are presently exclusively for adventure tourism involving four-wheel drive experiences during which the tourists use fly-camps, prepared by the concessionaire, designed to leave no trace
of their single-night use. To date, the concessionaires jointly oversee their own compliance with regulations of MET and no major violation has been reported.

The majority of these tourism concessions extend along the coastal reaches of the Namib Sand Sea, operating from Lüderitz to Walvis Bay. Permit conditions under which the five existing concessions operate allow for up to approximately 6,000 tourists per year, each spending five nights camping in the dunes. There are also a number of tourism concessions along the northern border that have mainly been granted to indigenous people living outside the Namib Sand Sea in the Kuiseb River valley. Other indigenous groups are also demanding and being awarded access based on purported historical territorial claims in the area. They usually hire professional tourism organisations to run the operations. This emergent community involvement and benefit sharing from the Namib Sand Sea is likely to expand as mechanisms for managing such issues mature.

Table 4.a.3 Active tourism concessions granted in the Namib Sand Sea

<table>
<thead>
<tr>
<th>Name of concession</th>
<th>Entry and exit points/route</th>
<th>Number of trips per month allowed</th>
<th>Conditions of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namab – using camp at Meob Bay</td>
<td>Kanaan, Elim or Rooibank; exit Sandwich Harbour</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles; 6-10 days at Meob</td>
<td>Permit from MET; designated routes</td>
</tr>
<tr>
<td>Uri Adventures (with Topnaars)</td>
<td>Lüderitz to Walvis Bay</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles</td>
<td>Permit from MET; designated route</td>
</tr>
<tr>
<td>Uri Adventures (with Topnaars)</td>
<td>Saagberg to Conception Bay to Walvis Bay</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles</td>
<td>Permit from MET; designated route</td>
</tr>
<tr>
<td>Uri Adventures (with Topnaars)</td>
<td>Rooibank to Conception to Walvis Bay</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles</td>
<td>Permit from MET; designated route</td>
</tr>
<tr>
<td>Coastway Tours</td>
<td>Lüderitz to Walvis Bay via Saddle Hill</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles</td>
<td>Permit from MET; designated route</td>
</tr>
<tr>
<td>Omalwendu</td>
<td>Lüderitz to Walvis Bay</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles</td>
<td>Permit from MET; designated route</td>
</tr>
<tr>
<td>Belvedere</td>
<td>Lüderitz to Walvis Bay</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles</td>
<td>Permit from MET; designated route</td>
</tr>
<tr>
<td>Gobabeb</td>
<td>Northern dunes between Kuiseb River and Tsondab Flats</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles (not activated)</td>
<td>Permit from MET; designated route</td>
</tr>
<tr>
<td>Pending</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-road Tours and Safaris</td>
<td>Springbok Vlakte Uri-Hauchab to Kuiseb</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles</td>
<td>Permit from MET; designated route</td>
</tr>
<tr>
<td>Wild at Heart</td>
<td>NE corner of dune field</td>
<td>2 trips/mo with 12 tourist vehicles &amp; 2 guide vehicles</td>
<td>Permit from MET; designated route</td>
</tr>
</tbody>
</table>
Currently, one community-initiated Lodge Concession is under consideration at Meob Bay on the coast within the Namib Sand Sea, pending an Environmental and Social Impact Assessment (ESIA) and approval of an Environmental Management Plan (EMP). The tourists would traverse the width of the Sand Sea from the south-eastern border of the identified Property to Meob Bay. Another proposal, designed to support job creation, targets development at Tsondab Vlei, but has yet to be approved due to the sensitivity of the area and its zonation as a strict nature reserve.

A platform where tourism concession holders can interact with the MET and each other has been recently established. The Namib Concession Holder Forum, attended by the heads of all the concession holding companies operating in the Namib Sand Sea, meets under the chair of the Under Secretary of the MET. Topics for discussion include the need for the concessionaires to police themselves and their clients. MET intends to introduce the concept of developing a dune travel training programme which will be discussed at this forum.

Conservation depends on having information about the area to be conserved. The major part of research undertaken in the Namib Sand Sea consists of fifty years of research conducted by the Gobabeb Training and Research Centre. The Centre is located on the northern banks of the Kuiseb River adjacent to the proposed Property boundary. The largest part of their research has focused on the northern part of the Namib Sand Sea although research excursions have covered most of the proposed area. Research subject areas include, inter alia, archaeology, climatology, ecology, geography, geology, geomorphology, animal and plant physiology and behaviour. Many publications covering these fields are included in the extensive bibliography attached (Annex 21).

Figure 4.a.2: Sandwich Harbour with its myriad endemic Damara terns and other seabirds is a haven for migratory species, while at the same time a popular destination for adventure tourists and nature lovers (van Schalkwyk)
The MET has undertaken ornithological research at Sandwich Harbour and censuses of large mammals on the eastern edge of the identified Property. A variety of other persons and institutions have made short-term studies of select areas and topics in the Namib Sand Sea. They are responsible for reporting to MET, as part of their permit regulations, and the majority of the research reports are in the library at the Gobabeb Centre and included in Annex 21.

Support for complementary research by visiting scientists was recently initiated at the private NamibRand Nature Reserve just outside the eastern boundary of the identified Property. Similarity of the landscape means that many of the results could be applicable to the Namib Sand Sea.

Conservation of special attributes of the Namib Sand Sea is supported by the designation of Sandwich Harbour as a Ramsar Site and zoning in the Namib Sand Sea. Day visits are popular with bird watchers and support a thriving tourism industry. The geographic area of Sandwich Harbour itself is very dynamic, continually changing shape, size and character as the long-shore currents move sand northwards and winds sculpt the landscape. Nevertheless, the area with its fresh water seepages and tidal flats is well conserved and an important element of the Property.

The results of the long-term, ongoing research from the Gobabeb Centre, as well as the outcomes of the extensive tourism developments in the area, contribute greatly to the promotion of the sand sea as an icon and symbol of Namibia and desert landscapes in general and will continue to contribute to promotion of the Namib Sand Sea as a World Heritage Site.

4.b FACTORS AFFECTING THE PROPERTY

(i) Development Pressure

All human activities within the nominated Property take place under the jurisdiction of the Ministry of Environment and Tourism (MET) with the Ministry of Mines and Energy (MME) presently being the most important other national authority. Tourism and mining represent the two key development pressures. Visitor/tourism pressures are described under Section iv below.

Most of the Namib Sand Sea is surrounded by Exclusive Prospecting Licences (EPLs) for uranium and other minerals. EPLs along the western and northern edges of the Property are speculative, are not being actively prospected and, upon expiry, will be withdrawn permanently by the MME who grant the EPLs. No new EPLs will be granted within the designated Property by the Ministry. This protection from active prospecting will be guaranteed through a pending cabinet decision.

(ii) Environmental Pressure

Negative environmental pressures on the Namib Sand Sea are almost entirely absent. Located in a hyper-arid environment, the climate is naturally very variable ranging from decades of aridity, to occasional exceptionally high rainfall years. In this hyper-arid environment, climatic extremes are to be expected and mortalities, primarily of larger game animals, will be monitored on an ongoing basis.

Fire is a potential pressure on the eastern plains bordering the Namib Sand Sea. This is likely to happen after infrequent good rain years followed by a flush of ephemeral grasses. The resultant grasslands are then vulnerable to lightning strikes and possible wildfire at the beginning of the following rain season. Fires from lightning in the eastern plains would not expand far into the sparse vegetation of the Namib Sand Sea. However fires may destroy the grazing for the larger herbivores until new growth appears after the next rain, which may not happen for many years. Outbreaks of wildfire also destroy multiple smaller fauna as well as the flora and present an abrupt transition in the ecological status from a bountiful environment to the usual barrenness expected of desert habitats.

Figure 4.b.1: The Namib Sand Sea is a very variable environment as exemplified in the rapid changes in the habitat structure of the Sandwich Harbour Ramsar Site (Swart/NASA)
Floods are another potential environmental pressure. Exceptionally high rainfall years resculpt the landscape by massive but short-lived floods in some ephemeral rivers flowing into the Namib Sand Sea. These events may occasionally drown unaware fauna or uproot trees in the watercourse. At the same time, the floods lead to rejuvenation and regrowth of the woody and shrubby vegetation. Floods are generated on the escarpment to the east of the Namib Sand Sea and inundate the ephemeral watercourses and their terminal endorheic pans. These floods are part of the natural dynamics of the variable arid climate and, while changing the topography for years, decades or centuries, would not cause disturbance beyond the natural capabilities of the environment to adapt.

Climate change, on the other hand, has the potential to influence the Namib Sand Sea. Warming of the Benguela Coastal Current could decrease the frequency and extent of fog occurrences over the Property as well as cause more frequent floods and rainfall events. A decrease in fog would have an impact on the occurrence and distribution of the fauna and flora that depend on fog as a primary or supplementary water source through range contraction and lower population densities. Similarly, ocean warming would change the wind regime that could influence the key factor that supplies the sand for the Namib Sand Sea and redistributes it throughout the erg. Shorter, more intense rain seasons are also predicted with climate change. This could influence flood regimes of the ephemeral rivers – perhaps causing more intense, short floods from the neighbouring escarpment. In combination with these effects, climate change is likely to stimulate the natural variability of the Namib Sand Sea through range and population contractions and extensions of different species as local conditions in the dunes change. These conditions may become more pronounce through climate change but are unlikely to result in effects outside the natural variability of the current environment.

Exotic or alien species currently pose no threat to the values of the Property. Some domesticated and introduced plants and animals occur within the buffer zone but only as vagrants inside the Property. These are mainly used for agricultural production, transport, or psychological well-being. A feral horse population occurs in the southern buffer zone, and the occasional feral cat, dog, or donkey may stray into the Namib Sand Sea. Invasive or adventive aliens (Table 4.b.1) are also more common in the buffer zone but rare inside the Property. Those posing the biggest threat, e.g. Prosopis, Opuntia and Rattus, are actively managed and mostly eradicated. Plant species spreading along ephemeral rivers and frequently re-introduced such as Nicotiana, Datura and Ricinus are irritating to all environmentalists but pose little risk. Most of the established alien populations of other species contribute to and do not interrupt natural ecological and geomorphological processes.

**Table 4.b.1: Adventive exotic species recorded from the Namib Sand Sea**

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>Common name</th>
<th>Occurrence within Namib Sand Sea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apocynaceae</td>
<td>Nerium</td>
<td>oleander</td>
<td>Oleander</td>
<td>Human settlements</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>Ricinus</td>
<td>communis</td>
<td>Castor bean</td>
<td>Ephemeral rivers</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Prosopis</td>
<td>glandulosa</td>
<td>Prosopis tree</td>
<td>Ephemeral rivers, mostly eradicated</td>
</tr>
<tr>
<td>Papaveraceae</td>
<td>Argemone</td>
<td>orchroleuca</td>
<td>Mexican poppy</td>
<td>Ephemeral rivers</td>
</tr>
<tr>
<td>Poaceae</td>
<td>Arundo</td>
<td>donax</td>
<td>Arundo</td>
<td>Ephemeral rivers</td>
</tr>
<tr>
<td>Poaceae</td>
<td>Cynodon</td>
<td>dactylon</td>
<td>Cynodon</td>
<td>Human settlements (also)</td>
</tr>
<tr>
<td>Family</td>
<td>Genus</td>
<td>Species</td>
<td>Common Name</td>
<td>Habitat</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------</td>
<td>---------</td>
<td>----------------------------------</td>
<td>----------------------------------------------------</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Datura</td>
<td>ferox</td>
<td>Thorn-apple</td>
<td>Ephemeral rivers</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Datura</td>
<td>innoxia</td>
<td>Thorn-apple</td>
<td>Ephemeral rivers</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Datura</td>
<td>metel</td>
<td>Thorn-apple</td>
<td>Ephemeral rivers</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Datura</td>
<td>stramonium</td>
<td>Thorn-apple</td>
<td>Ephemeral rivers</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Nicotiana</td>
<td>glauca</td>
<td>Wild tobacco</td>
<td>Ephemeral rivers</td>
</tr>
<tr>
<td>Cyprinidae</td>
<td>Cyprinus</td>
<td>carpio</td>
<td>Common carp</td>
<td>Rare Vagrant after floods</td>
</tr>
<tr>
<td>Columbidae</td>
<td>Columba</td>
<td>livia</td>
<td>Feral pigeon</td>
<td>Human settlements (also abandoned)</td>
</tr>
<tr>
<td>Ploceidae</td>
<td>Passer</td>
<td>domesticus</td>
<td>House sparrow</td>
<td>Human settlements (also abandoned)</td>
</tr>
<tr>
<td>Muridae</td>
<td>Mus</td>
<td>musculus</td>
<td>House mouse</td>
<td>Human settlements (also abandoned)</td>
</tr>
<tr>
<td>Muridae</td>
<td>Rattus</td>
<td>rattus</td>
<td>Common house rat</td>
<td>Eradicated</td>
</tr>
<tr>
<td>Pholcidae</td>
<td>Pholcus</td>
<td>phalangiooides</td>
<td>Long-legged spider</td>
<td>Human settlements (also abandoned)</td>
</tr>
<tr>
<td>Pholcidae</td>
<td>Smeringopus</td>
<td>pallidus</td>
<td>Long-legged spider</td>
<td>Human settlements (also abandoned)</td>
</tr>
<tr>
<td>Theridiidae</td>
<td>Latrodectus</td>
<td>geometricus</td>
<td>Black-widow spider</td>
<td>Sandwich Harbour, human settlements</td>
</tr>
<tr>
<td>Uloboridae</td>
<td>Uloborus</td>
<td>plumipes</td>
<td>spider</td>
<td>Sandwich Harbour</td>
</tr>
<tr>
<td>Lepismatidae</td>
<td>Ctenolepisma</td>
<td>longicaudata</td>
<td>Silverfish</td>
<td>Human settlements (also abandoned)</td>
</tr>
<tr>
<td>Blattellidae</td>
<td>Blatella</td>
<td>germanica</td>
<td>Kitchen cockroach</td>
<td>Human settlements (also abandoned)</td>
</tr>
<tr>
<td>Cerambycidae</td>
<td>Arhopalus</td>
<td>ferus</td>
<td>Longhorn seeetle</td>
<td>Beach driftwood</td>
</tr>
<tr>
<td>Ptinidae</td>
<td>Stethomeziun</td>
<td>squamosum</td>
<td>Ptinid seeete</td>
<td>Coastal area</td>
</tr>
<tr>
<td>Gryllidae</td>
<td>Acheta</td>
<td>domestica</td>
<td>Cricket</td>
<td>Human settlements (also abandoned)</td>
</tr>
<tr>
<td>Gryllidae</td>
<td>Gryllus</td>
<td>bimaculatus</td>
<td>Cricket</td>
<td>Human settlements (also abandoned)</td>
</tr>
<tr>
<td>Pthiridae</td>
<td>Pthirus</td>
<td>pubis</td>
<td>Pubic lice</td>
<td>Human ectoparasite</td>
</tr>
<tr>
<td>Pulicidae</td>
<td>Pulex</td>
<td>irritans</td>
<td>Common flea</td>
<td>Human settlements (also abandoned)</td>
</tr>
</tbody>
</table>
(iii) Natural Disasters and Risk Preparedness

No known potential natural disasters or risks have been identified that may threaten the values of the Namib Sand Sea with the exception of fire and flood as described in the section above. The potential of marine pollution, e.g. oil spills, along the western boundary has been considered but will not affect any of the attributes that will contribute to the OUV of the Property. Nevertheless, risk preparedness is undertaken by three ministries, Ministry of Environment and Tourism (MET), Ministry of Fisheries and Marine Resources (MFMR) and Ministry of Mines and Energy (MME). These threats would be managed jointly by the MET and MFMR if they affect the area between high and low tide. The Ministry of Mines and Energy and Ministry of Fisheries and Marine Resources would be involved if the spill occurred off-shore.

Figure 4.b.2: Fire is one potential natural hazard which inevitably follows good rainfall events caused by dry lightning at the beginning of the next rain season (2011, Gobabeb Centre)

Fire management planning and directives for fire suppression are in place for the Namib-Naukluft Park. Experienced staff with suitable equipment ensures that the effect of outbreaks of wildfire is constrained and guide new staff that were trained in the principles of fighting fires, but without practical experience. Areas prone to outbreaks are known, e.g. areas subject to frequent lightning strikes, while an effective communication and rapid-response system allows additional manpower and equipment to be recruited for very large outbreaks, whether in the park or not. Long-term management experience shows that fire is part of the landscape-level ecological processes, thus total suppression is not desirable or required.
(iv) Visitor / Tourism Pressure

The Ministry of Environment and Tourism is responsible for control of all visitors and tourism in the identified Property. Visitors entering through the Sesriem gate to visit Sossus Vlei increased from a recorded 58,800 during 2005/06 to 102,250 in 2011. Similarly there was an increase of permits recorded for Ganab from 20,700 in 2005/06 to 34,000 in 2011. Detailed numbers are provided in Table 5.h.1.

Because of the vast distances involved and relative inaccessibility of the Namib Sand Sea, short scenic flights of several hours duration are one of the common tourism activities over the identified area. However, low flying aircraft over the Sandwich Harbour wetlands, Tsondab Vlei, Sossus Vlei, Gobabeb and other areas of the Property or buffer have been and will continue to be a law enforcement challenge. Low flying aircraft, that is aircraft flying at less than the gazetted legal elevation of 1000 m over a park, disturb the tranquillity of the area and have an adverse effect on wildlife. The breeding success of the Lappet-faced Vulture, *Aegypius tracheliotus*, seems to have fluctuated in the past ten years, possibly as a result of this pressure. Although regulations to control this pressure are in place, innovative approaches to resolve this threat are required.

![Figure 4.b.3: Heavy tourism traffic to Sossus Vlei 2x4 parking lot warranted a 60 km tarred road to reduce dust and ease road maintenance (Gobabeb Centre)](image)

Tourism takes place directly under the control and regulation of the Ministry of Environment and Tourism. Management is either implemented directly by the ministry itself, as at Sossus Vlei, or under the management of a variety of tourism concessionaires granted authority by the ministry. The area of dunes impacted by four-by-four travel is estimated to represent no more than 10% of the Namib Sand Sea.

Tourism development pressures are varied but are judged high overall considering the nature of the Namib Sand Sea. Travel within the Namib Sand Sea has increased exponentially over the past two decades. It is currently restricted to four-by-four vehicles with purportedly experienced guides and drivers. If carried out as required, the tourist groups only travel on designated tracks when traversing solid substrates. The remainder of four-by-four travel is restricted to dune surfaces that are rapidly restored by wind. Overnight camps take the form of fly-camps where no evidence of their occupation
is left behind. The tourist road to Sossus Vlei was tarred in the last decade as the track became progressively broader because of drivers attempting to avoid ruts and corrugations. In addition, the exponential growth in visitor numbers resulted in an almost permanent dust cloud in the Tsauchab Valley that obscured the spectacular view and increased accidents with other vehicles and wildlife. With well-controlled road contractors maintaining the road, this pressure has been eliminated.

Waste management is another development pressure associated with tourism in the Namib Sand Sea. MET has been experimenting with waste removal from Sossus Vlei itself, which poses particular problems as a high-density tourism destination. One current plan is to install holding tanks that are emptied by bowers, with the waste being safely disposed well outside the Namib Sand Sea in evaporation ponds. Dehydration toilets would be an alternative. Tourism guides must make arrangements for their clients to remove all human waste from the sand sea. This may consist of portable toilets or similar devices. This and all other waste is removed from the area and disposed of in one of the coastal towns servicing the area.

Development pressures from tourism also include continual requests to open up new areas for exclusive access, particularly on the eastern edge of the Namib Sand Sea. This demand is likely to remain a constant issue as the number of tourists increases and the perception that the existing ‘desert solitude experience’ is diminished. To date the Ministry of Environment and Tourism has not set a cap on the number of tourists allowed into Sossus Vlei as the main attraction, or throughout the entire Sand Sea, although this approach is being discussed. It is strongly recommended that zonation, caps on different types of use and creative, adaptive tourism management planning should be introduced as tourism continues it inexorable increase.
The increase of tourism establishments bordering the Namib Sand Sea, with up to 60 establishments in the greater catchment area for Sossus Vlei alone, has influenced conservation of the sand sea in at least three different ways. By accommodating more tourists who expect to experience the Namib Sand Sea, these private enterprises have contributed to the development pressure – although this is often only a fairly quick morning drive to Sossus Vlei where a tall dune can be climbed and photographs taken. On the other hand, some of the establishment operators have diversified the tourism offerings in the immediate vicinity of the Namib Sand Sea thus showing the potential for relieving the pressure on the protected area itself. Such diversified offerings may range from guided dune walks and nature related activities to marketing aspects such as the geology and evolution of the bordering Great Western Escarpment and other elements of the magnificent landscape. Alternatives also include ballooning and flights over and on the border of the Property. A third change, as tourism experiences evolve, is the increasing involvement of local inhabitants from the surrounding regions.

Moreover, the increase in tourism and associated enterprises and facilities has, reciprocally, highlighted the attractiveness and importance of the Namib Sand Sea leading to greater attention to its conservation. Tourism operators, through their individual efforts, have extended the variety of tourism attractions in the vicinity of the identified Property. While not directly impinging on the Namib Sand Sea, these developments have created diversity and enhanced the regional tourism product. Currently (September 2011) a programme designed to explore, initiate and develop modalities of co-management between MET and the surrounding private tourism establishments is being implemented. Establishment of World Heritage status would greatly enhance the attractiveness as well as the management potential of the Namib Sand Sea.
(v) Number of inhabitants within the Property and the Buffer Zone

Estimated population located within:
Area of nominated Property: 0
Buffer zone: maximum 400
  ca. 110 Namibia Wildlife Resorts (NWR) and MET in the east
  ca. 270 in Topnaar community and
  ca. 20 at Gobabeb Centre in the north
Total: maximum 400
Year: 2011

There are no inhabitants in the nominated Property. Some permanent inhabitants of the buffer zone (approximately 110) are employees of the Ministry of Environment and Tourism and its affiliated state owned enterprise Namibia Wildlife Resorts and sub-contractors. They are concerned with tourism at Sesriem, the campsite nearby the entrance gate for vehicular traffic to Sossus Vlei. In the buffer zone on the northern boundary of the Namib Sand Sea, rural members of the Topnaar community and residents of the Gobabeb Training and Research Centre live along the north bank of the Kuiseb River (approximately 250-300 people).

Figure 4.b.7: Tourist groups are guided to the Dead Vlei at Sossus Vlei (Gobabeb Centre)
Ballooning – a tourism venture leaving only a light footprint in the Namib Sand Sea (Paul van Schalkwyk)
5 Protection and Management of the Property

5.a OWNERSHIP

All of the nominated Property is state owned. It falls within the Namib-Naukluft Park, which is an integral part of the planned Namib-Skeleton Coast National Park.

Table 5.a.1: Overview of land ownership of the nominated Property.

<table>
<thead>
<tr>
<th>Area</th>
<th>ha</th>
<th>km²</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namib Sand Sea</td>
<td>3,077,700</td>
<td>30,777</td>
<td>State owned</td>
</tr>
<tr>
<td>Buffer zone, all within the Namib-Naukluft Park</td>
<td>899,500</td>
<td>8,995</td>
<td>State owned</td>
</tr>
</tbody>
</table>

Figure 5.a.1: The buffer zone (blue line) follows the borders of the Namib-Naukluft Park in the west, south and east, while the northern boundary parallels the Namib Sand Sea. The Namib Sand Sea (red line) with its buffer zone is part of the Namib-Naukluft Park and is owned and protected by the Ministry of Environment and Tourism of the Government of the Republic of Namibia.
5.b PROTECTIVE DESIGNATION

The Namib Sand Sea as an integral part of the Namib-Naukluft Park is subject to comprehensive protection on a national basis. It falls directly under and is managed by the Ministry of Environment and Tourism (MET). Much of the research and monitoring of the Namib Sand Sea environment is carried out by the Gobabeb Training and Research Centre (Gobabeb Centre) located on the northern border of the identified property.

The legal establishment of the Namib-Naukluft Park occurred during seven different steps dating from the first decade of the 20th Century. The first proclamation as a game reserve took place in March 1907 and encompassed the dunes directly south of the Kuiseb River on the northern edge of the Namib Sand Sea. In 1962 the Namib Desert Research Association was established at Gobabeb and evolved over the years. The Gobabeb Training and Research Centre is now a Joint Venture between the Ministry of Environment and Tourism and the NGO known as the Desert Research Foundation of Namibia.

In 1968 the Namib Desert Park and the Naukluft Mountain Zebra Park were declared as game parks under the Nature Conservation Ordinance (Ordinance 31 of 1967). This expansion encompassed parts of the dune sea inland from Sandwich Harbour eastward to the Kuiseb River course. These parks were withdrawn in 1975 and the area was integrated as the Namib-Naukluft Park and declared a game park in 1979 (Gazette No 118, 1 August 1979). This consolidated game park, encompassing most of the northern portion of the Namib Sand Sea, also incorporated the north-eastern portion of Diamond Area #2.

The boundaries of the Namib-Naukluft Park were amended and enlarged in 1986 under Section 15 of the Nature Conservation Ordinance, 1975 (Ordinance 4 of 1975). This included adding the remainder of Diamond Area #2 and the portion of Diamond Area #1 north of the Aus/Lüderitz road. By 1986 almost the entire Namib Sand Sea was afforded protection within the Namib-Naukluft Park. Two minor amendments of terminology and boundaries were made in 1989 and 1990 so that today the park covers an area of approximately 50,700 km² including the Namib Sand Sea.

Sandwich Harbour was declared a Wetlands of International Importance on 23 December 1995, under the Ramsar Convention. Tourism is currently the only use of Sandwich Harbour.

Figure 5.b.1: The Namib-Naukluft Park evolved to its current size over the past century (Robertson)
The southern part of the area borders on a Cabinet-approved Marine Protected Area. The entire inter-tidal zone bordering the identified Property is co-managed by the Ministry of Environment and Tourism and the Minister of Fisheries and Marine Resources.

Portions of the area are designated as an Important Bird Area (IBA) and qualify as a Key Biodiversity Area (KBA).

Currently the Namib Sand Sea is protected by a variety of plans, policies, legislation and regulations. All are derived from or support the Namibian Constitution, Article 95(1), which affirms that ‘the State shall actively promote and maintain the welfare of the people by adopting ... policies aimed at maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future; ...’

Policies represent statements of intent to carry out specific or general measures to support the governance of Namibia. Some of these policies focus directly on protecting and managing natural resource assets throughout Namibia while others indirectly affect such management and protection. A number of the relevant policies have been summarized in Table 5.b.1 below (see also Table 5.c.1).

While the majority of the listed policies do not specifically mention the Namib Sand Sea, they do impinge on its protection and management. In most instances they relate, directly or indirectly, to the exceptional natural beauty and aesthetic importance of the Property (Criterion vii) and to its in-situ conservation of biological diversity (Criterion x). Those policies of particular importance are highlighted in bold:

Figure 5.b.2: Protection of the Namib Sand Sea is afforded by policies, legislation and regulations of the Ministry of Environment and Tourism. Vehicle access is limited to designated areas, leaving a major section of the sand sea pristine for exploring on foot (Gobabeb Centre)
### Table 5.b.1: Key elements of the policy framework relevant to protection of the Namib Sand Sea

<table>
<thead>
<tr>
<th>Policies</th>
<th>Relevance to natural criteria</th>
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<tr>
<td>Decentralisation Policy, 2000</td>
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<td><strong>Environmental Assessment Policy, 1993</strong></td>
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<td><strong>Namibia’s Policy to Combat Desertification, 1994</strong></td>
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<td><strong>Namibia Tourism Board Marketing Plan, 2004</strong></td>
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<td><strong>Namibia Tourism Policy, 2006</strong></td>
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<tr>
<td>National Agricultural Policy, 1995</td>
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<tr>
<td><strong>National Biodiversity Strategy and Action Plan, 2001 - 2010</strong></td>
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<tr>
<td>National Gender Policy, 1998</td>
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<td>National Land Policy, 1998</td>
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<td><strong>National Policy on Tourism for Namibia, 2008</strong></td>
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</tr>
<tr>
<td><strong>Wetlands Policy, 2004</strong></td>
<td>X X X X</td>
</tr>
<tr>
<td>Wildlife Management, Utilization and Tourism in Communal Areas Policy, 1995</td>
<td>X X X X</td>
</tr>
</tbody>
</table>

The Ministry of Mines and Energy has the right to issue Exclusive Prospecting Licences over the area but has agreed to let those that currently exist run their allocated duration before being withdrawn (Cabinet submission November 2011). Meanwhile, the entire area is excluded from the granting of new licences.

Based on consideration of the above as well as the active prospecting in EPLs in the Koichab Pan south of the sand sea and the use of the Koichab fossil aquifer as a water supply for Lüderitz, the boundaries of the identified Property designated as the Namib Sand Sea were established to encompass all four natural criteria.
o The 30,777 km² area contains superlative natural phenomena and vast areas of exceptional natural beauty and aesthetic importance. A portion of the sand sea was allocated to the buffer area to the south where the criteria are also met but potential also exists for more intrusive tourism developments.

o The boundaries were designed to incorporate this outstanding example of the interplay of marine, atmospheric and terrestrial processes encompassing major stages of the earth’s history as well as significant ongoing geological, geomorphic and physiographic processes. The fossil dune desert, the Tsondab Sandstone Formation, extends beyond the current active dune desert. The boundaries encompass a large proportion of the fossil dune desert underlying today’s active dune desert. Again, buffering processes were allocated to the areas surrounding the identified Property to enhance its essential integrity.

o Ongoing ecological and biological processes in the evolution and development of terrestrial ecosystems and communities of biota are fully encompassed within the boundaries of the identified Property. The Namib Sand Sea provides complete and ample coverage to ensure the continuation of these dynamic processes.

o The boundaries were drawn to include the most important and significant natural habitats for the in-situ conservation of biological diversity represented by the Namib Sand Sea. These include species of Outstanding Universal Value from the point of view of science and conservation. The buffer areas within the Namib-Naukluft Park contribute to the conservation status of the nominated area but are not essential for its realisation within the identified Property.

5.c MEANS OF IMPLEMENTING PROTECTIVE MEASURES

Protective measures are supported by a variety of legislation, directly and indirectly impinging on the Namib Sand Sea. Table 5.c.1 provides an overview of the diverse legislative framework and its relevance to the four natural criteria relating to the identified Property. All of these pieces of legislation relate to the regulatory framework under which the Ministry of Environment and Tourism manages the Property. Many of these legislative elements are not actively invoked but are applied when required.

Much of the actual protection for the Namib Sand Sea has been indirectly achieved because of its past history and the current inaccessibility and isolation of the Property. Until 1979, the entire Namib Sand Sea was designated as Diamond Areas #1 and #2 and protected under the strict diamond mining regulations. In 1979, the northern half of the Namib Sand Sea previously designated as part of Diamond Area #2 was incorporated into the Namib-Naukluft Park. The remainder of the Namib Sand Sea was incorporated into the Namib Naukluft Park only in 1986, by redesignating the remainder of Diamond Area #2 and that portion of Diamond Area #1 inland from the coast and north of the Aus-Lüderitz road. Thus until firmly integrated into the Namib-Naukluft Park, the Property was essentially off limits to the public with entry allowed only under a strict permitting system. This system did not include entry for tourism but only endeavours such as research with various objectives ranging, for example, from identifying sources of groundwater or elucidating the geology to investigating biodiversity of the inselbergs or structure of the dune array.
### Table 5.c.1: Key elements of the legislative framework relevant to management and implementing protective measures of the Namib Sand Sea

<table>
<thead>
<tr>
<th>Legislation (directly important legislation is indicated in bold)</th>
<th>Relevance to natural criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vii</td>
</tr>
<tr>
<td>The Access to Genetic Resources Bill, 2010</td>
<td>X</td>
</tr>
<tr>
<td>Agriculture (Commercial) Land Reform Act, 1995</td>
<td>X</td>
</tr>
<tr>
<td>Cooperatives Act, 1996</td>
<td>X</td>
</tr>
<tr>
<td>The Environmental Investment Fund of Namibia Act, 2001</td>
<td>X</td>
</tr>
<tr>
<td><strong>Environmental Management Act, 2007</strong></td>
<td>X</td>
</tr>
<tr>
<td>Foreign Investment Act, 27/1990</td>
<td>X</td>
</tr>
<tr>
<td>Forest Act, 2001</td>
<td>X</td>
</tr>
<tr>
<td>Game Products Trust Fund Act, 1997</td>
<td>X</td>
</tr>
<tr>
<td>Inland Fisheries Resource Act, 2003</td>
<td></td>
</tr>
<tr>
<td>Labour Act, 1992</td>
<td>X</td>
</tr>
<tr>
<td>Local Authorities Act, 1992</td>
<td>X</td>
</tr>
<tr>
<td>Locust Suppression Proclamation, 34/1923</td>
<td>X</td>
</tr>
<tr>
<td>Marine Resources Act, 2000</td>
<td></td>
</tr>
<tr>
<td><strong>Minerals (Prospecting and Mining) Act, 1992</strong></td>
<td>X</td>
</tr>
<tr>
<td>Mountain Catchment Areas Act, 63/1970</td>
<td>X</td>
</tr>
<tr>
<td><strong>Namibian Tourism Board Act, 2000</strong></td>
<td>X</td>
</tr>
<tr>
<td>Namibia Water Corporation Act, 1997</td>
<td>X</td>
</tr>
<tr>
<td>Namibia Wildlife Resorts Company Act, 1998</td>
<td>X</td>
</tr>
<tr>
<td><strong>National Heritage Act, 2004</strong></td>
<td>X</td>
</tr>
<tr>
<td>National Monuments Act, 20/1969</td>
<td>X</td>
</tr>
<tr>
<td>The Parks and Wildlife Management Bill (will replace Nature Conservation Ordinance)</td>
<td>X</td>
</tr>
<tr>
<td>Petroleum (Exploration and Production) Act, 1991</td>
<td>X</td>
</tr>
<tr>
<td>Petroleum Products and Energy Act, 13/1990</td>
<td>X</td>
</tr>
<tr>
<td>Plant Quarantine Act, 2008</td>
<td></td>
</tr>
<tr>
<td>The Pollution Control and Waste Management Bill</td>
<td>X</td>
</tr>
<tr>
<td>Regional Councils Act, 1992</td>
<td>X</td>
</tr>
<tr>
<td>Soil Conservation Proclamation, 76/1969</td>
<td>X</td>
</tr>
<tr>
<td>Territorial Sea and Exclusive Economic Zone of Namibia Act, 1990</td>
<td>X</td>
</tr>
<tr>
<td>Traditional Authorities Act, 175/1995</td>
<td>X</td>
</tr>
<tr>
<td>Water Proclamation, 54/1956 (will be replaced by Water Resources Management Bill)</td>
<td>X</td>
</tr>
<tr>
<td><strong>Water Resources Management Bill, 2004</strong></td>
<td>X</td>
</tr>
<tr>
<td>Wild Birds Protection Proclamation, 6/1967</td>
<td>X</td>
</tr>
</tbody>
</table>
Under the MET, the strict protected status of the Namib Sand Sea has been maintained. Daily entrance is only by permit to two well-patrolled designated areas, i.e. Sandwich Harbour and Sossus Vlei. Concessions have been granted recently along designated routes elsewhere in the area (e.g. Section 4.a) with, in addition, each individual visit led by a concessionaire with a permit from MET.

Providing another backbone to the framework for implementing protective measures are the various Multilateral Environmental Agreements (MEAs) established by the United Nations and other multilateral agencies (Table 5.c.2). Namibia is a signatory to a number of Multilateral Environmental Agreements that influence the protection and management of the designated Property. These MEAs may be invoked to contribute to protective measures but are considered by Namibia as secondary to the national legislation.

Table 5.c.2: Multilateral environmental agreements influencing the protection and management of the Namib Sand Sea.

<table>
<thead>
<tr>
<th>Multilateral Environmental Agreement</th>
<th>Relevance to natural criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compensation of Oil Pollution Damage, 1971, as replaced by the 1992 Protocol – effective 2003</td>
<td>x    x    x    x</td>
</tr>
<tr>
<td>Convention Concerning the Protection of the World Cultural and Natural Heritage, 1972 – effective 2000</td>
<td>x    x    x    x</td>
</tr>
<tr>
<td>Convention for the Safeguarding of the Intangible Cultural Heritage, 2003 – effective 2007</td>
<td>x    x    x    x</td>
</tr>
<tr>
<td>Convention of the Protection and Promotion of the Diversity of Cultural Expressions, 2005 – effective 2007</td>
<td>x    x    x</td>
</tr>
<tr>
<td>Convention on Biological Diversity, 1992 – effective 1997</td>
<td>x    x</td>
</tr>
<tr>
<td>Convention on the Conservation and Management of Fishery Resources in the South East Atlantic Ocean, 2001 – effective 2001</td>
<td>x    x</td>
</tr>
<tr>
<td>Convention on Wetlands of International Importance, especially as Waterfowl Habitat, 1971 (Ramsar Convention) – effective 1995</td>
<td>x    x    x</td>
</tr>
<tr>
<td>International Convention on Civil Liability for Oil Pollution Damage, 1969, as replaced by the 1992 Protocol, as amended in 2000 – effective 2003</td>
<td>x    x    x    x</td>
</tr>
<tr>
<td>International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 – effective 2007</td>
<td>x    x    x    x</td>
</tr>
<tr>
<td>SADC Protocol on Fisheries, 2001 – implemented 2003</td>
<td>x    x</td>
</tr>
<tr>
<td>SADC Protocol on Wildlife Conservation and Law Enforcement, 1999 – implemented 2003</td>
<td>x    x</td>
</tr>
<tr>
<td>United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa, 1994 – effective 1997</td>
<td>x    x    x    x</td>
</tr>
<tr>
<td>United Nations Framework Convention on Climate Change, 1992 – effective 1995</td>
<td>x    x    x    x</td>
</tr>
<tr>
<td>World Heritage Convention, 1975 – effective 2000</td>
<td>x    x    x    x</td>
</tr>
</tbody>
</table>
As espoused in the Management and Tourism Development Plan for the Namib-Naukluft Area, covering the period 2009–2013, use of the area is planned and managed to retain a ‘Desert Discovery’ atmosphere. This encompasses safeguarding its wilderness and ‘sense of place’ attributes within a zonation and management framework under the Environmental Management Act of 2007.

Protective measures are driven by the Ministry of Environment and Tourism (MET) but also involve consultation with the Ministry of Fisheries and Marine Resources and park neighbours. The Ministry of Mines and Energy supports identified protective measures. Nevertheless, the designated Property is entirely under the jurisdiction of the MET.

An essential element contributing to protective measures for the Namib Sand Sea is an extensive ‘informal buffer zone’ provided by privately owned land on the eastern boundary of the Namib-Naukluft Park. Many privately owned farms actively practice conservation, e.g. NamibRand Nature Reserve, and many are in the tourism business, thus contributing to conservation generally. However, until recently each owner managed his/her property according to his/her own guidelines and there was no coordinated approach.

Plans are ongoing to establish a Namib Co-management and Development Plan with local landowners extending 180 km along the eastern border of the identified Property from NamibRand north to Solitaire. This will be legally constituted under law as the Private Protected Areas Association of Namibia. Conservation, monitoring and adaptive management of this area will be the key objective of the association. Moreover, this area will be integrated into a Protected Landscape Conservation Area to be known as the Greater Sossus Vlei-Namib Landscape that is currently being established under the NamPlace project of MET funded by the Global Environmental Facility.

However, at this time there is no domestic legislation in place that will ensure compliance with conservation objectives and principles by landowners. Compliance will be voluntary. World Heritage inscription requires the management authority of the state party, which is the MET for the Namib Sand Sea, to ensure appropriate management. At present it is not possible for the MET to enforce compliance on private land. Thus all private land has been excluded from the buffer zone. This may change in the future as co-management practices mature.

Figure 5.c.1: Appropriate road signs allow MET to facilitate natural rehabilitation by redirecting traffic along designated routes (Gobabeb Centre)
Conservation and tourism endeavours along the eastern border of the Namib-Naukluft Park contribute to protection of the identified area itself, as the east represents the main area of potential access to the Property. The level of protection has increased as the number of tourism ventures increases. The success of conservation in the area has demonstrated that conservation-focused land use far outweighs livestock farming and contributes significantly more to social, economic and environmental benefits for all involved. Moreover, conservation and tourism bring more to the national economy, provide more jobs and have less impact on the environment. Evidence of this is indicated by the 10-fold increase in land values over the past decade. Thus the identified Property of the Namib Sand Sea will benefit greatly from these privately owned enterprises that provide buffering processes to the identified Property and, in turn, are expected to benefit by the inscription of the World Heritage Site.

Protective measures for the Namib Sand Sea are augmented by the area of the Namib-Naukluft Park that extends to the north of the identified Property beyond its northern buffer area. Moreover, Dorob National Park then extends further northwards along the coast and the Sperrgebiet National Park lies to the south of the identified Property beyond its southern buffer area. The dangerous and inhospitable ‘skeleton coast’ forming the western boundary of the Namib Sand Sea provides protection from the west.

5.d EXISTING PLANS RELATED TO MUNICIPALITY AND REGION IN WHICH THE PROPOSED PROPERTY IS LOCATED

The entire area of the nominated Property is subject to a coherent protection and management system under the Ministry of Environment and Tourism in its designated status as part of the Namib-Naukluft Park. The Property itself is centrally located in the proposed Namib-Skeleton Coast National Park network that will include almost the entire coastline of Namibia from the Orange River in the south to the Kunene River in the north.

A variety of independent plans, some coordinated and others complementary but not formally coordinated, contribute to protection processes surrounding the identified Property, directly and indirectly. These range from the overarching Vision 2030 to regional and individual municipality and village plans. None of these plans override those of the Ministry of Environment and Tourism, thus the Namib Sand Sea is rarely referred to but they contribute to buffering of the designated area. Most of these plans simply generically recognise the importance of conservation areas as a magnet for tourism and associated development.
Table 5.d.1: National, Regional and Local plans supporting conservation of the Property

<table>
<thead>
<tr>
<th>Plans (the key plans of MET are highlighted in bold)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vii  viii ix  x</td>
</tr>
<tr>
<td>Aus Village Tourism Development Plan</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>Erongo Regional Development Plan, 2001/2-2005/6</td>
<td>X  X</td>
</tr>
<tr>
<td>Gondwana Collection Strategic Plan (not reviewed)</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>Hardap Regional Development Plan, 2001/2-2005/6</td>
<td>X  X</td>
</tr>
<tr>
<td>Karas Regional Development Plan, 2001/2-2005/6</td>
<td>X  X</td>
</tr>
<tr>
<td>Lüderitz Municipality Development Plan</td>
<td>X  X</td>
</tr>
<tr>
<td>MET Management and Tourism Development Plan for the Namib-Naukluft Park, 2009-2013</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>MET Management Plan, 2003</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>MET Strategic Plan</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>MFMR Strategic Plan</td>
<td>X  X</td>
</tr>
<tr>
<td>Namibia Wildlife Resorts Strategic Plan (under review)</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>NamibRand Strategic Plan</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>NamPlace project</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>National Biodiversity Strategy and Action Plan, 2001 - 2010</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>National Coastal Management (NACOMA) Project</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>National Development Plan (NDP) III (2008), IV (2013) and ongoing</td>
<td>X  X</td>
</tr>
<tr>
<td>National Sanitation Strategy and Plan</td>
<td>X  X</td>
</tr>
<tr>
<td>National Tourism Board Strategic Plan (not available)</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>National Tourism Plan</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>Strategic Coastal Management Plan (Nacoma)</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>Supporting Protected Areas Network (SPAN) project (completed)</td>
<td>X  X  X  X</td>
</tr>
<tr>
<td>Vision 2030, 2005</td>
<td>X  X</td>
</tr>
<tr>
<td>Walvis Bay Municipality Development Plan</td>
<td>X  X</td>
</tr>
<tr>
<td>Wilderness Safari Strategic Plan (not reviewed)</td>
<td>X  X  X  X</td>
</tr>
</tbody>
</table>

5.e PROPERTY MANAGEMENT PLAN OR OTHER MANAGEMENT SYSTEM

A Management and Tourism Development Plan for the Namib Naukluft Park for the period 2009-2013 provides the basis for contemporary management actions. A draft Parks and Neighbours Policy, currently being developed, will contribute to indirectly support overall property management.

The "Namib Sand Sea Management Plan" (hereinafter the "Management Plan") has been drafted in order to properly conserve and manage the natural environment of the nominated Property well into the future. It is characterised by:
**Wholeness:** all necessary attributes to demonstrate the outstanding values of all four natural criteria are encompassed and abundantly represented within the identified Property.

**Intactness:** maintaining more than 80% of the identified area as undisturbed wilderness. The primary development process envisaged for the Namib Sand Sea is well regulated and there is controlled tourism access to identified parts of the nominated Property, with limited access for the purpose of science and management to the whole area.

**Absence of threats:** ensuring early identification of development challenges and identifying particular attributes that may come under stress through development. The precautionary principle, based on an ecosystem management approach and minimal intervention, will be used to test potential management approaches to likely anthropogenic impacts.

*Figure 5.e.1: Intactness, wholeness and absence of threats are guaranteed by the immense expanse of the Namib Sand Sea (including myriad dune types, ephemeral rivers, bordering plains and mountains) included in the nominated Property (Swart/NASA)*

The management vision for the Namib Sand Sea is to conserve the outstanding value of the natural environment of the nominated Property in perpetuity for the enjoyment and edification of all people. Within that context, the overall goal of the Management Plan is to conserve the austere but spectacular beauty and continuous expanses of majestic dunes of the Namib Sand Sea, including the outstanding diversity of endemic species integrated into vibrant and resilient communities. This is in a setting virtually devoid of human constructs and is a source of inspiration and enjoyment to Namibians and people of all cultures in the world. Appreciation for the dynamic processes that shape
and maintain the dunes, and the adaptations that allow life to flourish in an environment of limited resources, will be promoted and explained through continuous research and monitoring to increase the level of understanding. Ensuring the sense of place and awe that the Namib Sand Sea and its biodiversity invokes in the human spirit is a gift to humankind that Namibia will aspire to maintain despite the very human desire to conquer, to change, to exploit and to profit from the environment that they admire so much.

The Management Plan clarifies basic policies to facilitate the smooth and proper management of the Namib Sand Sea through close cooperation between the mandated management authority (the MET) and other related government organizations, decentralised local and regional governments, traditional societies, local residents, bodies engaged in tourism, researchers and NGOs. The Management Plan addresses issues such as conservation, research, monitoring, enforcement, education, traditional practices, and cultural heritage resources.

The Management Plan conforms to government policies and procedures related to the implementation of an integrated system of strategic (long-term), operational (medium-term), and activity (annual) planning. The Property is wholly on state land, thus is legally held in trust for the Namibian nation and subject to procedures for public asset management. Vast areas of the Property have been inaccessible or under conservation management for more than a century, during which time management approaches have evolved and adapted to ensure the best possible conservation outcome. During the long history of the conservation of the Namib Sand Sea, a diversity of management challenges based on emergent economic prospects, technological innovation, and socio-political imperatives had to be confronted. The nearly pristine condition of the nominated Property is evidence of the success of that past effort. The Management Plan is expected to evolve within the context of the management of surrounding public and private conservation areas, including participatory processes for the co-management of wilderness areas.

The direct management authority for the nominated Property is the Directorate of Regional Services and Parks Management within the Ministry of Environment and Tourism. Other organic bodies within its parent body have subsidiary responsibilities that have direct and indirect effects on management procedures. The integrated mechanisms through which all conservation areas and wildlife resources are managed in Namibia are intended to make optimal use of limited manpower and financial assets. It is not envisaged that the nominated Property will be managed in isolation. Although the management system has some

Figure 5.e.2: Control of off-road vehicle traffic is a major focus of the MET to maintain the pristine and splendid condition of the Namib Sand Sea (Gobabeb Centre)
disadvantages, as the Namib Sand Sea will not be managed as a distinct entity. However it does benefit from the flexibility of having access to a large potential resource base and being managed in accordance with a national system of a wider protected area network.

The outline of the Management Plan follows below. The full text of the Management Plan is included as Annex 1.

The Management Plan consists of two sections. Section 1, the management framework, includes key elements to move towards an ecosystem approach to management. The framework comprises the following elements:

- The legal and policy basis for managing the Namib Sand Sea
- The Vision and Guiding Principles that guide the development of policies and operational plans for the Namib Sand Sea
- Goals to guide the implementation of specific action plans to address priority management needs
- Regulations and zoning to manage human activities and threats
- Concepts to move toward a coordinated ecosystem approach to management
- Institutional arrangements for management coordination with stakeholders.

Section 2 includes key action plans to address priority management needs within the Namib Sand Sea and its buffer zone. Priority areas for management are:

- Conserving wildlife and their habitats
- Understanding and interpreting Namib Sand Sea resources
- Reducing threats to Namib Sand Sea resources
- Managing human activities
- Facilitating coordination
- Consistent management planning and implementation.

Each action plan consists of multiple strategies and activities to address one or more priority management area to achieve desired outcomes. Performance measures will be developed to evaluate implementation of the Management Plan. Additional activities to assess the health of the resources of the Namib Sand Sea are outlined in Section 6 ‘Monitoring’ of this nomination document.

The ecosystem approach forms the principal philosophy for conservation and sustainable utilisation of the nominated Property. All habitats included within the Namib Sand Sea, consisting mainly of dune fields (erg), ephemeral riverbeds and associated riparian ecosystems, endorheic pans and vleis (terminal playas), inselbergs or mountain islands in the sand sea, tidal areas inclusive of estuaries, tidal inlets, salt marshes, beaches and the off-shore areas are covered by the conservation system in order to protect the ecological processes that are fundamental to the geomorphology, fauna, flora and ecosystem conservation.
An ecosystem approach to the management of the Namib Sand Sea requires that implementation of multiple activities have to be coordinated for:

- Ecosystem level planning
- Defining cross-jurisdictional management goals
- Developing and testing co-management approaches
- Adaptive management
- Ecosystem zoning
- Long-term observing, monitoring and research.

The Management Plan will be reviewed every five years. The review represents an essential element of the adaptive management process and includes public involvement, characterisation of issues, and review and evaluation of action plans and their outcomes. The review will incorporate lessons learned and new data and information from monitoring, ecosystem science, and traditional knowledge, along with a comprehensive evaluation to develop or refine management strategies and actions.
5.f SOURCES AND LEVELS OF FINANCE

The main source of finance for management of the proposed Property, located within the Namib-Naukluft Park, is the MET through the Ministry of Finance. There is no specific budget for the Namib Sand Sea, although Sesriem gate and associated facilities are dedicated to management of the identified Property. The level of finance allocated by the MET, based on a five-year future rolling budget system, is primarily intended for staffing and operational costs. It includes funding for monitoring of the Ramsar Site at Sandwich Harbour twice a year. Monitoring of other components of the Property is being undertaken by Gobabeb Training and Research Centre on the northern boundary of the Property, which is dependent on donor funding or consultancies for various elements of its programme. The amount available to the Centre for monitoring is less than N$1 million annually. If this Property is designated as a World Heritage Site, options for additional funding would become available.

The allocation for fixed and operational costs for the last two years increased substantially from N$9.682 million in 2010/2011 to N$13.554 in 2011/2012. This budget covers the five central parks of which the Namib-Naukluft Park receives 50%. The Namib-Naukluft Park, which includes the Namib Sand Sea, is one of five ‘central’ parks that include Cape Cross Seal Reserve, Daan Viljoen Game Reserve, von Bach Recreation Resort and Waterberg Plateau Park. The regional heads (Chief Wardens) serve as cost centre managers who are given a budget to allocate for operational expenses, e.g. utilities, overtime, field allowances, transport and office supplies, and services such as monitoring and other kinds of outsourced labour. The annual allocation for fixed and operational costs for 28 staff members of the Directorate of Regional Services and Parks Management and their activities remains relatively stable with a steady increase over the past five years.

Variable additional funding may be allocated to create new infrastructure, large maintenance projects, implementation of special programmes, e.g. game counts, fence repairs, and vehicle purchases. Such expenses are planned in advance to be included in the budget and prioritised for specific years. Serious emergency allocations requiring immediate attention may be approved by the Permanent Secretary.

Capital funding for the year 2011/2012 for the five central parks totalled N$6 million specifically for upgrading tourist roads. Of this N$1 million was allocated for upgrading the Sesriem Canyon road located in the buffer area of the identified Property within the Namib-Naukluft Park and an important part of the overall tourist experience in the area. N$0.5 million was allocated for water provision to
game within the park. Yet another element of importance for the identified Property, although not directly within it, is the allocation of funding for preparation of a feasibility study to upgrade sewage treatment at Sesriem and Sossus Vlei. Overall the capital budget for the Namib-Naukluft Park for 2011/2012 totalled N$2.4 million.

Funds from other directorates in MET contribute to management of the Namib-Naukluft Park, e.g. Scientific Services does game counts when requested and Environmental Affairs makes a contribution to maintenance of infrastructure at Gobabeb. The Game Products Trust Fund can be approached for specific requests such as the recent purchase of a radio system and vehicles to improve management effectiveness.

Should the nomination for the Namib Sand Sea as a World Heritage Site be approved, this development could be used to increase funding for the management and monitoring of the Property.

5.g SOURCES OF EXPERTISE AND TRAINING IN CONSERVATION AND MANAGEMENT TECHNIQUES

The MET provides the expertise in terms of conservation and management techniques for the Namib Sand Sea. This is backed-up by the Polytechnic of Namibia (PoN) which has a School of Natural Resource Management with a focus on agriculture, lands and natural conservation, and provides the main source of staff for the MET. The Polytechnic of Namibia grants Diplomas for three year courses, a B Tech degree based on a fourth year of study as well as MSc degrees. See Annex 22 for an extract from the curriculum, summarising relevant courses.

Additional to the Polytechnic of Namibia, the University of Namibia (UNAM) also offers a number of relevant courses in their Faculty of Agriculture and Natural Resources that could contribute to the knowledge of MET staff. See Annex 23 for a list of relevant courses at UNAM.

The Gobabeb Training and Research Centre has programmes that increase understanding of the Namib Sand Sea, the Namib desert in general and its conservation at all levels. In addition, it provides opportunities for students to do projects and undertake graduate degree research that contributes to understanding the desert environment and its conservation for future MET staff. Regular hosting of Polytechnic students to do in-service training and specialised courses for UNAM ensure that these institutions remain involved. Although not a degree-granting institution, the staff at Gobabeb co-supervise students for Diplomas, MSc and PhD degrees. When necessary other national specialist agencies are involved.

Figure 5.g.1: Skills and understanding are developed while studying the Namib Sand Sea (Gobabeb Centre)
5.h VISITOR FACILITIES AND STATISTICS

The vast majority of visitors to the Namib Sand Sea currently enter the Property via Sesriem Gate on the eastern boundary (Table 5.h.1). Sesriem is the entrance and administrative centre for visitors to Sossus Vlei and the Sesriem Canyon. A petrol station, small food and curio shop and a large bar and restaurant are located immediately inside the entrance. Visitor facilities at Sesriem consist of a campsite for 24 groups and the Sossus Dune Lodge of Namibia Wildlife Resorts (NWR) with 25 chalets (50 beds) (Table 5.h.2). A rudimentary interpretation centre at Sesriem used to provide some information about the Namib Sand Sea but was dismantled by NWR. The Management Plan makes provision for substantially upgrading information provided. A new amenity is the clinic currently being built that will support a full time doctor and four nurses to attend to visitors and staff alike.

Table 5.h.1: Visitor statistics for the Namib-Naukluft Park. Visitors entering through the Sesriem gate are all visiting the Namib Sand Sea, while permits issued elsewhere (combined as Ganab) may be used to visit parts of the Namib Sand Sea, e.g. Sandwich Harbour. Many of those with Ganab permits do not visit the Namib Sand Sea but other attractions in the Namib-Naukluft Park.

<table>
<thead>
<tr>
<th></th>
<th>2005/06</th>
<th>2009</th>
<th>2010</th>
<th>2011¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overseas</td>
<td>31,759</td>
<td>12,153</td>
<td>17,088</td>
<td>17,756</td>
</tr>
<tr>
<td>Africa</td>
<td>12,351</td>
<td>2,713</td>
<td>4,980</td>
<td>1,935</td>
</tr>
<tr>
<td>Namibia</td>
<td>14,703</td>
<td>5,869</td>
<td>9,245</td>
<td>9,673</td>
</tr>
<tr>
<td>Subtotal</td>
<td>58,813</td>
<td>20,735</td>
<td>21,430</td>
<td>34,029</td>
</tr>
<tr>
<td>TOTAL</td>
<td>79,548</td>
<td>87,618</td>
<td>51,448</td>
<td>123,393</td>
</tr>
</tbody>
</table>

¹Until October 2011; ²Data compiled by SIAPAC 2007; ³Sesriem entry gate extremely unreliable

Inside the boundaries of the Property at Sossus Vlei, 60 km of tarred road along the Tsauchab River corridor leads to a 2x4 car park near Sossus Vlei. From there, a five km sand track exclusively for 4x4 vehicles guides visitors from the car park to further parking areas providing walking access to the Dead Vlei and Sossus Vlei itself. A shuttle service using six 4x4 vehicles is provided by NWR to ferry people from the 2x4 parking area to the further sites. One short gravel road ending in a designated parking area leads directly from the tarred road to Dune 45. From there visitors have easy access to climb this tall dune. All vehicle parking areas are clearly demarcated and provided with pit toilets, waste bins and picnic tables.

Table 5.h.2: Lodge occupancy at Sesriem, inside the Namib Naukluft Park

<table>
<thead>
<tr>
<th>Lodge</th>
<th>Accommodation available</th>
<th>Annual average occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sossus Dune Lodge</td>
<td>50 beds in 25 chalets</td>
<td>60%</td>
</tr>
<tr>
<td>Sesriem Campsite</td>
<td>24 campsites (max. 8 people/campsite)</td>
<td>88%</td>
</tr>
</tbody>
</table>

Outside the park, at least 35 lodges and campsites are situated in the near vicinity to take advantage of the Namib Sand Sea. These lodges, with at least 660 beds, and the many associated campsites outside the park, enjoy an occupancy rate estimated at 60% – a tremendous economic engine in the
vicinity of the Namib Sand Sea. Tourists usually stay at the lodges for at least two nights with an early morning visit to Sossus Vlei in the Namib Sand Sea as the highlight of their stay. If the larger catchment is taken into account, the number of privately owned tourism facilities increases to at least 60 establishments.

Figure 5.h.1: On the northern boundary of the Namib Sand Sea within the buffer area, the Gobabeb Training and Research Centre hosts numerous scientists and students who study various aspects of the dunescape (Gobabeb Centre)

Other concession holders (see Table 4.a.3) conduct adventure tours elsewhere in the sand sea. During such tours the operators establish temporary flycamps and remove all waste from the area. A concession has been granted to establish a lodge at Meob Bay within the Property. Permission to construct a lodge has not yet been granted, however, pending an EIA and EMP. Day visits are allowed for self-drive 4x4 vehicles to Sandwich Harbour from Walvis Bay via a sand track. It ends at a demarcated area at Sandwich Harbour but there are no facilities of any kind.

5.i POLICIES AND PROGRAMMES RELATED TO THE PRESENTATION AND PROMOTION OF THE PROPERTY

Policies related to presentation and promotion of the Property are integrated into those used by the Ministry of Environment and Tourism (MET), the Namibian Wildlife Resorts (NWR) and the Namibian Tourism Board (NTB) throughout Namibia. The Gobabeb Training and Research Centre regularly compiles and distributes books, posters and booklets that describe aspects of the Namib Sand Sea. Well developed tourist information centres at Walvis Bay and Swakopmund provide substantial information about various aspects relating to the Namib Sand Sea. The Management Plan makes provision for specific activities to present the values and attributes for which the Namib Sand Sea is nominated (Table 5.i.1).
### Table 5.i.1: Envisaged activities to promote the Namib Sand Sea

<table>
<thead>
<tr>
<th>Activity</th>
<th>Co-ordination</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop and open information center at Sesriem with duplication of information products to other tourist information centers</td>
<td>MET Department of Tourism/National Committee for World Heritage</td>
<td>Dissemination of information on values for which the Namib Sand Sea is nominated</td>
</tr>
<tr>
<td>Develop information boards, concise tourist information and improved signage for key destinations</td>
<td>MET Chief Warden/National Committee for World Heritage</td>
<td>Site-specific information about key attributes</td>
</tr>
<tr>
<td>Develop information handbook and training syllabus for tour guides</td>
<td>Gobabeb Centre/Namibian Academy for Tourism and Hospitality</td>
<td>Informed tour guides that can provide better information to visitors</td>
</tr>
<tr>
<td>Summarise world heritage values of geology, ecology, biodiversity and key species into information booklet for schools and education centres nationwide</td>
<td>Gobabeb Centre/National Committee for World Heritage</td>
<td>National appreciation of the values for which the Namib Sand Sea was nominated</td>
</tr>
<tr>
<td>Identification of the kind and numbers of world heritage signage required for installation</td>
<td>MET Chief Warden/Roads Authority</td>
<td>Appropriate marketing of prospective World Heritage status</td>
</tr>
<tr>
<td>Develop visitor survey tools to record visitor perceptions, understanding and appreciation of the Namib Sand Sea</td>
<td>National Museum/Gobabeb Centre</td>
<td>Assessment of visitor experience</td>
</tr>
<tr>
<td>Develop an appropriate international marketing strategy</td>
<td>Namibia Tourism Board/Hospitality Association of Namibia</td>
<td>Specific marketing of the Namib Sand Sea as a prime tourist destination</td>
</tr>
</tbody>
</table>

Programmes related to the presentation and promotion of the Property are diverse. The MET, NWR and NTB take advantage of various tourism fairs globally where the Property is promoted alongside other premier Namibian attractions such as the Etosha National Park and the Fish River Canyon. The Property features regularly in the AirNamibia in-flight magazine, Flamingo, and unique aerial photos of the Property have graced the cover almost every month for the past several years.
All the 60 lodges situated in the vicinity of Sesriem and surrounding the Namib-Naukluft Park promote the Property as one of the main attractions of a stay at their establishments. This is echoed by the accommodation found in the surrounding towns of Walvis Bay and Lüderitz and throughout Namibia. Travel guides to Namibia or the southern African region invariably have a stunning picture of the Property on their front or back cover. Indirect promotion of the Property results from the use of images of this iconic landscape on advertising ranging from heavy transport, to IT, to food products, to sanitation codes of practice and to insurance companies. The Property is extremely well known and recognised both within Namibia and globally.

Promotion of the geography and natural history of the Property is found in a variety of well-illustrated books and pamphlets on sale throughout Namibia and elsewhere. Materials from these books and other publications have been integrated into the knowledge base focused on arid lands, which is accessible throughout the globe.

Films by National Geographic, BBC, Anglia and lesser-known companies have promoted the unique scenery, geomorphology and biota of the Property. At least 1 – 2 films are made every year with support of the Gobabeb Training and Research Centre and other, product-promotional films are made in other parts of the Property at a rate of 2 – 3 per month.

**5.j STAFFING LEVELS (PROFESSIONAL, TECHNICAL, MAINTENANCE)**

The approved structure of the MET makes provision for 28 staff that are directly focused on the Namib Sand Sea as part of their responsibilities within the Directorate of Regional Services and Parks Management. These include: Deputy Director (1), Chief Control Warden (1), Chief Warden (1), Warden (2), Rangers (3), Operator/ Driver (2), Scouts (8), Watchman (6) and Workhand (4). This staff is supported by additional regional and national staff of the MET based in the capital and surrounding coastal towns. These include specialists from the Directorate of Scientific Services, the Department of Tourism and the Department of Environmental Affairs. All these Departments support activities as part of their overall mandate.

Staff members directly responsible for the Namib Sand Sea area of the Namib-Naukluft Park are based at Sesriem and Escourt with additional staff at Zeis and Ganab in the park. Other offices of MET are located in Walvis Bay, Swakopmund, Lüderitz and Windhoek although their staff members are not directly responsible for the Namib Sand Sea area. The approved structure of MET provides positions for three conservation scientists for the Namib-Naukluft Park area.
Research staff, interns and technicians numbering approximately 15, augmented by visiting scientists and tertiary institution interns, are resident at the Gobabeb Training and Research Centre situated on the northern boundary of the Property.
Monitoring
A light blanket of fog covers the coastal Namib Sand Sea (Paul van Schalkwyk)
Monitoring of the property is a long-term process focused on some locations but is not widespread. For at least the last century, the climate, primarily rainfall, evaporation, wind, temperature and humidity has been monitored in the two coastal towns closest to the property, Walvis Bay and Lüderitz. Since 1962 the Gobabeb Centre has been recording these same parameters as well as fog, soil temperatures and incidence of solar radiation. For the past decade, climate measurements have been made on NamibRand Nature Reserve bordering the property to the east. Data from numerous rainfall gauges at Sesriem and on farms bordering the eastern boundary have not been collated.

The MET has been monitoring migratory birds at the Sandwich Harbour Ramsar Site since the 1970s, more recently supported by the Coastal Environmental Trust of Namibia (an NGO). Breeding of vultures, particularly *Torgos tracheliotus*, has been monitored by MET and is pursued by the Vulture Study Group – Vultures Namibia (an NGO) along the larger ephemeral rivers in the east. Monitoring of vultures and other birds of prey also takes place in NamibRand Nature Reserve and other farms along the eastern boundary of the property.

![Image](image_url)

**Figure 6.1: Monitoring fauna is both an important process and a learning opportunity (Gobabeb Centre)**

Vegetation and invertebrates have been the focus of research at the Gobabeb Centre and long-term monitoring has been conducted since the mid-1970s in the northern part of the Namib Sand Sea. Additional studies have been carried out by MET researchers and national agencies, such as the National Botanical Research Institute, which includes the National Herbarium, and the National Museum. Much of this information has been published in peer-reviewed literature or as research reports that are available in the Gobabeb library.
To enhance monitoring throughout the property by various contributors in various places, accurate baseline maps of roads, infrastructure, historical, archaeological and palaeontological sites should be available and shared. A comprehensive meta-database and an overall research database would also support monitoring of the property. The need for such information has been mooted but not put in place. Elements of a meta-database, and extensive data records, are available at the Gobabeb Centre.

Processing of data to inform management planning and decision making has been sporadic and uncoordinated. The management plan includes elements to improve the situation. Extensive information about the Namib-Naukluft Park including the Namib Sand Sea was compiled by the Gobabeb Centre and made available to the MET in preparation for their formulation of the 2003 Management Plan. Several Environmental Updates prepared by the Desert Research Foundation of Namibia for Parliament have touched on elements of the Namib Sand Sea, and more could be compiled in the future.

Information about birds of prey and vultures is processed by the Vulture Group and made available to the MET. The MET itself has been assembling data but, with the exception of bird counts at Sandwich Harbour, most has not been processed. Information on tourist numbers has been compiled by MET and made available to the Namibia Tourism Board (NTB). This will in future be coordinated by the Gobabeb Centre for more comprehensive information about activities in the Namib Sand Sea.

![Figure 6.2: Population dynamics of assorted invertebrates, mammals and birds are part of the monitoring process (Gobabeb Centre)](image)

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6.a KEY INDICATORS FOR MEASURING STATE OF CONSERVATION

The Management Plan indicates a series of management targets for the Namib Sand Sea. Indicators for measuring management of the state of conservation in the property are included (Table 6.a.1).

Ongoing monitoring of the Namib Sand Sea has been limited, focused mainly on aspects of weather, climate, birds, large mammals, invertebrates and vegetation. The majority of longer-term monitoring has taken place in the northern part of the Namib Sand Sea undertaken by the Gobabeb Training and Research Centre. The MET has focused intermittent, long-term monitoring on birds and large mammals. The Ministry of Fisheries and Marine Resources (MFMR) maintains a number of automatic weather stations on the coast and on the off-shore islands that provide valuable supporting data for the Namib Sand Sea. The Coastal Environmental Trust of Namibia (CETN) coordinates summer and winter bird counts of the Walvis Bay Lagoon and Sandwich Harbour in collaboration with MET. Also of value to measuring the state of conservation is the research and monitoring being conducted by NamibRand directly bordering the south-eastern boundary of the proposed property.

Table 6.a.1: Proposed indicators for monitoring state of conservation of the Namib Sand Sea

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Periodicity</th>
<th>Responsible</th>
<th>Location of records</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Management indicators</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning, management and monitoring framework updated</td>
<td>5 year intervals</td>
<td>Chief Control Warden</td>
<td>Office: Chief Control Warden; Gobabeb Centre</td>
</tr>
<tr>
<td>Detailed tourism plan updated</td>
<td>5 year intervals</td>
<td>Director of Tourism</td>
<td>Office: Director of Tourism; Chief Control Warden; Gobabeb Centre</td>
</tr>
<tr>
<td>Strategic Forum annual meetings (MET, Gobabeb, neighbours)</td>
<td>Annual review</td>
<td>Chief Control Warden</td>
<td>Office: Chief Control Warden; Gobabeb Centre</td>
</tr>
<tr>
<td>Consultative Forum of interested parties for ongoing operational assistance, guidance, support and feedback</td>
<td>Annual review, quarterly meetings</td>
<td>Chief Control Warden</td>
<td>Office: Chief Control Warden; Gobabeb Centre</td>
</tr>
<tr>
<td>Honourary warden programme</td>
<td>Annual review</td>
<td>Chief Control Warden</td>
<td>Office: Chief Control Warden; Gobabeb Centre</td>
</tr>
<tr>
<td>Community interest group activities, e.g. birds of prey</td>
<td>Annual review</td>
<td>Individual interest groups (MET review)</td>
<td>Office: Chief Control Warden; Gobabeb Centre</td>
</tr>
<tr>
<td><strong>Human use indicators</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily detailed tourism records (numbers, types of activities)</td>
<td>Monthly submission; annual review</td>
<td>Sesriem gate; Chief Warden</td>
<td>Office: Chief Warden; Office: Director of Tourism; Gobabeb Centre; Sesriem Gate</td>
</tr>
<tr>
<td>Activity Description</td>
<td>Frequency</td>
<td>Responsible Party</td>
<td>Office:</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------</td>
<td>------------------------</td>
<td>-----------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Ongoing detailed concession allocations and use (numbers, types of activities)</td>
<td>Annual review</td>
<td>Chief Warden</td>
<td></td>
</tr>
<tr>
<td>Water use and management (tourism &amp; wildlife)</td>
<td>Annual review</td>
<td>Chief Warden</td>
<td></td>
</tr>
<tr>
<td>Records of research activities and results</td>
<td>Annual review</td>
<td>Chief Warden; compiled by Gobabeb Centre</td>
<td></td>
</tr>
</tbody>
</table>

### Geographical Indicators

<table>
<thead>
<tr>
<th>Indicator Description</th>
<th>Frequency</th>
<th>Responsible Party</th>
<th>Office:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt pans/flats; Endorheic pans (sensitivity 5 areas)</td>
<td>Annually</td>
<td>Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Ephemeral rivers, inselbergs, gravel plains, rocky shore (sensitivity 4 areas)</td>
<td>Two year intervals</td>
<td>Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Sand sea, Sandwich Harbour lagoon, eastern hills (sensitivity 3 areas)</td>
<td>Five year intervals</td>
<td>Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Landscape aesthetics</td>
<td>Two year intervals</td>
<td>Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Archaeological and palaeontological sites</td>
<td>Two year intervals</td>
<td>Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Daily weather and climate; Sesriem, Coast (MFMR), Gobabeb</td>
<td>Daily; monthly submissions; annual review</td>
<td>Sesriem Gate; MFMR; Gobabeb Centre; Review: Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Hydrology and flooding as occur</td>
<td>Intermittent observations</td>
<td>Sesriem Gate; Gobabeb Centre; Review: Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
</tbody>
</table>

### Ecological Indicators

<table>
<thead>
<tr>
<th>Indicator Description</th>
<th>Frequency</th>
<th>Responsible Party</th>
<th>Office:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual and perennial vegetation population dynamics</td>
<td>Annually</td>
<td>Gobabeb Centre with PoN for remote sensing</td>
<td></td>
</tr>
<tr>
<td>Invertebrate population dynamics, ongoing measurements</td>
<td>Annual review</td>
<td>Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Breeding birds of prey/vultures</td>
<td>Twice annual review</td>
<td>Vulture Group; Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Coastal migratory birds</td>
<td>Twice annually</td>
<td>CETN; Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Large mammal populations</td>
<td>Annually/5 year intervals</td>
<td>Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
<tr>
<td>Invasive aliens</td>
<td>Annually</td>
<td>Chief Warden; Gobabeb Centre</td>
<td></td>
</tr>
</tbody>
</table>
To address their responsibilities for monitoring the state of conservation in the Namib Sand Sea, the Chief Control Warden responsible for the property intends to establish the ‘event book’ system used widely in communal conservancies and elsewhere in Namibia. This entails all staff members having an event book wherein they fill in observations of note, e.g. the flow of the Tsau Chab river for the first time in five years, the eruption of a locust swarm, an ostrich nest. The entries include the event but also supporting information such as time, date, location and relevant surrounding circumstances. This is in addition to ongoing monitoring of key parameters.

The Gobabeb Training and Research Centre is well situated for overseeing and managing monitoring, research and data management with an extensive library, database and metadata base covering particularly climate, invertebrate and vegetation parameters. The Gobabeb Centre has been identified as the monitoring and research centre for the combined Namib-Skeleton Coast National Park network. It is currently gearing up to serve as the monitoring, research and data management centre on behalf of the Strategic Environmental Management Plan of the Ministry of Mines and Energy regarding the uranium rush taking place on the gravel plains well north of the Namib Sand Sea.

Reference areas for monitoring have not yet been established within the identified property. Two types of reference areas are envisaged. One would consist of areas that are known to be completely out of reach of any tourism or research activity within the Namib Sand Sea as baseline monitoring sites. The other type of reference area would be established where concession holders guide tourists in the Namib Sand Sea. These latter reference areas would help to establish and interpret the unknown influences of adventure tourism, thought but not established to be of low impact, on the property.
6.b ADMINISTRATIVE ARRANGEMENTS FOR MONITORING PROPERTY

Since the MET is the owner of the identified property, they would be expected to hold overall responsibility for monitoring the property. It is anticipated that they will outsource components of this responsibility to the Gobabeb Training and Research Centre who would be accountable to the MET.

A key advantage of outsourcing this responsibility to the Gobabeb Centre is the possibility to integrate short-term research projects and observations, made by many visiting local and international scientists, into the longer-term measurements and scenarios generated from different locations with a variety of subjects and organisms.

6.c RESULTS OF PREVIOUS REPORTING EXERCISES

Reporting exercises that have addressed the Namib Sand Sea have mostly focused on localised areas and specific elements of the biophysical and socio-economic environment with the exception of a few international studies that specifically considered future priorities for World Heritage (Table 6.c.1).

Various State of the Environment Reports, while not focusing on the Namib Sand Sea, will contribute background for an overall monitoring framework for the Namib Sand Sea. Refer to the bibliography attached as Annex 21.

Table 6.c.1: Previous reports relevant to the Namib Sand Sea

<table>
<thead>
<tr>
<th>Year</th>
<th>Type of Report</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>IUCN. World Heritage Desert Landscapes.</td>
<td>Global</td>
</tr>
<tr>
<td>2010</td>
<td>Federation of Namibian Tourism Associations. Conservancy Based Tourism Enterprises (CBTEs) in Namibia and the Business of Tourism: A Private Sector Point of View.</td>
<td>Economic</td>
</tr>
<tr>
<td>2010</td>
<td>Gobabeb Centre. Namib: Secrets of a desert uncovered.</td>
<td>Regional</td>
</tr>
<tr>
<td>2008</td>
<td>Ministry of Environment &amp; Tourism. Strategic Environmental Assessment (SEA) for the coastal areas of the Erongo and Kunene Regions.</td>
<td>Conservation</td>
</tr>
</tbody>
</table>
Most of these reports do not focus on the Namib Sand Sea specifically, though they contributed to determine the information needs and strategies for an overall monitoring framework. In the context of this nomination, the global studies undertaken by IUCN in support of a representative World Heritage list are particularly important. Two studies specifically referred to the Namib for its potential nomination (Goudie, A. & Seely, M. 2011. World Heritage Desert Landscapes. IUCN, 44 pp; WHC-04/28.COM/INF.13B. 2004. The World Heritage List: Future priorities for a credible and complete list of natural and mixed sites. IUCN, Gland. 21 pp.). A quote from the latter document refers: “Habitat types that emerge from a review of this data set which may have potential for WH nomination include: ... Namib desert” (WHC-04/28.COM/INF.13B, 2004, p. 9).

Figure 6.c.1: The northern boundary of the Namib Sand Sea terminates abruptly on the ephemeral Kuiseb River (Bowen/NASA)
Documentation 7
Black-backed jackel frequently patrol the Namib Sand Sea (Paul van Schalkwyk)
7. Documentation

7.a PHOTOGRAPHS, SLIDES, IMAGE INVENTORY AND AUTHORIZATION TABLE AND OTHER AUDIOVISUAL MATERIALS

Table 7.a.1: Photographs, slides, image inventory and authorization table and other audiovisual materials

<table>
<thead>
<tr>
<th>ID No.</th>
<th>Format</th>
<th>Caption</th>
<th>Date of photograph</th>
<th>Photographer &amp; Copyright owner</th>
<th>Contact details of copyright owner</th>
<th>Non-exclusive cessation of rights</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSS1</td>
<td>jpg</td>
<td>Wind-controlled linear dune crests in the forever changing Namib Sand Sea</td>
<td>Unknown</td>
<td>All images by Paul van Schalkwyk</td>
<td>PO Box 21593 Windhoek, Namibia tel: +264 81 277 3334 fax: +264 61 220 410 Email: <a href="mailto:elmarie@paulvans.com">elmarie@paulvans.com</a></td>
<td>yes</td>
</tr>
<tr>
<td>NSS2</td>
<td>jpg</td>
<td>Diverse magnificent desert landforms populate the Namib Sand Sea</td>
<td>Unknown</td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>NSS3</td>
<td>jpg</td>
<td>A water-filled vlei on the eastern edge of the Namib Sand Sea</td>
<td>Unknown</td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>NSS4</td>
<td>jpg</td>
<td>The extreme aridity of the Namib Sand Sea is ameliorated by coastal fog and episodic rainfall events</td>
<td>Unknown</td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>NSS5</td>
<td>jpg</td>
<td>The iconic Dead Vlei with its 800-year old Acacia erioloba ghost forest near Sossus Vlei</td>
<td>Unknown</td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>NSS6</td>
<td>jpg</td>
<td>The deep blue of the South Atlantic juxtaposing the transverse dune crests of the Namib Sand Sea</td>
<td>Unknown</td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>NSS7</td>
<td>jpg</td>
<td>Southward view over the Namib Sand Sea from the Kuiseb River Canyon</td>
<td>Unknown</td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>DNo.</td>
<td>Format</td>
<td>Caption</td>
<td>Date of Photographer</td>
<td>Copyright</td>
<td></td>
<td></td>
</tr>
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<td>---------</td>
<td>----------------------</td>
<td>-----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NNS8</td>
<td>jpeg</td>
<td>The ephemeral Tsauchab River truncates the magnificent linear dunes of the Namib Sand Sea</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NNS9</td>
<td>jpeg</td>
<td>Bi-directional winds sculpture sinuous dune crests in the Namib Sand Sea</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS10</td>
<td>jpeg</td>
<td>A light blanket of fog covers the coastal Namib Sand Sea</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS11</td>
<td>jpeg</td>
<td>A striking display of the two Namib Sand Seas, with the Sossus Sand Formation superimposed on the Tsodan Sandstone Formation</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS12</td>
<td>jpeg</td>
<td>Huge star dunes at Sossus Vlei dwarf the vegetation in the dry riverbed of the Tsauchab River</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS13</td>
<td>jpeg</td>
<td>Ballooning – a tourism venture leaving only a light footprint in the Namib Sand Sea</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS14</td>
<td>jpeg</td>
<td>The interplay of light and shadow on the dunes inspires the artistic soul in all of us</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS15</td>
<td>jpeg</td>
<td>The aerial view does not do justice to the magnificent dunes at Sossus Vlei</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS16</td>
<td>jpeg</td>
<td>Even after heavy rains, the ephemeral Tsauchab River is eventually swallowed by the Namib Sand Sea</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS17</td>
<td>jpeg</td>
<td>Endless sand supply from the South Atlantic to the Namib Sand Sea at Sandwich Harbour</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS18</td>
<td>jpeg</td>
<td>The Namib Sand Sea meets the southern Atlantic</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSS19</td>
<td>jpeg</td>
<td>Endemic Damara terns and other birds at the Sandwich Harbour Ramsar Site in the Namib Sand Sea</td>
<td>Un known</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* All photos taken between 2006 and 2008.
* Acknowledgement requested when used.
7.b TEXTS RELATING TO PROTECTIVE DESIGNATION, COPIES OF PROPERTY MANAGEMENT PLANS OR DOCUMENTED MANAGEMENT SYSTEMS AND EXTRACTS OF OTHER PLANS RELEVANT TO THE PROPERTY

Texts relating to protective designation are attached as Annex 19. A copy of the main relevant property Management Plan is attached in Annex 20.

7.c FORM AND DATE OF MOST RECENT RECORDS OR INVENTORY OF PROPERTY

Information concerning the property is to be found in different locations. Information on management is in annual reports of the MET, and ancillary documentation, can be found in the library of the Directorate of Environmental Affairs, MET, and in the offices of the senior staff of MET, including the Chief Control Warden responsible for the Namib Sand Sea. The Management Plan makes provision for the review of which essential inventory information needs to be captured into a central database. More detailed information is included in Table 7.c.1

Table 7.c.1: Data inventories and archives relevant to the Namib Sand Sea

<table>
<thead>
<tr>
<th>Type of Record</th>
<th>Depository were kept</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual overview of management</td>
<td>MET Office: Chief Warden</td>
<td>Annual reports for MET and the Namib-Naukluft Park</td>
</tr>
<tr>
<td>Archaeological inventories</td>
<td>MYNSSC: National Museum of Namibia</td>
<td>Location and object data for recorded archaeological and national heritage material</td>
</tr>
<tr>
<td>Biological resource exploitation</td>
<td>MET Permit Office</td>
<td>Type and quantity of biological resources exploited under permit</td>
</tr>
<tr>
<td>Climate information</td>
<td>MWT: National Meteorological Institute; MFMR: National Marine Research &amp; Information Centre; Gobabeb Training &amp; Research Centre</td>
<td>Weather information from national recording stations; climate interpretation</td>
</tr>
<tr>
<td>Current management</td>
<td>MET Office: Chief Control Warden</td>
<td>All current files pertaining to management over the past 25 years, including planning, personnel, funding, concessions, reports</td>
</tr>
<tr>
<td>Ecological functioning</td>
<td>Gobabeb Training &amp; Research Centre</td>
<td>Published and unpublished research results and interpretation</td>
</tr>
<tr>
<td>Environmental impact assessments</td>
<td>MET Office: Environmental Commissioner</td>
<td>All Environmental Impact Assessments directly and indirectly linked to the Namib Sand Sea</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>----------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Geological inventories</td>
<td>MME: Geological Survey of Namibia</td>
<td>Geological maps, recorded mineral resources, geological exploration and research reports</td>
</tr>
<tr>
<td>Illegal activities</td>
<td>MET Office: Chief Control Warden</td>
<td>Type and frequency of law enforcement</td>
</tr>
<tr>
<td>Long-term ecological monitoring data</td>
<td>Gobabeb Training &amp; Research Centre</td>
<td>Site-based data and analysis of long-term monitoring results</td>
</tr>
<tr>
<td>Management history</td>
<td>MYNSSC: National Archives of Namibia</td>
<td>Official management authority files older than 25 years</td>
</tr>
<tr>
<td>Mineral resource exploitation</td>
<td>MYNSSC: National Archives of Namibia; MME: Commissioner of Mines</td>
<td>Type and quantity of geological resources that have been exploited historically and more recently</td>
</tr>
<tr>
<td>National heritage</td>
<td>MYNSSC: National Heritage Council</td>
<td>Records, evaluations and reports on national heritage (including generic heritage, e.g. shipwrecks)</td>
</tr>
<tr>
<td>National infrastructure</td>
<td>MLR: Surveyor-General</td>
<td>Roads, property ownership, structures, aerial photography and topography</td>
</tr>
<tr>
<td>Paleontological inventories</td>
<td>MME: Geological Survey of Namibia</td>
<td>Location data for palaeontological sites and contents</td>
</tr>
<tr>
<td>Plant species inventories</td>
<td>MAWF: National Botanical Research Institute</td>
<td>Location data for recorded plant species</td>
</tr>
<tr>
<td>Population &amp; household numbers</td>
<td>NPC: National Statistics Office</td>
<td>Decadal information on population numbers and household structures</td>
</tr>
<tr>
<td>Ramsar monitoring and reporting</td>
<td>MET Office: Chief Control Warden</td>
<td>Semi-annual migratory bird count information and Ramsar reports</td>
</tr>
<tr>
<td>Research activity</td>
<td>MET Permit Office</td>
<td>Applications and reports for all research activity in the Namib Sand Sea</td>
</tr>
<tr>
<td>Terrestrial animal species inventories</td>
<td>MYNSSC: National Museum of Namibia</td>
<td>Location data for recorded animal species</td>
</tr>
<tr>
<td>Visitor numbers</td>
<td>National Tourism Board; MET Office: Chief Control Warden</td>
<td>General information on tourism numbers (mainly foreign) and specific visitor numbers</td>
</tr>
<tr>
<td>Water and discharge information</td>
<td>MAWF: Department of Water Affairs</td>
<td>Water quality, geohydrology and surface hydrology information, flood information</td>
</tr>
<tr>
<td>Wildlife census information</td>
<td>MET Office: Wildlife Survey &amp; Monitoring</td>
<td>Wildlife aerial and waterhole census data per species</td>
</tr>
</tbody>
</table>
7.d ADDRESS WHERE INVENTORY, RECORDS AND ARCHIVES ARE HELD

Ministry of Environment and Tourism
Private Bag 13346
Windhoek
Namibia

Gobabeb Training and Research Centre
P O Box 953
Walvis Bay
Namibia

National Archives
Private Bag 13250
Windhoek
Namibia

National Museum of Namibia
P O Box 1203
Windhoek
Namibia
7.e BIBLIOGRAPHY

An indicative bibliography of approximately 1,000 publications including information about the Namib Sand Sea and located within the comprehensive library of the Gobabeb Centre is attached as Annex 21.

Key references used in preparation of this nomination dossier are included here (Section 7.e).

Archaeology & History

Biodiversity


Climate and Weather


Soderberg KS. 2010. The role of fog in the ecohydrology and biogeochemistry of the Namib Desert. PhD. Department of Environmental Sciences, University of Virginia: 200 pp.


Ecology


**Ephemeral rivers, water and hydrology**


**General**


NACOMA. 2010. *Strategic Environmental Assessment (SEA) for the Coastal areas of Namibia – Combined Report*.


**Geomorphology**


Invertebrate behaviour, physiology and ecology


**Natural History**


**Tourism**


**Vegetation physiology and ecology**


Vertebrate behaviour, physiology and ecology


World Heritage Council / IUCN


Southward view over the Namib Sand Sea from the Kuiseb River Canyon (Paul van Schalkwyk)
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COUNTRY: Namibia  
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FAX: +264 61 263790  
E-MAIL: met.nnp@iway.na

8.d OFFICIAL WEB ADDRESS
http://www.met.gov.na

CONTACT NAME: Permanent Secretary, Ministry of Environment & Tourism  
E-MAIL: ps@met.na
The rhythmic interplay of sand, light and shadow in the Namib Sand Sea inspires artists and scientists alike (Paul van Schalkwyk)
Signature on Behalf of the State Party

The Hon. Kazenambo Kazenambo

Minister of Youth, National Service, Sport and Culture

Republic of Namibia
Namib Sand Sea