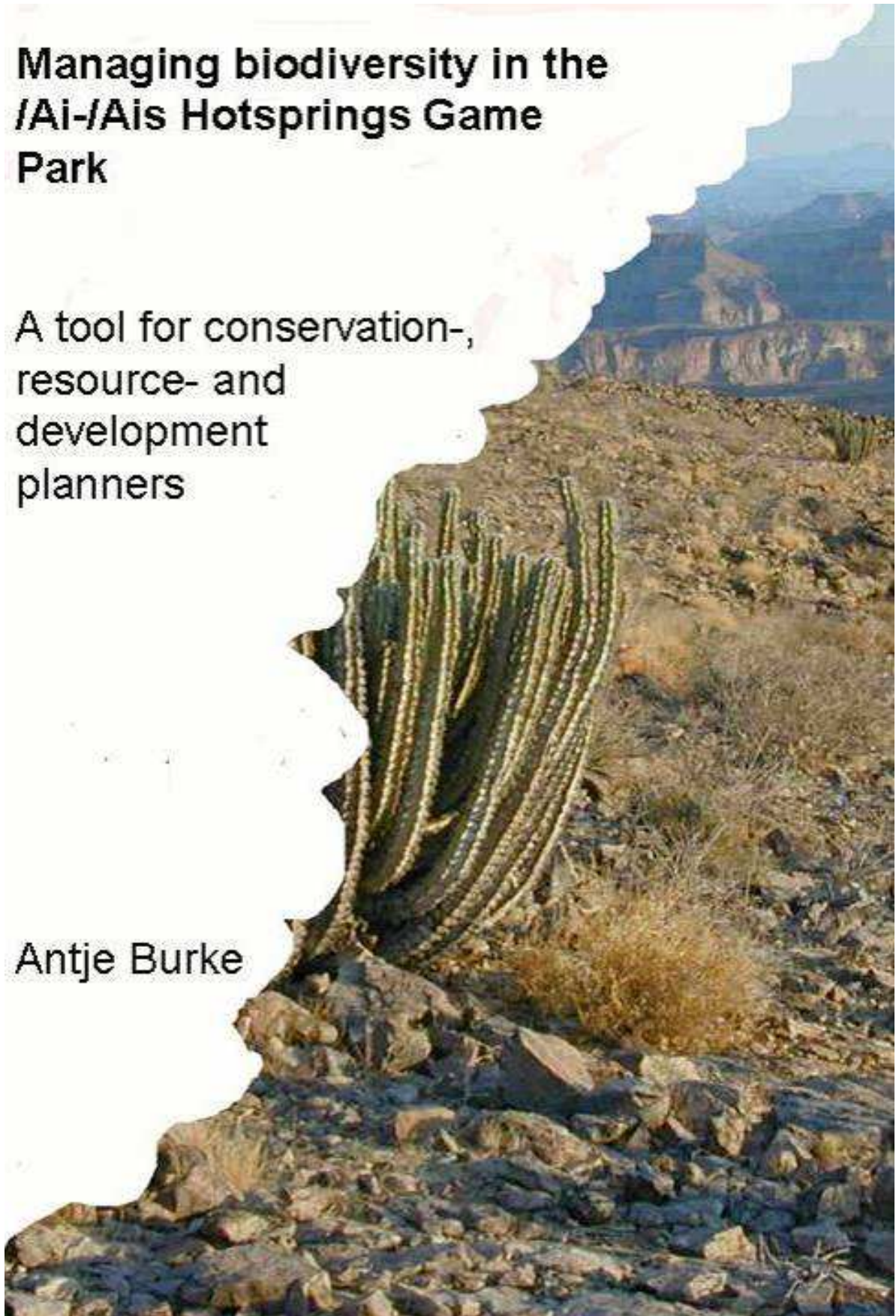


Managing biodiversity in the /Ai-/Ais Hotsprings Game Park

A tool for conservation-,
resource- and
development
planners

Antje Burke



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FOREWORD

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SUMMARY

The /Ai-/Ais Hot Springs Game Park is the Namibian Section of the /Ai-/Ais/Richtersveld Transfrontier Park (ARTP) in the south of Namibia. Although a joint management plan exists for the Transfrontier Park, detailed information on biodiversity in the Namibian section of the park was lacking. This document addresses this gaps and

- describes landscape units and their biodiversity importance,
- highlights knowledge gaps
- reviews current land uses and proposed zoning and
- provides guidelines for managing these landscape units.

The park is characterised by extremely rugged and largely inaccessible terrain in the majority of the area, while the eastern section is traversed by the Fish river which has deeply incised into bedrock and now provides the main attraction of the park – the Fish river canyon.

Biogeographically at the border of two, possibly three major biomes – the Succulent Karoo, Nama Karoo and Desert biomes – and largely within the Gariep Centre of Endemism, the park of great biodiversity importance.

Biodiversity inventories are, however, incomplete, but likely over 350 plant species are expected to occur within the park boundaries.

The combination of river and mountain habitats – many of these inaccessible – provides a kaleidoscope of different microhabitats and with this, niches for a diverse plant and animal life. The sheer inaccessibility of many parts of the park has resulted in true wilderness where access is only possible on foot and by helicopter, thereby providing protection for plants and animals, many of which are as yet unknown.

However, where access is possible, such as along the Orange river, the impacts of livestock and irrigation farming and particularly small-scale mining have taken their toll. Although localised, the impacts of tourism developments are also evident and could be greatly reduced by more prudent environmental management.

The park has been divided into 14 landscape units and their biodiversity importance, resource use, threats and research needs are described and recommendations for management provided. The canyon slopes, southern Huns and Namus mountains, and the Fish- and Boom and associated rivers were classified of very high conservation importance. They cover more than half of the study area.

Based on this the current joint management zoning of the ARTP is recommended to be adapted in the area between the Fish, Gamkab and lower Konkiep rivers.



Intermingling of Succulent and Nama Karoo is indicated on the upper slopes west of the Gamkab river – here the Gariep aloe (*Aloe garipensis*) grows alongside *Euphorbia virosa* and *Euphorbia gregaria*. The biome boundary may be near, but more detailed field surveys are required to confirm this.

INTRODUCTION

The /Ai-/Ais Hotsprings Game Park is the Namibian Section of the /Ai-/Ais/Richtersveld Transfrontier Park (ARTP). The park is managed by a Joint Management Board with conservation officials from both, South African National Parks (SANParks) and the Namibian Ministry of Environment and Tourism.

The /Ai-/Ais Hotsprings Game Park was proclaimed in several steps from 1968 to 2002 and covers today 4348 km².

Although management of the park is guided by the joint management plan for the transfrontier park, management zoning of the area was initially undertaken at a high level, lacking detailed information on biodiversity for the Namibian section of the transfrontier park.

This document addresses this gap and

- describes landscape units and
- their biodiversity importance,
- highlights knowledge gaps
- reviews current land uses and proposed zoning and
- provides guidelines for managing these landscape units.

The park is positioned in the very south of Namibia, just north of the Orange River at the boundary with South Africa. The area of the park is somewhat disjointed as private farmland divides the western and eastern portions of the park, which is only continuous along an approximately 18 km broad band along the Orange River. There is also former farmland on the plains east of the Gamkab River which has recently been added to the park. This section is only joined by a narrow 3 km strip to the remainder of the park.

Part of the adjoining farmland is managed as private nature reserves (e.g. the Canyon Nature Park and Canyon Private Nature Reserve in between the two sections of the park and the Gondwana Canyon Park to the east). (Figure 1).

Biogeographically there is some debate amongst ecologists whether this area forms part of the Succulent Karoo-, the Nama Karoo- or Desert Biome (Irish 1994; Rutherford 1997; Mucina & Rutherford 2006). However, the park lies within the planning domain of the Succulent Karoo Ecosystem Project, and with this in one the world's global biodiversity hotspots (Myers et al. 2000).



An amazing assemblage of protected, rare and range-restricted plant species grows on the slopes of the Namus mountains – here the stem-succulent halfmens (*Pachypodium namaquanum*), *Aloe ramosissima* and *Tylecodon paniculatus* form a conspicuous group, with smaller equally important succulents providing the undergrowth.

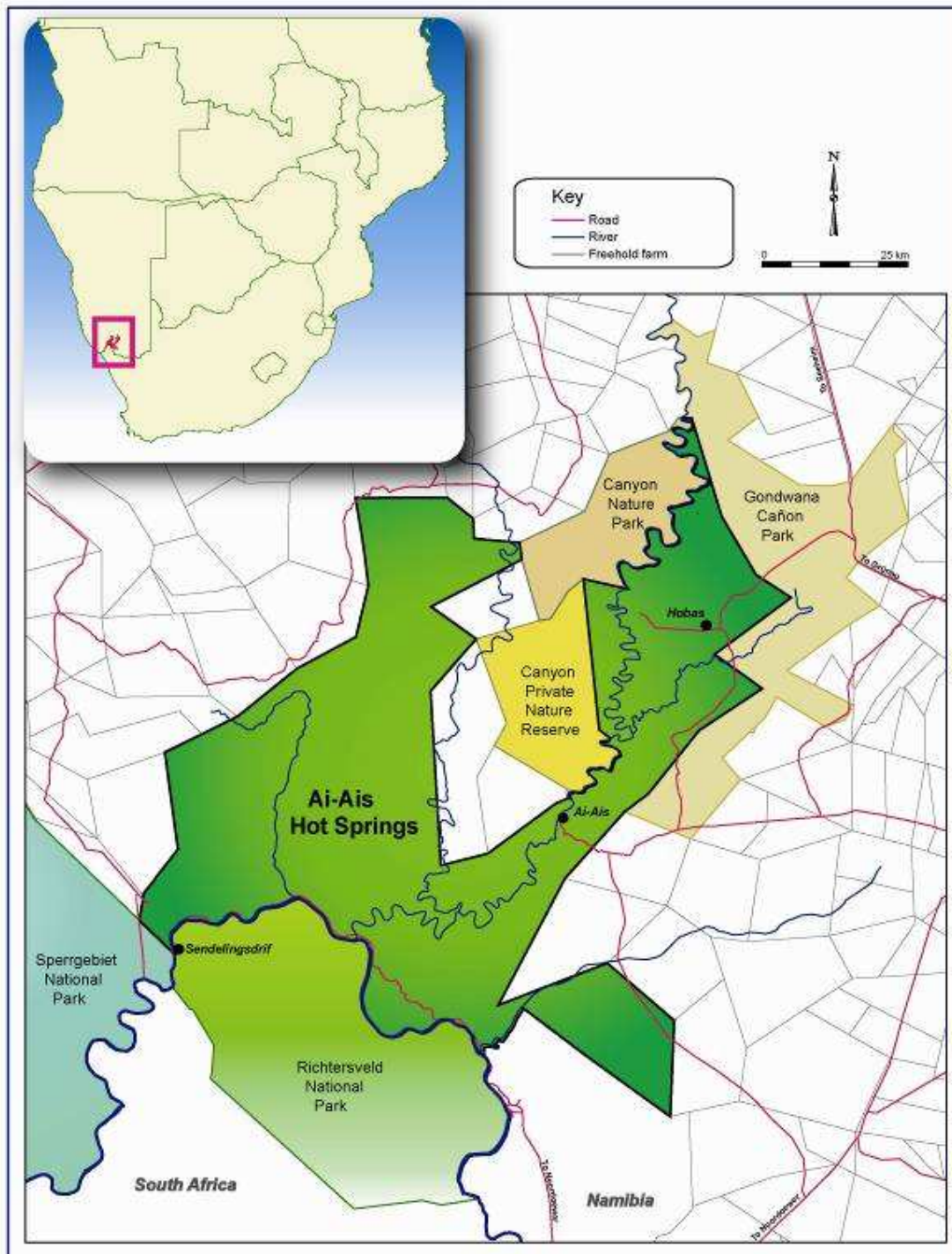


Figure 1: Position of the Ai-Ais Hot Springs Game Park and conservation context.

THE ENVIRONMENT

The study area covers some 4348 km² and is positioned in southern Namibia, just north of the border with South Africa (Figures 1 and 2).

Landforms

The park is characterised by extremely rugged and largely inaccessible terrain in the majority of the area. The impressive Namus- and Huns mountains rise up to about 1250 m (amsl) and dominate the western section of the park. The Huib Hoch Plateau, the southern-most extension of the Namibian Great Western Escarpment, reaches into the northern portion of the park. The eastern section of the park is dissected by the north-east to south-west running Fish River which has deeply incised into the bedrock over millions of years and now forms the key attraction of the park – the spectacular Fish River Canyon. The level plain along the eastern margin of the park becomes more undulating to the west as it approaches the Fish River.

Although only partially within the park, the Konkiep River drains from the north along the eastern boundary of the Huns Mountains. The Gaab and Kanabis Rivers drain from the east into the Fish River. The Boom- and Gamkab rivers run southwards into the Orange River. Many more, smaller rivers and drainage lines dissect the rugged mountain terrain and the undulating plains in the east of the park.

Some of the oldest rocks in Namibia can be found in the southern section of the park mainly exposed along the Orange River – the granites of the Vioolsdrift Granite Suite, and gneisses of the Haib Group which date from some 2600 – 1650 million years ago. Underlying the eastern plains and the south-eastern portion of the Huns Mountains are rocks of the Namaqua Metamorphic Complex (1400-1050 million years old). The remainder of the area is composed of limestone, sandstone and shale of the Nama Group (600-543 million years). These form typical table mountains where harder layers on top have protected these rocks from erosion, such as in the south-east of the park. The stepped appearance of the northern Huns Mountains is very typical of these limestone and shale formations. Geomorphologic processes in the past have created a wonderland for observing landform features such as landslides and the deeply incised canyons of the rivers expose different rock strata which tell a story of the geological history of the area.

Different soil types have developed based on the underlying rock types and prevailing climatic

conditions. Due to the arid climate, most are poorly developed regosols, except in rivers and drainage lines where sandy and loamy soils accumulate.

Climate

Overall, the climate of the study area is arid. Average annual rainfall ranges from 0-50 mm per annum along the Orange River and south-eastern portion of the park, and increases to 50-100 mm per annum towards the north-east (Mendelsohn et al. 2004). The park falls into a transitional area between summer- and winter-rainfall, and both, frontal rains from the Cape can occur during the winter months (May-August), and thunderstorms in summer (February-April).

Temperature regimes in the study area can be extreme. An average maximum of 34-36°C has been recorded in the eastern portion of the park, including the Fish River Canyon, decreasing steadily to 28-30°C in the west. The annual average temperature, however, masks these extremes and does not show such differences, decreasing from 18-19°C in the east to 16-17 °C in the west (Mendelsohn et al. 2004). Frosts are experienced rarely.

However, climatic conditions experienced by biota are considerably more varied than expressed by average temperatures and rainfall. The rugged mountain terrain in the majority of the park results in a tremendous array of microhabitats which are related to elevation, slope angle and aspects and other landform features (e.g. Irish 2008). There are unfortunately no data for these microclimatic variations.

Land use

Tourism, mining, prospecting, livestock- and irrigation farming occur within the park boundaries – the latter only locally (and illegally) along the Orange River.

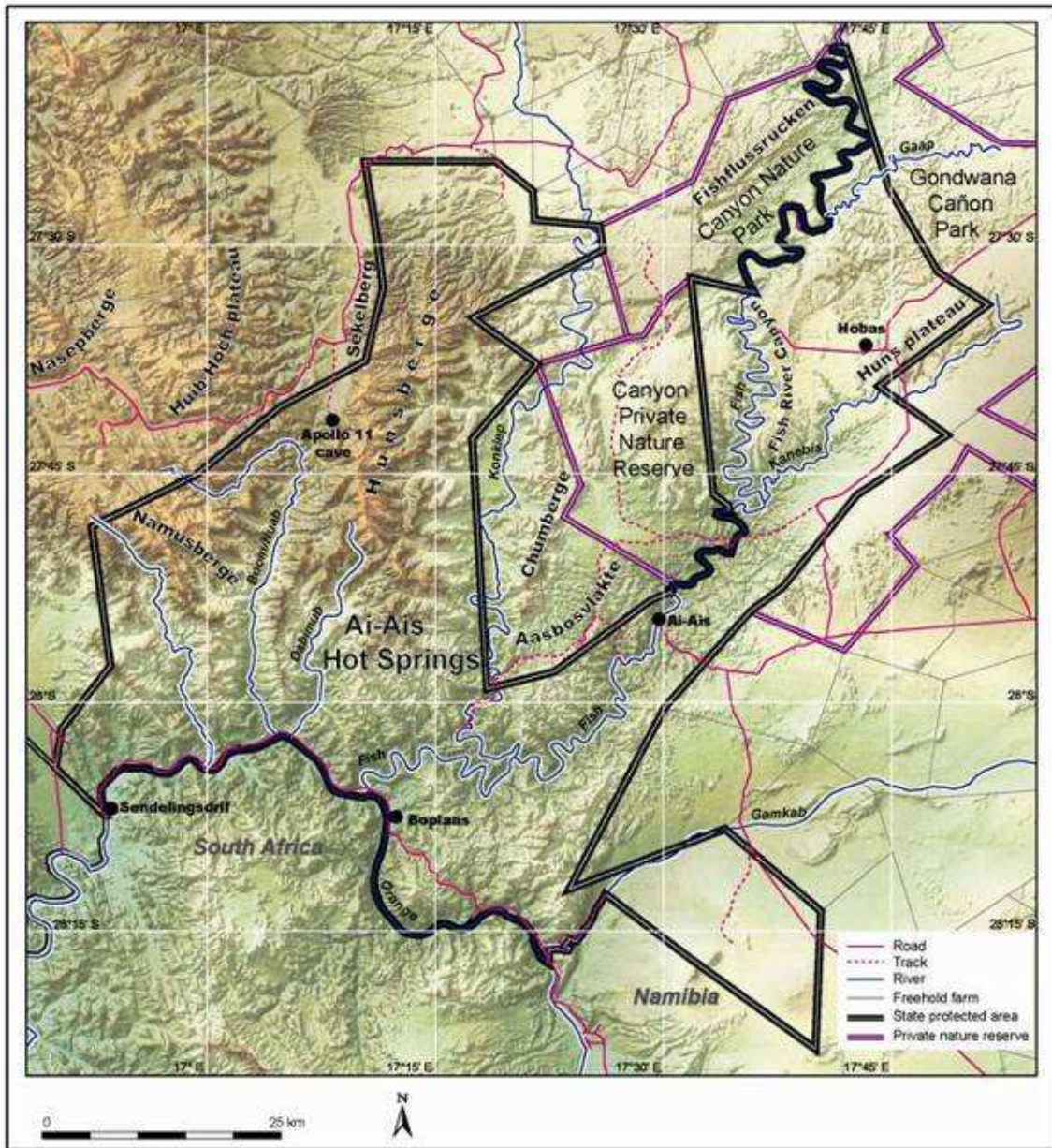


Figure 2: Landmarks and localities in the Ai-Ais Hot Springs Game Park.

Biomes and vegetation

Although there is some debate regarding the exact boundaries of the biomes in the south of Namibia (Irish 1994, Rutherford 1997), biogeographically Succulent Karoo, Desert, and Nama Karoo biomes influence the /Ai-/Ais Hotsprings Game Park (Figure 3). This means that leaf-succulents, ephemeral grasses and dwarf shrubs form the main components of the vegetation. On a national scale, the vegetation in the park has been classified succulent steppe (Giess 1971), and as desert dwarf shrub transition (Burke et al. 2002).

On a catchment-wide scale the highest biodiversity has been recorded in the western mountain areas around Rosh Pinah and the Fish River Canyon area (Irish 2008). The Huns Mountains and Fish River Canyon have also been classified as a centre of endemism in the Fish River Basin (Irish 2008).

The majority of the park falls into the Gariep Centre of Endemism, as defined by van Wyk & Smith (2001) for plants.

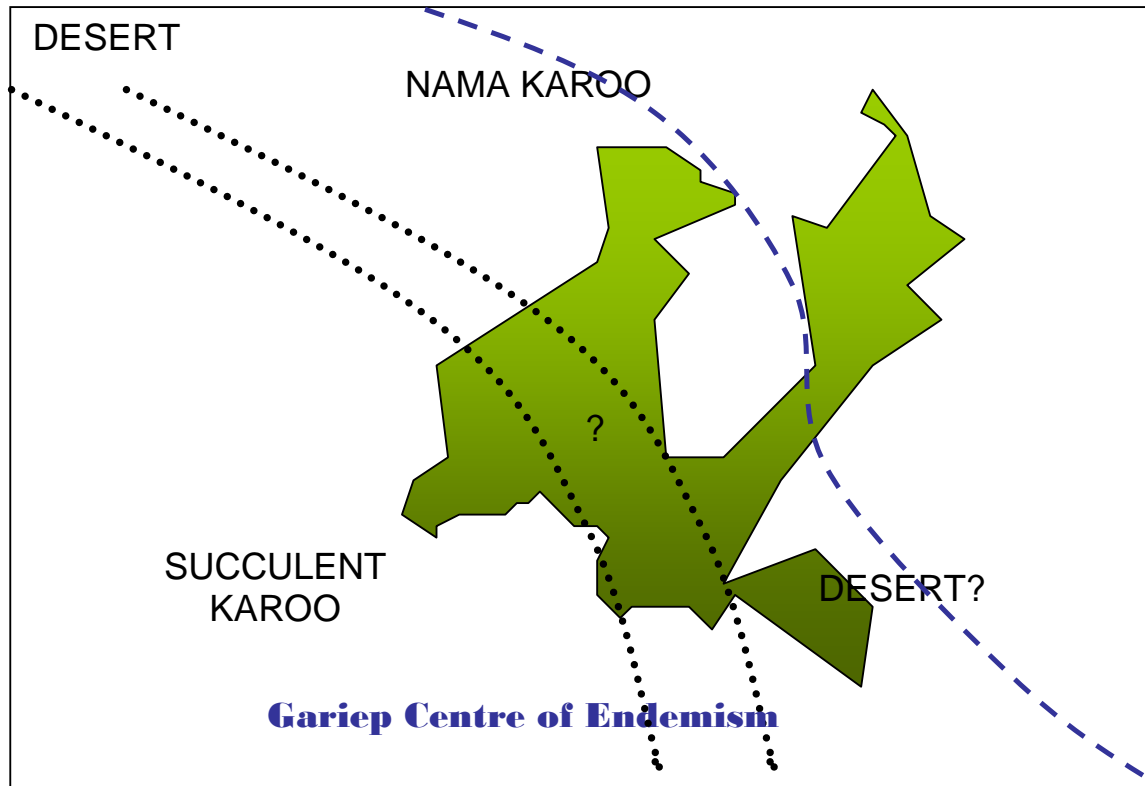


Figure 3: Approximate position of Succulent Karoo - Nama. Karoo boundary and border of Gariep Centre of Endemism.

APPROACH AND METHODS

Data review and analysis

The Terms of Reference for this study asked for a zonation based on biodiversity. Due to the short time frame for this study, this zonation was largely limited to the use of readily available information, such as plant data per quarter degree square from the National Botanical Research Institute's Specimens database, (summarised by Mannheimer 2007). Plants were thus used as biodiversity indicators. Information on animals of conservation importance, i.e. reptiles from museum records and birds from the Bird Atlas database (Robertson & Jarvis 1999) were included to supplement the descriptions of the landscape units where appropriate.

Field work

Budget and time constraints limited the fieldwork for this study to just two weeks of reconnaissance survey during the period of 22 September – 5 October 2011. The field survey focussed on hitherto botanically poorly collected areas, as far as these were accessible.

Mapping

Only landscape-level mapping was possible at the scale of the information available. A Google image was used to delineate homogenous mapping units which were mainly based on landforms. Most mapping was done at the scale of 1: 50 000 to 1: 100 000.

Information analysis

Plant species lists were compiled for each landscape unit, based on the reconnaissance field survey, and where possible, supplemented by data from the Herbarium Specimens Database.

Due to the limited sampling, the species lists are incomplete and only served as a relative indicator to provide some means of describing the landscape units and their attributes (Table 1).

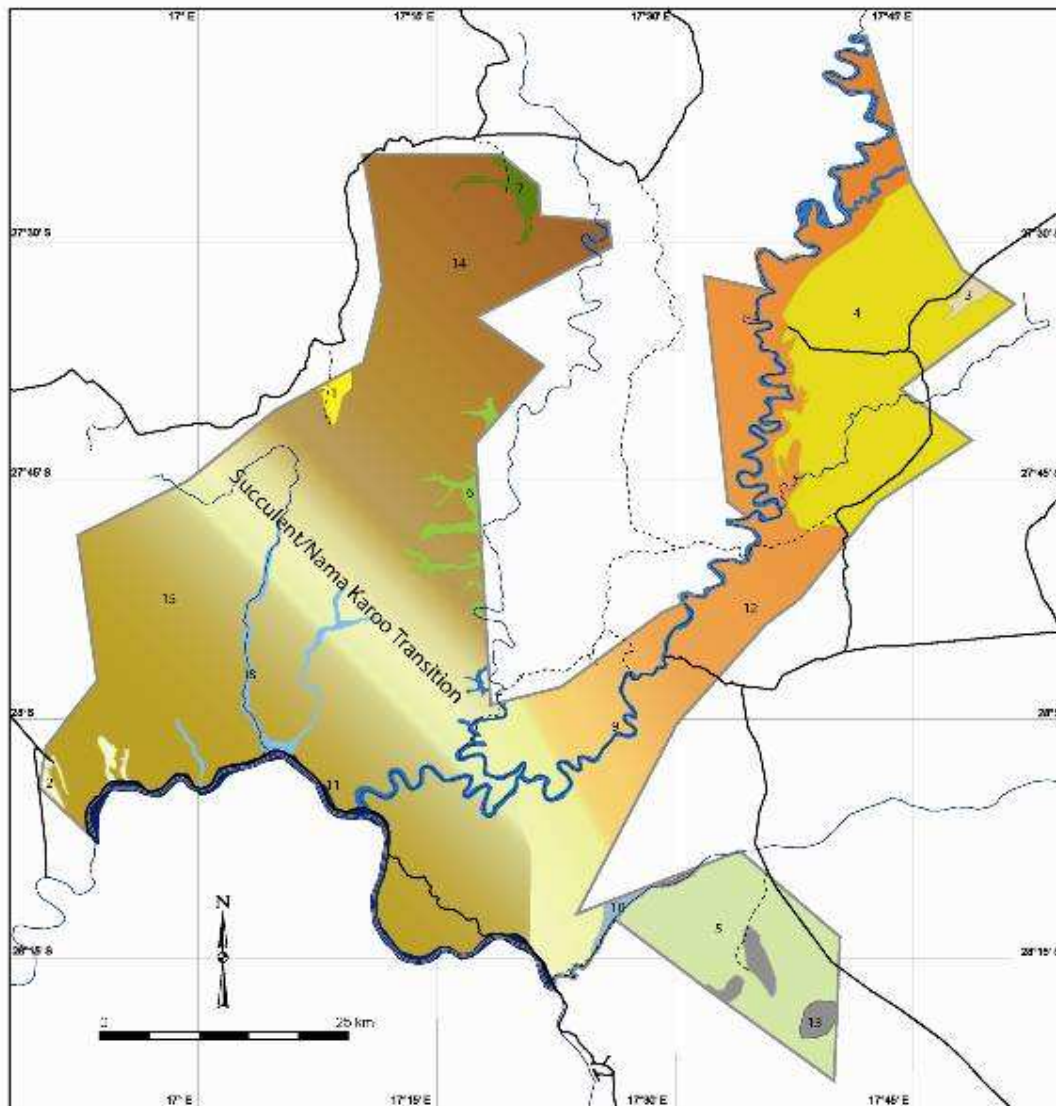
Plant species of conservation importance were defined as species:

- 1) protected under proposed Forestry and Nature Conservation legislation,
- 2) endemic to Namibia (Craven 1999, 2002),
- 3) listed on Cites (International Convention on Trade in Endangered Species) and
- 4) red-listed as near-threatened, vulnerable or endangered (IUCN 1994, Golding 2001, Loots 2005).

As plant species lists were incomplete, a quantitative data analysis was not possible. The biodiversity importance of a landscape unit is therefore based on expert assessment, taking into account likely concentrations of plant species of conservation importance, importance for wildlife (e.g. grazing area, movement corridor or water provision) and importance for ecological functioning.



In contrast to the northern section in the park, Fish River winds more gently between the hills and adjoining mountains south of /Ai-/Ais.



Landscape units

Plains

- 1 Arimas plains
- 2 Dreigrat plains
- 3 Eastern sand plains
- 4 Eastern undulating plains
- 5 Gamkab plains
- 6 Konkiep plains
- 7 Moedhou plains

Rivers

- 8 Boom river
- 9 Fish river and tributaries
- 10 Gamkab river
- 11 Orange river valley

Mountains and inselbergs

- 12 Canyon slopes
- 13 Eastern inselbergs
- 14 Northern Huns mountains
- 15 Southern Huns and Namus mountains

— Road - - - - - Track — River

Figure 4: Landscape units in the /Ai-/Ais Hot Springs Game Park.

Each landscape unit was named and described by outlining locality, habitat and environmental parameters and key biodiversity components of each landscape unit (Table 1). The conservation importance was rated and

resource use and other aspects of biodiversity importance described. Management recommendations and research needs were also provided for each landscape unit.

Table 1: Aspects included in the descriptions of the landscape units.

Aspect	Description
Landscape unit	Descriptive name based on geographic landmark
Locality	Geographical position
Extent	Surface area covered by landscape unit
Habitat and environmental parameters	Geology, landform, substrate, climate and other main physical environmental parameters
Description	Growth forms and vegetation cover
Key plant species	List of characteristic plant species, based on very few accessible sampling points
Conservation importance	Estimate of conservation importance, based on occurrence of important plant species (protected, endemic, Cites and/or red-listed) and importance for wildlife and ecological functioning ; biota other than plants of conservation importance
Alien plant species	Invasive alien plant species recorded
Resource use and other aspects	Importance of landscape unit for wildlife other uses, as well as other information related to this mapping unit
Threats	Imminent and possible threats
Management	Management guidelines, including proposed zoning category
Research needs	Needs regarding biological data in general and particularly with regard to plant species and vegetation

A SUMMARY OF THE FINDINGS

General observations

Succulent – Nama Karoo boundary

From a biodiversity point, one of the most exciting features in the /Ai-/Ais Hotsprings Game Park, is the fact that the Succulent Karoo- Nama Karoo boundary traverses the park. This boundary cannot be envisaged as a clear-cut line, as biota from both biomes intermingle in a wide transitional area. This boundary is further complicated by specific microclimatic conditions (e.g. on south-facing and south-west-facing slopes) and special habitats (e.g. saline areas) which influence the distribution patterns of species considered characteristic of one or the other biome. To further add to this complexity

one has to factor in altitude which results in species more typical of the Succulent Karoo being more prevalent in the higher reaches.

Projecting the Succulent Karoo – Nama Karoo transitional area onto the topography of the park indicates the complexity (Figure 5). This area runs exclusively through the most rugged mountain terrain, providing a multitude of microhabitats of different exposure and angle to the sun, different underlying rock types and altitudes.

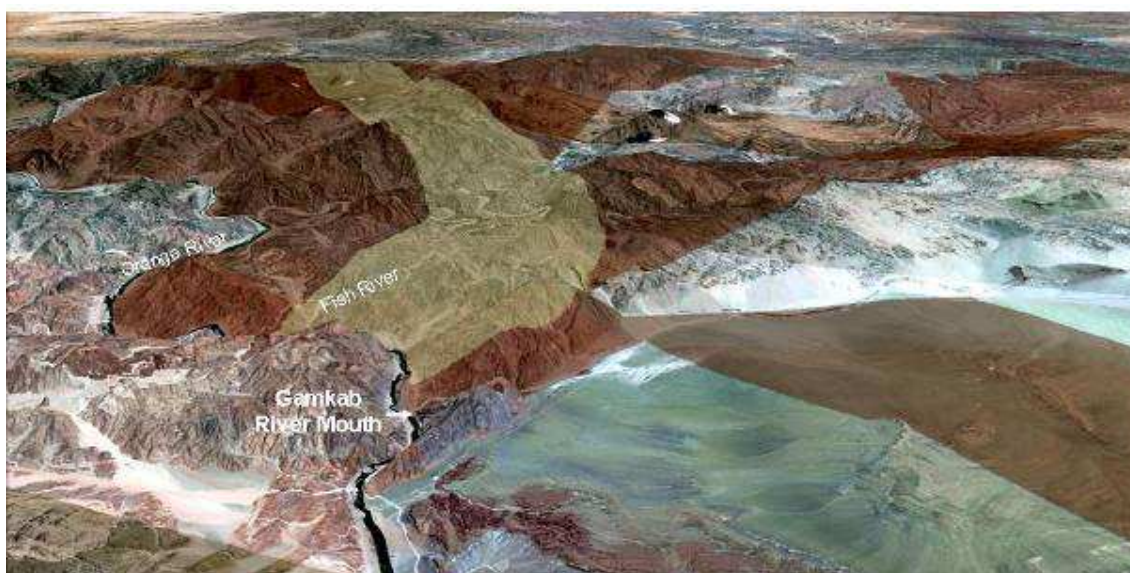


Figure 5. View towards the northwest from the Gamkab river mouth indicating the park (shaded brown area) and hypothesised Succulent Karoo – Nama Karoo transitional area (shaded light brown area).

Wildlife migrations

On a regional scale, the rugged mountain terrain of the AHGP provides a safe territory for larger animals such as Hartmann's mountain zebra, klipspringer, gemsbok and springbok, and their predators. Leopards, for example, occur in this area. While the undulating plains in the east, and particularly the more sandy plains in the north-east support extensive grasslands after good rains, grasslands are rare in the mountain areas. Those present are thus of great importance, such as some stretches of grassland on the plains adjoining the Konkiep river on private farmland between the two northwards extending prongs of the park (e.g. the farms Soutkuil and Wegdraai).

In the north movement between the eastern plains and the mountains is channelled to few accessible areas where it is possible to cross the Fish river canyon. Wildlife crossings are less impeded along the southern section of the Fish river and the rivers themselves also provide a convenient corridor for wildlife to move. Not sufficient long-term data could be sourced during this brief period for this study to delineate wildlife migrations spatially.

Landscape units

At a 1:100,000 scale of mapping, 14 landscape units, organised according to mountain, plain and river habitats, were determined. These are

sufficient to give a broad overview of the ecological units and habitats for planning purposes, but they are not adequately detailed for areas where developments are proposed.

Biodiversity importance

Based on numbers of endemic, red-listed and/or protected plant species, importance for wildlife and ecological functioning, the landscape units were assigned a three-scale rating of biodiversity importance (moderate, high and very high) (Figure 6).

Four of the 14 landscape units were classified of “moderate” biodiversity importance: Arimas plains, Eastern sand plains, Easter undulating pains and Gamkab plains. With the exception of Arimas plains, they are all in the eastern part of the study area and they cover 13.4% of the study area. Six landscape units were of “high” biodiversity importance (Dreigrat plains, Gamkab river, Moedhou plains, Northern Huns mountains, Orange River valley and the eastern inselbergs).

The remaining four landscape units (Boom river and associated rivers, Canyon slopes, Fish river and tributaries and the southern Huns and Namus mountains) were rated of “very high” biodiversity importance. Together they cover more than half of the study area (56.7%).

The data were too fragmentary to provide plant species lists and thus species diversity per landscape unit, but some trends can be described here. Well over 800 plant species were recorded on the NBRI specimens database in the quarter degree squares covering the park. More than half of these species were recorded in the south-western most grid on the Orange River and in the Sendelingsdrif-Rosh Pinah area, indicating by far the species-richest area. Where accessible, the Huns Mountains also indicated high species richness and so did grids with the Fish River. Far less plant species were recorded in other grids, but there is a clear sampling bias. However, it is evident that species richness declines with decreasing distance from the Succulent Karoo biome in the west.

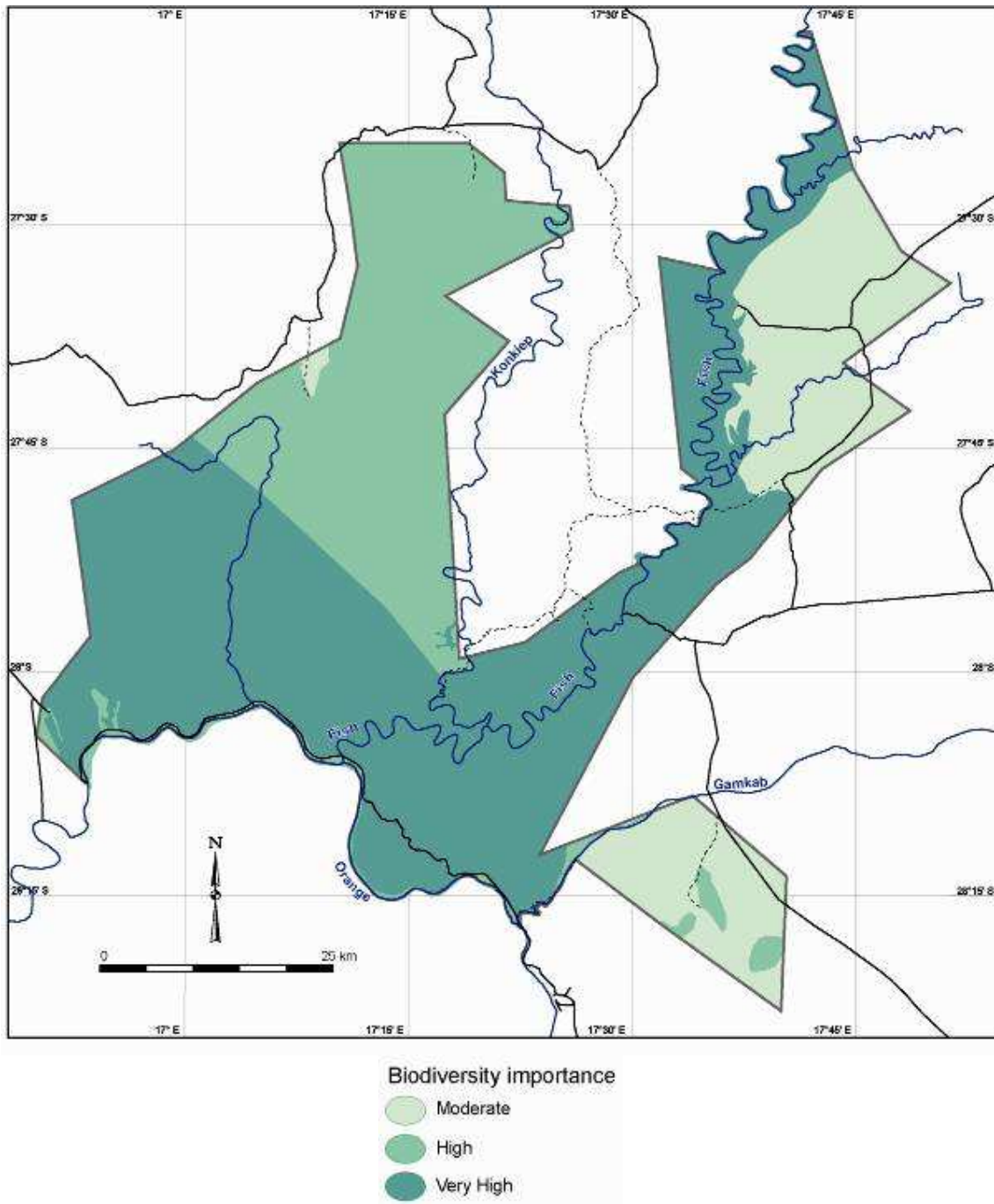


Figure 6: Biodiversity importance of landscape units in the /Ai-/Ais Hot Springs Game Park.

Invasive alien plant species

The majority of the /Ai-/Ais Hotsprings Game Park is characterised by vegetation free of invasive alien species. To date, invasive alien plant species have only been recorded in the vicinity of settlements (/Ai-/Ais, Hobas) and along the rivers which serve as convenient conduits. The perennial Orange river, however, is a hotbed of invasive alien plant species with continuous replenishment of infestations from disturbed areas upstream.

Threats

The impending threat of climate change is applicable to all vegetation types in the /Ai-/Ais Hotsprings Game Park. The Succulent Karoo is expected to be the most severely affected biome by changes in global climate patterns in southern Africa (Midgley et al. 2001).

Mining, quarrying and prospecting activities target specific habitats such as diamond-bearing gravel deposits along the Orange River. The extensive nature of prospecting activities can affect large areas by developing networks of access roads, tracks and drill lines. Abandoned mines and prospecting areas, mainly concentrated along the Orange river, have never been rehabilitated, as the prospecting and mining licences are frequently being renewed and activities are resumed.

Quarrying for road material impacts on habitats in the park can result in a negative visual impact where such borrow-pits are in direct view of main access roads used by visitors (such as on the access road to Ai-Ais).

Another serious concern is the impact of illegal plant-collecting. These activities target the rarest and hence most vulnerable species. Entire populations of halfmens (*Pachypodium namaquanum*) and the rare southern quiver tree (*Aloe pillansii*) have been eliminated over the years and today only remnant populations remain in the park, largely in the most inaccessible areas. Smaller succulents such as *Crassula* species and dwarf succulent mesembs (e.g. *Cephalophyllum*, *Lapidaria*, *Schwantesia*) restricted to this area are also under threat.

The Orange river as the source of invasive plant species infestations has been mentioned above.

Other threats are more localised. In the vicinity of tourism nodes and roads, off-road driving, noise, uncontrolled path development, light pollution and habitat destruction associated with

infrastructure and tourism developments are the most serious concerns. Wildlife casualties occur on the main tourist routes.

Livestock and irrigation farming occur locally along the Orange river and are incompatible with the park's objectives.

Although not directly a biodiversity issue – due to lack of access control, rock engravings of the crucial Apollo cave heritage site have been vandalised and may deteriorate further without adequate protection.



Hardly any gravel terrace is left that has not been mined for diamonds along the Orange river – unfortunately most endeavours were uneconomical and left a legacy of scarred landscape, waste and abandoned equipment and infrastructure.

Research needs

Biome boundary

There is no question that one of the major biome boundaries in southern Africa traverses the study area. As this is where the effect of climate change will likely be most evident, it is important to establish this boundary more accurately. Currently lack of field information only allowed depicting an expected position (Figure 3).

Endemism

The study area is part of the Gariep Centre of Endemism (van Wyk & Smith 2001), and the Richtersveld is renowned for a number of endemic plants restricted to the Richtersveld – some with such limited distribution that they only occur in one particular kloof (Williamson 2000). It is possible that similar patterns are mirrored across the Orange river in the /Ai-/Ais Hotsprings Game Park. Yet there are no plant field data for most of the rather inaccessible areas.

One expedition into such a difficult-to-access area already resulted in the discovery of a new plant species (van Jaarsveld et al. 2007). The likelihood of more such finds is high.

Areas with concentrations of endemic plant species within the park need to be known and mapped to ensure that these highly sensitive areas can be adequately protected. The current information is too coarse to delineate such sensitive areas.

Although information on other small biodiversity components such as invertebrates is even more fragmentary than for plants, plants provide useful indicators for patterns that are also mirrored in certain animal groups. Where concentrations of endemic plant species occur, endemic insect and relative groups are also likely to occur.

Endemic invertebrates are also expected to be associated with localised habitat outliers, such as patches of wind-blown sand and azonal habitats such as springs and seepage areas, including hot springs (where they are undisturbed), which may provide a home to very specialised invertebrates (Irish, pers.com.).

Habitat mapping and biodiversity inventory

At a spatial level, the areas that need the most attention in terms of more detailed habitat mapping and completion of biodiversity inventories for these habitats within the park are the mountain areas in southern centre of the park, i.e. the southern Huns, eastern Namus mountains and the mountains along the southern Fish and Konkiep rivers. These are depicted as “high priority” areas on the map (Figure 7). The slopes west of the Gamkab river and the northern Huns and western Namus mountains also need more attention (indicated of “medium priority”).

On a smaller scale the most crucial areas requiring attention are those where developments are proposed. This is the case for all remaining gravel terraces along the Orange river and the slopes on the north-bank of the Orange river.

In order to better understand wildlife migration, habitat mapping and biodiversity inventories should also include the park neighbours, particularly those in crucial positions, such as the farms (Kochas, Soutkuil, etc.) in between the two prongs of the park.



The bridge over the Fish river near the Orange river confluence is washed out regularly by flash floods.

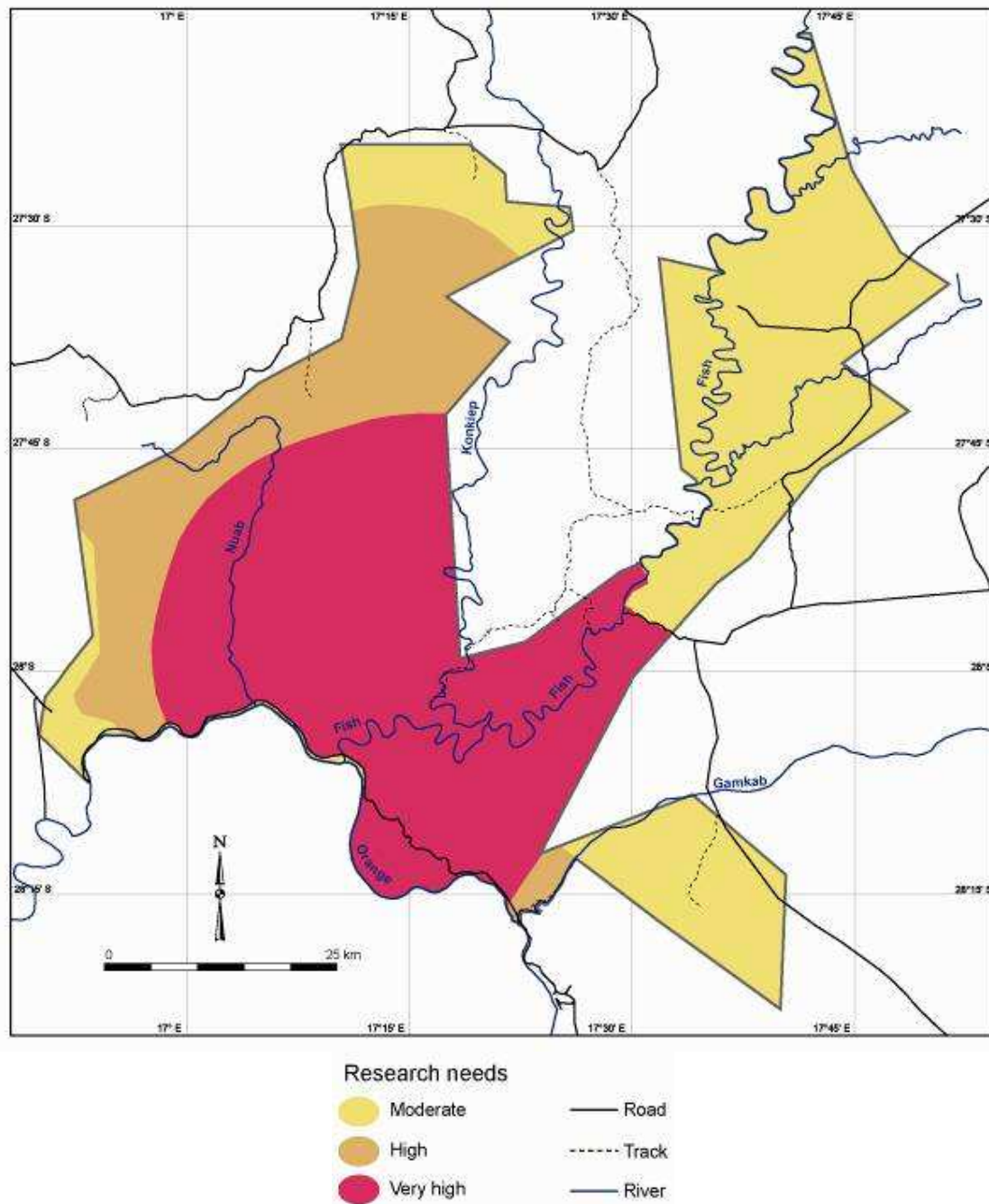


Figure 7: Areas that require more detailed biodiversity inventories and habitat mapping.

Understanding development impacts on biodiversity

Although impacts around tourism and development nodes are localised, their effect on biodiversity needs to be better understood, to develop management actions to curb such impacts.

- Are wildlife collisions rare or common? Do they occur in particular areas that can be delineated?
- What is the impact of uncontrolled footpath development on soil and the vegetation?
- Does waste and sewage disposal affect the water quality of the Fish river?
- Do light and noise affect wildlife and invertebrates significantly?

...are some of the pertinent questions that need to be answered.



Road kills on the main access road to the camp at /Ai-/Ais—here a black spitting cobra—need to be logged to establish whether this is a regular occurrence which requires management.

Appropriate restoration methods

Small-scale mining has left many scars in the park, particularly along the Orange river. Where mines have been abandoned it is now the Ministry of Environment & Tourism's responsibility to rehabilitate such areas. Methods and protocols appropriate to this environment need to be developed to restore these abandoned areas.

Invasive alien plants

Invasive alien plants are present in rivers and related habitats in the park. However, whether

they warrant eradication needs to be assessed holistically on a case-by-case basis. Many are today "naturalised" and provide habitat, shelter and food for other biodiversity components, such as birds and insects, in some instances even for threatened or range-restricted species (Schlaepfer et al. 2011). This is by no means a call to ignore them — it is a call to carefully consider all components of the ecosystem, assess the invasive aliens' impacts and consider whether their removal would result in a healthier ecosystem.

Red data assessments

Two "endangered" plant species occur in the park —the giant quiver tree (*Aloe pillansii*) (Duncan et al. 2006) and *Aloe erinacea* and the "vulnerable" *Juttadinteria albata*. The Cites 1 listed halfmens (*Pachypodium namaquanum*), however, is listed of "least concern" (NBRI 2009), despite its rarity and threat by illegal plant collecting. Backing these assessments by field-based information and a re-assessment based not only on current threats, but also size of the populations is desirable.



Clearly recognised by the pending inflorescence, the Huns and Namus mountains are the last refuge the endangered, Cites 1 species *Aloe pillansii* in Namibia.

Biodiversity and land use zoning

Taking a precautionary approach, based on the conservation importance of the mapped landscape units (Figure 4), and taking current uses into account, all areas that are presently recognised of high conservation importance, or expected to be so, where detailed field data are lacking, have been zoned as “strict nature reserve” (IUCN category 1a) (IUCN 1992). This includes the majority of the southern Huns and Namus mountains and the southern canyon slopes (Figure 8).



A dense cover of diverse succulent plants clothes the gravel terraces on the Orange River

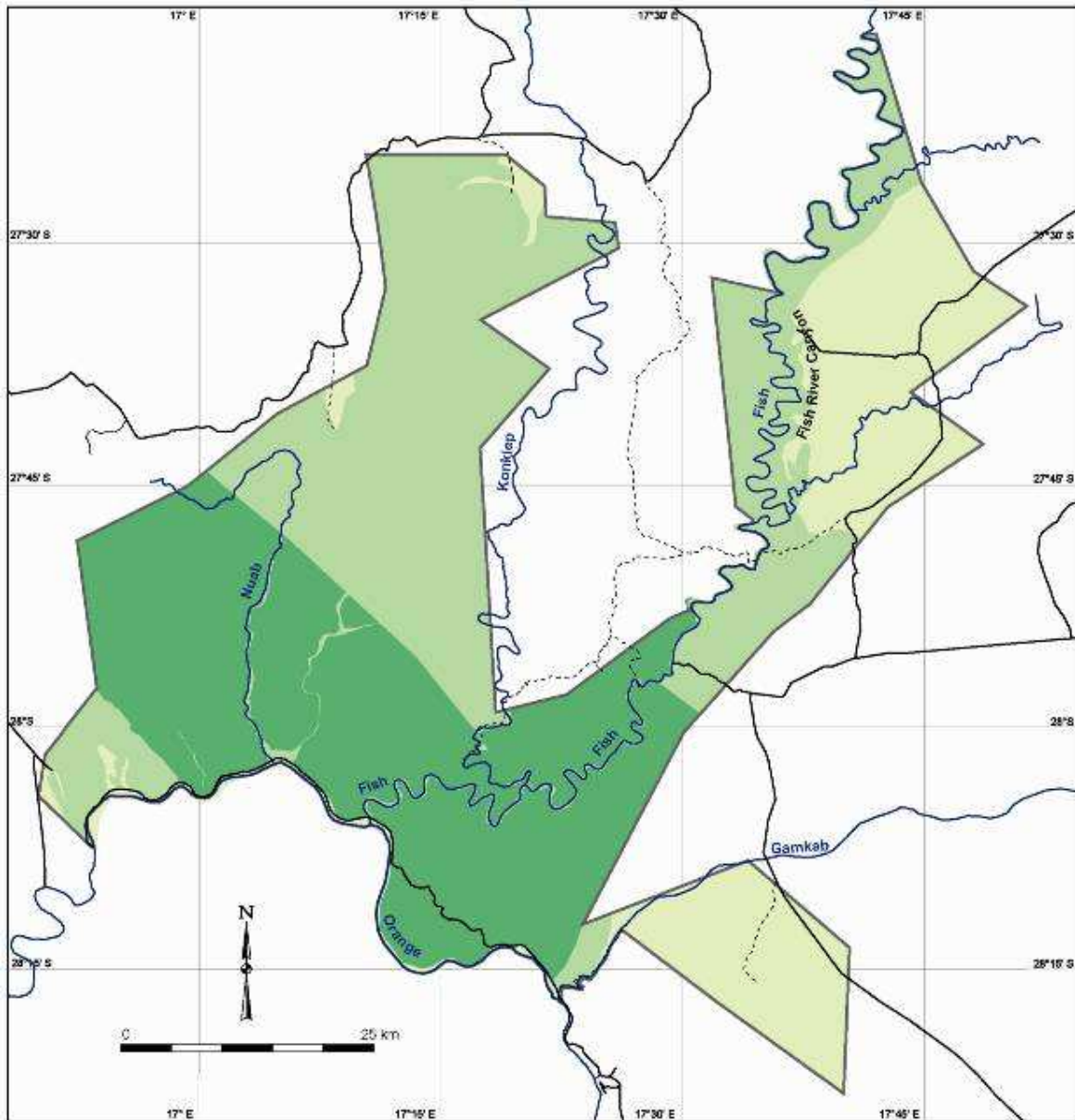
The eastern undulating and sand plains, the south-east corner, the Orange river valley, Gamkab river and plains in the vicinity of (Dreigrat, Arimas and Moedhou) have been zoned as “National Park” (IUCN category 2). The remaining area has been zoned as wilderness.

Table 2. Zoning categories of the ARTP and equivalent IUCN category.

ARTP	IUCN
Wilderness	1a and 1b
Remote	2
Primitive	2
Quiet	2
Low intensity	2
High intensity	2

At a coarse level (not taking the ARTP’s more detailed zoning for the equivalent of “National Park” into account), this conforms largely to the zoning of the /Ai-/Ais – Richtersveld Transfrontier Park. The only exception is an area in the south between the Gamkab, Fish and Orange rivers.

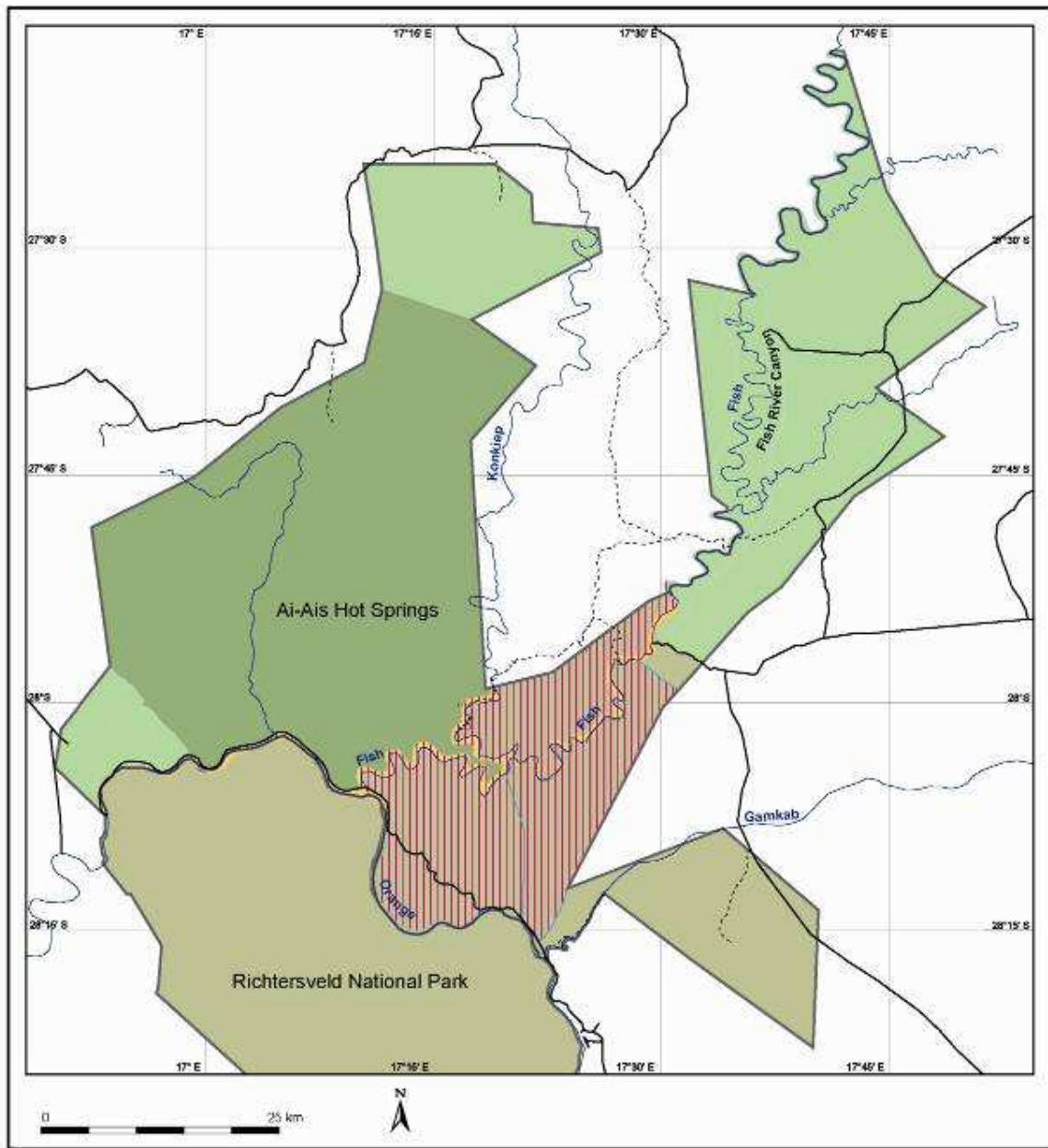
This is a completely under-collected area from a biodiversity point of view and likely the important transitional area between the Succulent and Nama Karoo. This area should therefore be zoned off limits for development and assigned “strict nature reserve” until biodiversity inventories have been compiled in sufficient detail. Zoning can then be reviewed and development options assessed in the light of this information.



Recommended zoning

- Strict nature reserve (IUCN 1a)
- Wilderness area (IUCN 1b)
- National park (IUCN 2)
- Road
- Track
- River

Figure 8. Recommended zoning based on IUCN categories.



Ai-Ais/Richtersveld transfrontier park - joint zoning

- Remote
- Wild
- Primitive
- Low density development
- Change required
- Road
- Track
- River

Figure 9. ARTP management zoning and changes required.

Biodiversity management

Implementation of policies and laws

A precondition for sound biodiversity management in the /Ai-/Ais Hotsprings Game Park is the rigorous implementation of Namibia's Environmental Management Act.

This means that

- All proposed developments are subjected to an environmental assessment involving appropriate specialists (e.g. biodiversity and national heritage experts).
- Environmental Assessments are thoroughly reviewed.
- MET field staff in the area has a legal appointment for checking compliance with Environmental Management Plans (EMP) and the authority to issue fines for non-compliance.
- MET field staff is appropriately trained to assess compliance with EMPs.
- Proposals for prospecting and mining are adequately reviewed particularly in terms of their financial viability.
- Rehabilitation costs have been factored into economic feasibility studies for mining and prospecting.
- Finance to cover the rehabilitation liabilities are provided up-front and held in an independently managed trust fund before activities can proceed.

Planning

The zoning in the joined ARTP management plan will need to be adapted.

As indicated in the section "biodiversity and land use zoning", the proposed development zones along the southern Fish and Konkiep rivers need to be reviewed, once adequately detailed biodiversity information is available for these landscape units.

In view of abandoned mines and quarries, requirements for rehabilitation need to be identified, mapped and rehabilitation measures detailed. This should be accompanied by an implementation plan. However, precondition for any rehabilitation in the park is formal assurance from all relevant ministries that the area to be rehabilitated is not used for development ever again.

A plan needs to be developed for borrow-pits (quarrying for road material), which results in a

reduction to the minimum required and rehabilitation of all superfluous borrow-pits.

Information exchange

Managing wildlife in conjunction with the park neighbours requires excellent information exchange. Climate data, wildlife counts and incidents, as well as biodiversity inventories should be managed jointly in readily accessible database (e.g. on the web). A starting point would be to make this report available to all park neighbours.

Management

Illegal farming

Irrigation farming and associated activities should not be allowed in the park.

Livestock crossing the Orange river from the Richtersveld Park remains to be a challenge, and such animals must be removed, if they are not herded back across the river by their owners. Illegal settlements and livestock farming on the north-bank of the Orange river is prohibited and such settlements must be removed.



Occasionally livestock from the Richtersveld park crosses the Orange river and utilises the north-bank of the Orange.

Wildlife

Free movement between the park and adjoining farms and private nature reserves is critical for wildlife populations to thrive. Many neighbouring farms are already managing their areas for conservation and tourism. Further agreements with regard to opening up more areas for free movement of game, i.e. taking down fences, and joint management should thus be pursued.

Reintroductions of larger animals that historically occurred in the area (Skead 1980), e.g. black rhinoceros (*Diceros bicornis*) and giraffe (*Giraffa camelopardis*) could be considered in areas where their habitat requirements are met. Top of the food chain predators, such as lions, were

sighted in the area in the past, but they require large ranges and were more likely to pass through rather than being resident. Where livestock is still farmed on neighbouring land, human-wildlife conflicts could arise and top predators should thus only be considered where such conflicts can be managed and ranges are sufficiently large.



Perhaps seeming out of place, historically giraffes used to occur in the area and have been re-introduced on farms neighbouring the park.

Off-road driving

Many places along the Orange and Gamkab rivers and the road to Rosh Pinah indicate uncontrolled track development. This is partly due to recreational use, and partly due to mining and prospecting. For the latter access roads need to be agreed with the MET staff, demarcated and then only these are allowed to be used. A few tracks to the Orange river should be marked for visitors and recreational use, and all other tracks closed. The track along the Gamkab river needs regular maintenance to prevent people from driving off the road to avoid corrugations.

Invasive alien plant control



The Orange river valley is a hotbed of invasive alien plants – here “plantations” of the white-flowered thorn apple (*Datura innoxia*) and the tall, spindly wild tobacco (*Nicotiana glauca*).

Invasive alien plants are present in masses along the Orange river and occasionally in the Fish and Konkiep rivers and their tributaries. While eradication of these in the Orange river is almost impossible, as it requires a concerted effort by all upstream users, controlling the spread into the Orange’s tributaries could be achieved, as infestations are currently localised. However, eradication of existing stands should follow a thorough assessment of the necessity to eradicate, considering ecosystem impacts.

Plant and animal poaching

Poaching of wildlife is sometimes a problem in the vicinity of short-term activities, such as construction and mining. Firewood collection occurs here too, and should be prevented.

Illegal collection of plants likely occurs, as many collector’s items grow in accessible areas, e.g. along the Orange river. Permanent staffing at the Dreigrat and Gamkab entrance gates, accompanied by adequate training, should enable MET staff to check suspicious vehicles and people. Random spot-checks should be undertaken which act as a deterrent and prevent illegal removal of plants and animals in future.

Tourism developments

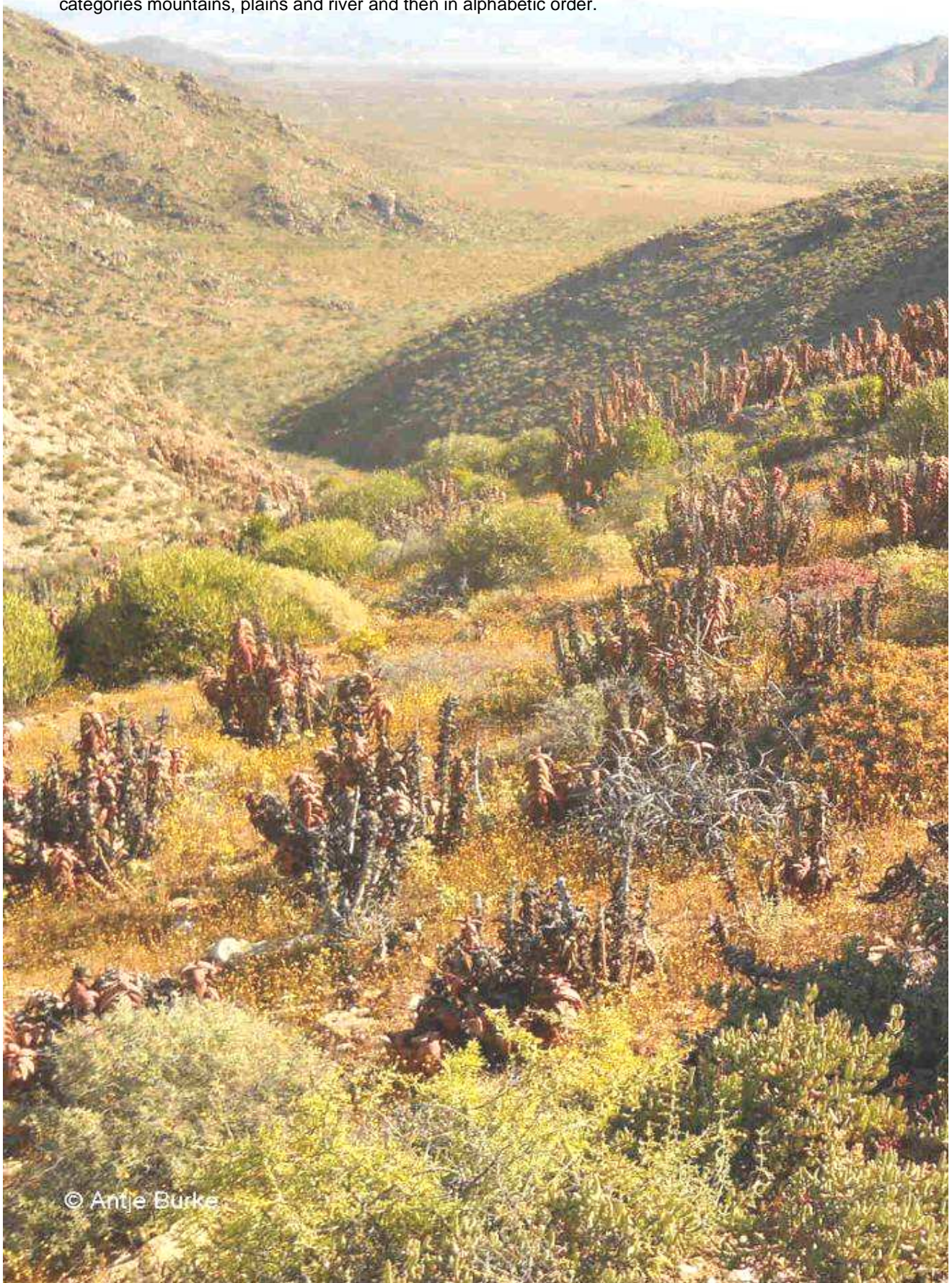
More environmentally sound practices in existing tourism development nodes are crucial to serve as a role model for potential future developments. The impacts of lighting at night, noise, uncontrolled paths and waste disposal need to be minimised around Ai-Ais camp and Hobas. Demarcated trails from the camp, lighting channelled to where it is really needed, yellow light for outside areas, and switching from generator power to solar are some of the measures that would lead to lower the impacts of these camps on biodiversity.



Not a good example of an environmentally- and visitor-friendly camp, sites at Ai-Ais offer no privacy, little shade, no view and are lit up brightly all night.

THE LANDSCAPE UNITS

The following section provides a description of the landscape units organised according to the main categories mountains, plains and river and then in alphabetic order.



Canyon slopes



Locality The canyon slopes have been mapped along the Fish river as an approximately 2-5 km wide strip to both sides of the river (where both sides fall into the park) and broadening to more than 10 km width per side in the south. The Fish river's slopes in the very south-west have been included in the Southern Huns and Namus mountains.

Extent 886 km² (20.4% of the AHGP)

Habitat and environmental parameters The canyon slopes ascent steeply from the Fish river becoming more undulating and open as they merge into the adjoining plains to the east and west. Traversing approximately 85 km in the study area bioclimatic conditions change from hot and arid in the north-east to moderately hot and arid in the south-west, where the influence of cooler temperatures from the ocean, channelling up the Orange River can be felt.

The underlying geology is complex as the Fish river has incised into the Nama Group, as well as the even deeper lying Namaqua Metamorphic Complex. Different rock types are thus exposed in close proximity such as black limestone, quartzite and schist as well as granites and gneissic rocks and dolerite.

Description Although during the dry season appearing almost barren, the canyon slopes are remarkably diverse in plant life, given the harsh climatic conditions. Low perennial

shrubs form a patchy and low plant cover, except in channels on these slopes where plant cover can reach 10%. Smaller riverbeds draining into the Fish river are included in this landscape unit and these provide a home to taller shrubs such as *Boscia foetida* and *Sisymbrium spartea*, and trees such as *Pappia capensis* and *Parkinsonia africana*.

Key plant species Along these over 85 km of mountain slopes with sparse vegetation cover it is difficult to select the dominant plant species. The tall *Euphorbia gregaria* is conspicuous though, along with *Ceraria namaquensis* and *Euphorbia avasmontana* which are locally co-dominant. The low shrubs *Calicorema capitata*, *Petalidium setosum* and *Zygophyllum cretaceum* are other frequent plant species. After the good rains of 2011 the succulent creeper *Mesembryanthemum garusianum*, the grass *Stipagrostis anomala* and the ground cover *Tribulus cristatus* were also frequent on many slopes.

Conservation importance: VERY HIGH

Many range-restricted plant species occur on the canyon slopes which contributes to their high conservation value. This includes Namibian endemics such as *Calicorema squarrosa*, *Dauresia alliariifolius*, *Euphorbia cibdela*, *Monsonia deserticola* and *Senecio hermannii*. The protected *Aloe dichotoma* and towards the south also *Aloe garipensis* grow on the canyon slopes, and three Gariep endemic *Commiphora* occur: *C. capensis*, *C. cervifolia* and *C. namaensis*. Protected *Conophytum* and *Crassula* species, as well *Ruschia abbreviata* and *Tylecodon hallii* grow on slopes in the south-western portion of this landscape unit.

The canyon slopes are also home to near-endemic reptiles, such as the Namibian dwarf gecko (*Lygodactylus bradfieldi*), rough scaled gecko (*Pachydactylus rugosus rugosus*) and the western sand lizard (*Pedioplanis undata*) (Griffin 2003).

Alien plant species Although none were recorded during the brief reconnaissance survey, there are invasive alien species in the Fish river which have likely also moved up the slopes in some places.

Resource use and other aspects The spectacular canyon scenery provides not only the main tourist attraction in the park, but is also the stage for a challenging 3 to 5-day hiking trail. The impacts of these activities on biodiversity could not be assessed in detail, but no wide-ranging disturbances such as litter carried downstream, or excessive soil compaction and erosion could be observed. However, the resort at the Hotsprings in /Ai-/Ais is a good example of how not to design and develop a facility in a National Park which ideally should be a good example of environmentally sound development. The excessive camp lighting which is on during the entire night creates enormous light pollution, not only obscuring the stars, but also attracting lots of insects which find these lights inescapable death traps. Trails from the camp are not marked and people wander at random on the slopes around the camp, creating numerous paths which lead to erosion in some places and soil compaction in others. Lots of water is wasted while attempting to keep alive rather neglected-looking patches of grass. Collisions with wildlife occur along the access roads to the camp.

Threats

- Impacts related to tourism activities around /Ai-/Ais camp and access roads (wildlife collisions on roads, paths, waste creation)
- Infrastructure developments
- Illegal plant collecting
- Quarrying for road material

Management

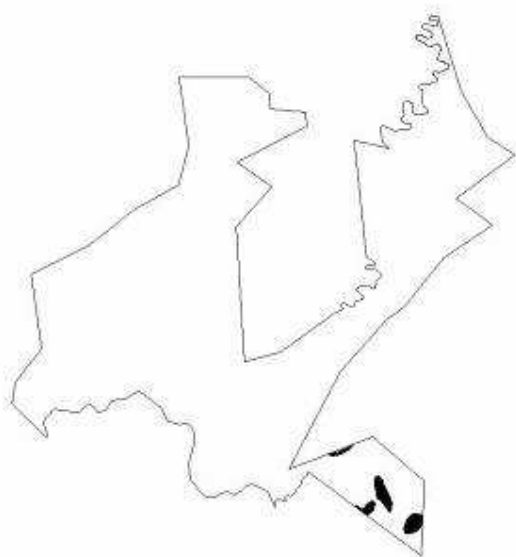
- Recommended management zoning: IUCN 1a and 1b (wilderness),
- MET zoning: IUCN 1a in the south and 1b in the north
- Current ARTP zoning: “primitive” in the north and “remote” in the southern part of the landscape unit; low intensity development along the Fish and Konkiep rivers
- Monitor wildlife incidents on roads, and if necessary, introduce speed bumps in critical areas
- Monitor occurrence of invasive alien plant species around potential tourism and mining developments and control
- Implement borrow-pit management

Research needs The impacts of tourism activities on the canyon slopes need to be better understood, managed and monitored around tourism development nodes. The ARTP zoning suggests low intensity development along the Konkiep and lower Fish river. No plant inventories have been done along these sections of the rivers and adjoining slopes. These are mandatory before any developments can be considered here. Some sections of the canyon slopes warrant highest protection status (IUCN 1a), but their exact extent needs to be based on better biodiversity baselines than presently available.



Endemic to the Fish River canyon and areas in the surrounding, *Senecio hermannii* is one of more restricted plant species in the /Ai-/Ais Hotsprings Game Park.

Eastern inselbergs



Locality The inselbergs in the south-eastern corner of the park and their foot slopes have been mapped in this landscape unit.

Extent 36.2 km² (0.83 % of the AHGP)

Habitat and environmental parameters The typical table-top mountains are composed of shale and sandstone of the Karoo Super group, while the ridges at the western boundary of this section of the park make are composed of granite and shale. The highest peaks are 850 m m (amsl), and with this approximately 150 m above the surrounding plains. These inselbergs are surrounded by an extensive network of shallow rivers which drain south-west into the Gamkab river.

Description The vegetation is usually very sparse and dominated by dwarf shrubs. A reasonable cover of grasses and herbs was, however, present after the good 2011 season.

Key plant species *Euphorbia gregaria* is the dominant perennial plant on the western inselbergs, but *Monechma cleomoides*, *Salsola cf barbata*, and the perennial grass *Stipagrostis brevifolia* are the dominant plants on the shale inselbergs.

Conservation importance: HIGH Considering the arid surrounding, these inselbergs are relatively species-rich and several plant species of conservation importance grow here. The Namibian endemic *Monsonia deserticola*, the Gariiep endemic *Commiphora namaensis* and the

protected *Aloe dichotoma* and *Parkinsonia africana* are some examples.

Alien plant species None recorded

Resource use and other aspects An abandoned quarry is present in this area. Several tracks lead into this section of the park – some of which are made by casual visitors.

Threats

- None evident presently

Management

- Recommended management zoning: National Park (IUCN 2)
- Current ARTP zoning: “remote”
- MET land use zoning: Managed resource protected area (IUCN 6)
- If access to this area is planned, maintain and clearly demarcate one dedicated access route.
- Prohibit off-road driving and enforce track discipline.

Research needs None presently.



Anybody out there who is not enchanted by inselbergs? The shale inselbergs in the south-east corner of the park offer stunning views and a rich assortment of plant species not found on the surrounding plains.

Northern Huns mountains



Locality The landscape unit delineated as the northern Huns mountains comprises the north-western portion of the AHGP.

Extent 1040 km² (24% of the AHGP)

Habitat and environmental parameters This mountain terrain is formed by limestone and shale deposited in a typical layered fashion in the northern and western section of this landscape unit. Various drainage lines have scoured impressive gorges into these largely dark rocks. These limestones are the southern-most extension of the Huib Hoch plateau. Various rock types of the Namaqua metamorphic complex underlie the south-eastern section of this landscape unit. Water draining towards the Konkiep river has dissected the former plateau resulting in a very irregular outline along its eastern margin. Altitudes on the plateau reach up to nearly 1600 m (amsl) at their highest peaks, but 1300 m (amsl) is the average, providing an elevation of over 300 m above the adjoining plains and dry rivers.

Description The perennial vegetation is patchy and often concentrated in depressions, gorges and drainage lines, and along the various steps that are created by the different horizontally layered rock types at erosion faces. After good rains grasses add a fair amount of biomass and form a more even plant cover. Dwarf leaf-succulent shrubs comprise the bulk of the vegetation, growing hardly taller than 30 cm. But trees and taller shrubs are prominent in the gorges and rivers. Overall, perennial plant cover hardly reaches 5%, but in rivers and sheltered

places, and after good rains it can reach 15–20%.

Key plant species *Zygophyllum decumbens* is the dominant plant on many parts of the northern plateau, accompanied by the grass *Stipagrostis anomala*. It is expected that dominant plant species may change towards the south-west and south-east.

Conservation importance: HIGH Nevertheless there are various plant species of restricted range associated with these rocky habitats. Of particular note are populations of the southern Namib endemic shrub *Caesalpinia merxmullerana* which only occurs in the Huns Mountains and some sections of the Huib Hoch plateau. Other endemic plants species of the south found here are *Jamesbrittenia primuliflora*, *Petalidium linifolium*, *Ruellia aspera* and *Senecio giessii*. The protected quiver tree (*Aloe dichotoma*), and the Gariep endemics *Commiphora namaensis* and *Pelargonium spinosum* are other striking plants of note.

The Huns mountains are a home to the endemic desert mountain adder (*Bitis xeropaga*) (Griffin 2003).

Alien plant species None recorded

Resource use and other aspects Many plants provide food and shelter for wildlife, particularly in the gorges. This landscape unit includes one of the most significant archaeological sites in southern Africa – the Apollo cave – and many other archaeological sites of interest are found in this area (Wendt 1976; Masson 2006).

Threats

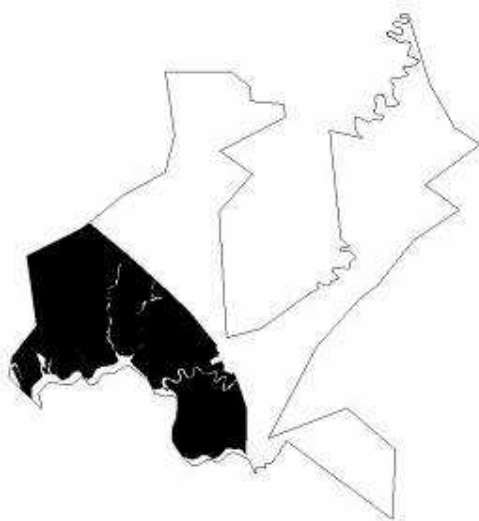
- Looting and vandalising of heritage sites
- Prospecting and mining

Management

- Management zoning: IUCN 1b (wilderness)
- Current zoning MET: IUCN 2 in the north, and 1b in the south.
- Current zoning ARTP: “remote” in the north and “wild” in the south.

Research needs A more thorough plant inventory of this mapping unit is required, as there are many areas which have to date never been accessed and the description of the landscape unit is based on only few observations in the north. The vegetation is expected to change towards the south-west and south-east.

Southern Huns and Namus mountains



Locality Covering nearly one third of the park area, this unit is situated in the south-west.

Extent 1297 km² (29.8 % of the AHGP)

Habitat and environmental parameters

Geologically the most diverse of all landscape units of the park, the north-west is formed by limestone, shale and quartzite of the southern extension of the Huib Hoch plateau, while the east and south comprise granite, gneiss and diverse other rock types of the Namaqua metamorphic complex, the Vioolsdrift granite suite and the Haib Group. The very west exposes rocks of the Gariiep complex. Level, stepped plateaus are prominent in the north, while the south, east and west comprises one of the most rugged mountain terrains in Namibia. The Boom/Nuab, Fasfontein and Dabimub rivers dissect these mountains in a north-southerly direction. The average of many peaks is approximately 1000 m (amsl), with the highest reaching 1230 m (amsl).

Bio-climatically possibly the transitional area between Succulent Karoo and Nama Karoo, rainfall and temperature decrease along a south-west gradient.

Description Overall low succulent shrubs dominate in valleys between the mountains, but taller shrubs of succulent, evergreen and deciduous nature grow on the slopes. The good rains of 2011 have also brought out various grasses, herbs and bulbs which are usually absent during dry years. Perennial plant cover is patchy and often denser in channels and on south- and south-west facing slopes which are cooler.

Key plant species Due to the limited access and the tremendous diversity of habitats contained in this mapping unit, it is difficult to settle on particular plant descriptors. Based on the few areas that have been visited, *Ceraria fruticulosa* and the more conspicuous stem-succulent shrub *C. namaquensis* are dominant on many slopes, accompanied by *Calicorema capitata* on foot slopes, and occasionally *Euphorbia virosa* and *Euphorbia gregaria* higher up. The low shrubs *Anticharis scoparia*, *Hermannia stricta*, *Microloma incanum*, *Monechma mollissimum* and *Psilocaulon salicornioides* occur often. The annuals *Acanthosicyos disperma* and *Heliophila deserticola* were well presented after the good season of 2011, as was the grass *Enneapogon scaber*. Moving south towards the Orange River and west towards the Namus mountains brings an additional suite of plant species. *Brownanthus arenosus*, *Cissampelos capensis*, *Diospyros ramulosa*, *Rhus populifolia* and *Zygophyllum prismatocarpum* indicate the transition towards a species spectrum more typical of the Succulent Karoo Biome. The slopes of the Namus mountains in the west are covered almost exclusively by Succulent Karoo species, are extremely diverse and a home to many endemics.

Conservation importance: VERY HIGH This mapping unit is characterised by extremely high plant diversity – some 480 plant species were recorded in one of the western quarter degree squares over the years (NBRI specimens database). This includes a long list of species of conservation importance. The endangered and Cites 1 plants *Aloe pillansii*, and the halfmens *Pachypodium namaquanum* grow on slopes in these mountains. The protected *Aloe ramosissima*, *Aloe pearsonii* and *Aloe garipensis* are prominent features on slopes along the Orange and in the Namus mountains. Various protected *Antimima*, *Amphibolia*, *Crassula* and *Stoeberia* species, *Eberlanzia cyathiformis* and various Cites 2 *Euphorbia* species are present. The Gariiep endemics *Commiphora capensis*, *cervifolia*, *C. namaensis* and the tall *Hoodia alstonii* grow on several slopes. Of note are also populations of dwarf succulent *Conophytum* species, *Lapidaria margaretae*, *Lavrana* species and *Schwantesia herrei*. The gravel banks and slopes along the Orange River harbour many more range-restricted species such as *Cephalophyllum herrei*, *Dracophilus dealbatus*, *Hartmanthus pergamentaceus* and *Juttadinteria albata*. The foot slopes of the western Namus

mountains support the same species, but also a very rare endemic *Sarcocaulon* – *S. peniculinum*.

With regards to endemic fauna, the desert mountain adder (*Bitis xeropaga*) occurs in the Huns mountains (Griffin 2003).

Alien plant species None recorded, but are likely present on lower slopes and in drainage lines in the vicinity of the Orange and Fish rivers.

Resource use and other aspects The succulent shrubs are important food sources for wildlife. Mining and exploration has impacted on many plant populations of conservation importance on the gravel banks and slopes along the Orange river. No restoration of impacted habitats and biodiversity has been attempted by either past or current mining and exploration activities.

Threats

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

Management

- Recommended management zoning: IUCN 1 a (strict nature reserve) and 1b (wilderness), with a narrow exclusion zone around development areas along the Orange River

and the road to Rosh Pinah – re-assessment of ARTP and MET zoning required

- Current ARTP zoning: “wilderness” in most parts, and “remote” in the west
- Current MET zoning: “National Park” in the west (IUCN 2) and “wilderness” in the north and east
- Red list assessments and monitoring of critical plant populations (e.g. *Aloe pillansii* and *Pachypodium namaquanum*)

Research needs More detailed plant surveys are required to delineate the Succulent Karoo – Nama Karoo/Desert biome boundary and to divide this large mapping unit into smaller units for management purposes. Parts of this landscape unit warrant the zoning as “strict nature reserve” (IUCN 1a), but biodiversity information is currently not sufficiently detailed to delineate the most critical areas. For example the slopes and terraces along the Orange River likely warrant a separate unit, and they are under severe threat from mining and exploration activities. Some plants are restricted to these gravel terraces on the Orange River only, and the cumulative impact of mining all these gravel terraces could result on the elimination of entire species. The Red Data assessments of range-restricted species are important.



Large populations of the near-threatened, near-endemic *Aloe pearsonii* grow on the western slopes of the Namusberge.

Boom river



Locality This landscape unit includes the Boom river, and both rivers to the east (Dabimub) and west (Fasfontein) of the Boom.

Extent 30.6 km² (0.7% of the AHGP)

Habitat and environmental parameters

These largely north-south trending rivers cut deeply into the southern Huns mountains and flow into the Orange river. Situated further west than the other rivers, temperatures are lower and winter-rain influence is greater. Water is found in many sections of the river, near the Boom river mouth forming almost constant river flow.

Description Although concentrations of large trees are found at the mouth of the Boom river, these become scarce as one moves northwards and are replaced by tall and low shrubs.

Key plant species Near the confluence with the Orange river *Acacia karroo*, *Phragmites australis*, *Rhus pendulina* and *Tamarix usneoides* form dense thickets in the Boom river. Sedges, grasses and diverse shrubs, such as *Codon royerii*, *Hermannia stricta*, *Lycium* species, *Petalidium setosum* and *Zygophyllum prismatocarpum* are more common further upstream.

Conservation importance: VERY HIGH Relatively high plant diversity, with a fair number of plant species of conservation importance, and the rivers importance for

wildlife and ecological functioning justify a “high” rating. Endemic plant species occur here, amongst others, *Salsola arborea* and *Senecio giessii*.

Alien plant species *Datura innoxia* and *Prosopis glandulosa* were reported during this survey and have likely moved in from the Orange river.

Resource use and other aspects The Boom river is wedged between two active areas of diamond-mining, which has also impacted on the river habitat. Almost permanent water and the occurrence of trees make this landscape unit an important area for wildlife.

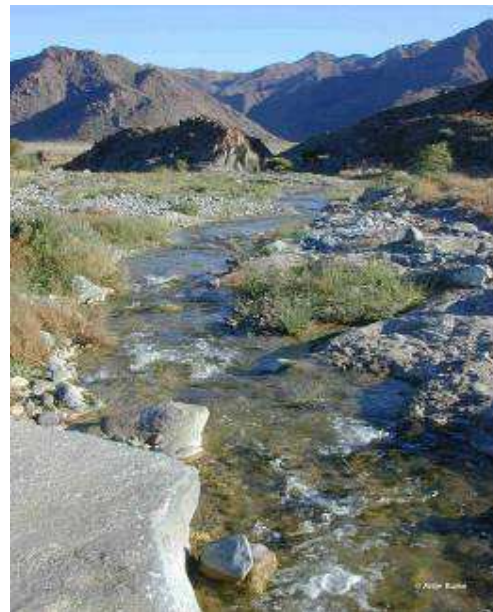
Threats

- Mining and prospecting

Management

- Recommended management zoning: IUCN 1b (wilderness),
- Current ARTP zoning: “primitive”
- MET land use zoning: IUCN 1 b (wilderness)
- Monitor occurrence of invasive alien plant
- Restoration of disturbed habitats

Research needs Biodiversity in the upper reaches of the Boom river and both the Dabimub and Fasfontein) has not been recorded.



Fish river and tributaries



Locality This landscape unit includes the Fish River and its larger tributaries such as the Konkiep and Gaap rivers.

Extent 93.5 km² (2.2 % of the AHGP)

Habitat and environmental parameters The Fish river is the largest ephemeral river in Namibia with an enormous catchment originating in the central highlands just west of Rehoboth. The last approximately 120 km before confluence with the Orange river are part of the AHGP. The river cuts deeply into the bedrock forming the famous Fish River Canyon. The width of the riverbed varies, and is in places up to 1 km wide, sometimes interrupted by buttes (erosion remnants). The riverbed is mostly sandy and framed by gravel banks, followed by steep slopes. Access is only possible along sizeable tributaries. Although the 2011 season was exceptional and a lot of water was present during the survey, there are usually always some areas which retain open water all year round. The Konkiep is also a relatively large river which flows into the Fish just 20 km upstream of the Fish and Orange river confluence. The Konkiep's riverbed is largely composed of boulders and gravel, with less sandy stretches than the Fish River. Permanent seepage areas also occur in the lower Konkiep.

Description Patches of riparian woodland, and relatively well vegetated river banks of varying width alternate along the main channel of the Fish river. The woodlands support tall trees and

dense thickets, the river banks more open, sparse shrubland. Gravel beds are the key feature in the Konkiep river, with only localised patches of woodland and dunes. Vegetation changes occur frequently associated with flooding, and vegetation communities near the main river channels are usually of short-lived nature.

Key plant species The woodland patches in the Fish river are composed of sweet-thorn (*Acacia karroo*), tamarisk (*Tamarix usneoides*) and false ebony (*Euclea pseudebenus*). The invasive alien mesquite (*Prosopis glandulosa*) is present near the camp at /Ai-/Ais and has spread downstream and into tributaries. Large stands of the tall shrubs *Tetragonia schenkii* and *Sisymbrium spartea* grow on the gravel banks and in dune areas, both in the Fish and the Konkiep rivers, accompanied by a variety of herbs and grasses. Areas with permanent water support a variety of sedges and grasses.

Conservation importance: VERY HIGH

Although the number of plant species of conservation importance is lower than recorded in the mountain areas, several protected trees such as *Euclea pseudebenus* and *Maerua schinzii*, and endemic species like *Psilocaulon salicornioides*, *Senecio hermannii*, *Salsola arborea* and *Tetragonia schenkii* occur here. These rivers are, however, extremely important habitats for wildlife and the ecological functioning of ecosystems by the provision of water, nutrient cycling and purification processes.

Many reptiles, including the near-endemic Namibian dwarf gecko (*Lygodactylus bradfieldi*), rough scaled gecko (*Pachydactylus rugosus*) and the western sand lizard (*Pedioplanis undata*) occur in the Fish river area (Griffin 2003).

The in Namibia rare African black duck (*Anas sparsa*) has been recorded in the lower Fish river.

Alien plant species All dryland invasive aliens in Namibia likely occur in the Fish river. Mexican poppy (*Argemone ochroleuca*), thorn apple (*Datura innoxia*) and mesquite (*Prosopis glandulosa*) were recorded, but wild tobacco (*Nicotiana glauca*) and castor oil (*Ricinus communis*) are also expected to occur, as they were recorded in adjoining landscape units. Infestations are, however, localised.

Resource use and other aspects The water in these river systems is the most reliable and thus important water source for wildlife in the eastern section of the park, away from the Orange river. This together with a higher structural diversity in vegetation is likely to support a greater array of small wildlife, than the plains and mountain areas. Water is abstracted for the camps at Hobas and /Ai-/Ais. Other impacts associated with the camps have been discussed (see canyon slopes and eastern undulating plains). Further tourism developments are planned for both, the Fish and the Konkiep rivers, according to the ARTP's zoning. The lower Konkiep river should not be developed at all. This would infringe on the "strict nature reserve" and "wilderness" status the area can presently maintain due to difficult access. Low density development along the lower Fish river can only be considered after a rigorous environmental assessment, including a comprehensive biodiversity inventory.

Threats

- Infrastructure developments
- Tourism developments

Management

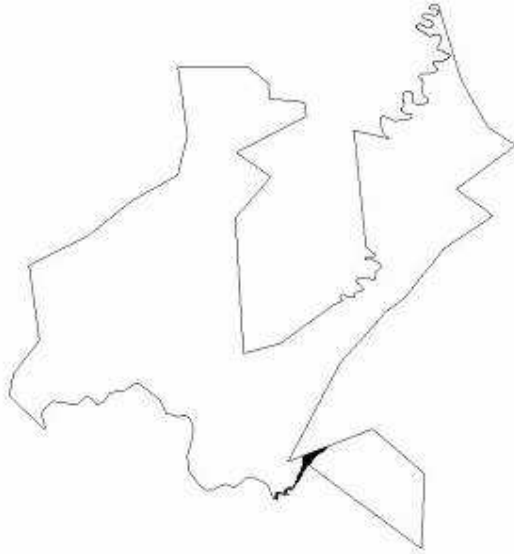
- Recommended management zoning: IUCN 1b (wilderness) – re-assessment of ARTP zoning required
- Current ARTP zoning: low density development
- MET land use zoning: strict nature reserve (1a) lower Fish and Konkiep river and 1b (wilderness upper Fish river)
- Control of invasive aliens (e.g. investigate feasibility of bio control for *Prosopis*) and monitor occurrence of invasive alien plant species around potential new tourism developments

Research needs Biodiversity inventories for the lower sections of the Fish and Konkiep rivers are lacking.



Some gravel banks of the Fish river are relatively densely vegetated, largely with *Tetragonia schenkii* and *Sisymbrium spartea*.

Gamkab river



Locality The wide Gamkab river links the otherwise isolated south-east corner to the remainder of the park.

Extent 11.4 km² (0.3% of the AHGP)

Habitat and environmental parameters Very different from the other rivers, the Gamkab river is the collective, final channel of an extensive network of smaller drainage lines on the open plains in the south-east of the study area. The river connects with the Orange river approximately 35 km upstream of the Fish river confluence. This is one of the driest and hottest areas in the park, and the river flows only rarely.

Description The shallow riverbed and associated banks support sparse, but tall shrubland. Seepage areas occur in the lower reaches, but open water is only present after good rains. Sedges and short grasses occur around these seepage areas.

Key plant species *Tetragonia schenkii* is the dominant plant in most parts of the riverbed, accompanied by *Sisymbrium sparteae*. Very few other plants are usually present, but after the good rains of 2011, carpets with the low succulent creeper *Mesembryanthemum garusianum* as well as *M. longipapillosum* were found. Several other herbs, such as *Myxopappus acutilobus*, *Helichrysum cf. garipepinum*, *Sesuvium sesuvioides*, *Tribulus cristatus* and *Zygophyllum simplex* were also present. The southern-most section of the river also supports *Mesembryanthemum hypertrophicum*, associated with saline seepage areas. In some places

Scirpoides dioecus and *Odyssea paucinervis* grow around these seepages.

Conservation importance: HIGH Few plant species of conservation importance, but the rivers' importance for wildlife and ecological functioning resulted in a "medium" rating.

Alien plant species Interestingly no invasive alien plant species were recorded during this survey. Whether this due to the low sampling effort, or a true reflection of the river's status requires some further investigation.

Resource use and other aspects The seepage areas which are mostly saline (except for short periods after good rains) provide salt licks for animals.

Threats

- Uncontrolled track development
- Infrastructure developments (the track through the Gamkab river requires maintenance)

Management

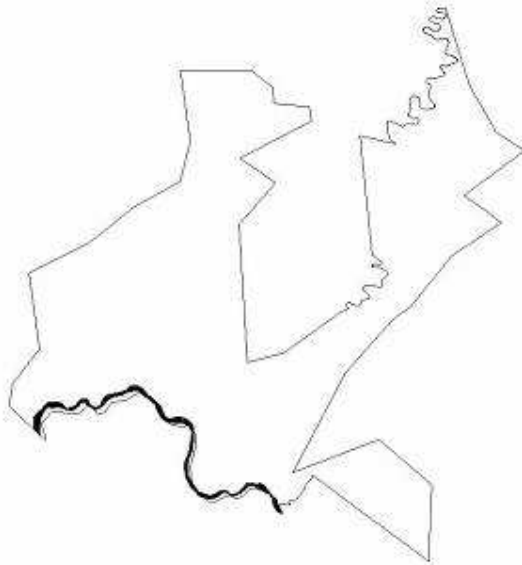
- Recommended management zoning: IUCN 2 (national park),
- Current ARTC zoning: low density development
- MET land use zoning: IUCN 1a (strict nature reserve)
- Prohibit off-road driving and enforce track discipline
- Monitor occurrence of invasive alien plant species

Research needs Whether or not invasive alien plants are present requires more detailed investigation.



Tall shrubs – mainly *Tetragonia schenkii* (left) and *Sisymbrium sparteae* (right) – grow in the main channel of the Gamkab river.

Orange river valley



Locality This landscape unit comprises an approximately 80 km stretch of the Orange river, adjoined by an on average 1.5 km wide strip on the north-bank of the river.

Extent 57.2 km² (1.3% of the AHGP)

Habitat and environmental parameters The permanently flowing Orange river has one of the most extensive catchments in southern Africa and originates in the Lesotho highlands. The wide, open valley of the river has enabled a coastal influence to intrude much further inland than in adjoining areas. Fog moves in from the west occasionally, reaching the western-most sections of the river, likely up to the Boom river, and the strong southerly and south-westerly sea breeze can also be experienced along the western section of the river on the AHGP.

Description This landscape unit comprises the main riverbed and adjoining river banks. Reed beds, grass patches, concentrations of sedges and aquatic plants alternate and intermingle along the main river channel, constantly changing according water level and flood impacts. The river banks support stands of riparian woodland and shrubland. These woodlands and shrublands are not continuous, but interrupted where tributaries join the Orange river. Vegetation cover is thus extremely variable, and can reach 100% in dense woodlands and sedge, and grass communities, but many areas are also only sparsely vegetated, hardly reaching 5% plant cover.

Key plant species The riverine plant communities are dominated by the tall reeds *Phragmites australis*, occasionally accompanied by *Typha capensis*, various sedges such as *Cyperus*, *Bolboschoenus*, *Schoenoplectus* and *Scirpoides* species the short grass *Cynodon dactylon*. The riparian woodlands support the tall trees Cape willow (*Salix mucronata*), *Rhus pendulina*, *Acacia karroo*, and *Ziziphus mucronata* and the smaller trees *Euclea pseudebenus* and *Tamarix usneoides*. Shrubs include, amongst others various *Lycium* species, *Diospyros lycioides*, *Gymnosporia linearis*, *Salsola* species and *Zygophyllum microcarpum*. A variety of herbs grows in the shelter of the woodland and shrublands, such as *Amaranthus hybridus*, *Cullen obtusifolia*, *Doellia cafra*, *Laggera decumbens* and *Litogyne garipensis*. Localised aquatic plants such as *Ludwigia* and *Potamogeton* species form floating mats.

Conservation importance: HIGH Although relatively diverse, not many plant species of formal conservation importance occur in the Orange river valley. However, the river is one of the most important habitats for wildlife in the park, and due to the permanent river flow and plays a critical role in maintaining ecological functions well beyond the park boundary. However, the river is heavily utilised (see “resource use”).

Two near-endemic reptiles – the western sand lizard (*Pedioplanis undata*) and the Namibian worm snake (*Leptotyphlops occidentalis*) have been recorded in the Orange river valley (Griffin 2003).

The Orange river is also an important habitat for water birds of conservation importance, such as African fish eagle, goliath and purple heron, little bittern, yellow-billed duck and African black duck. Cape Weaver, black and white stork, malachite and lesser double collared sunbird, Namaqua warbler and Cape francolin are also rarer birds that have been recorded in the Orange River valley and surroundings.

Alien plant species Every invasive alien plant species of concern in the semi-arid and arid parts of Namibia occurs on the banks of the Orange river. Mesquite (*Prosopis* species) has replaced indigenous woodlands along many stretches of the river, often impenetrable, monospecific thickets. Castor oil (*Ricinus communis*), Mexican poppy (*Argemone ochroleuca*), wild tobacco (*Nicotiana glauca*) and various thorn apple species (*Datura ferox*, *D. innoxia*) also form,

sometimes monospecific, dense stands locally, replacing the indigenous vegetation.

Resource use and other aspects The Orange river is ecologically not in a healthy state due to damming upstream, water abstraction and pollution impacts through fertilisers from irrigation farming and sewage disposal. Irrigation and livestock farming occurs even within the boundaries of the AHGP, an aspect which is currently being addressed.

The gravel banks have been or are currently mined at several places along the river. Where mining has ceased, no attempt of rehabilitation has ever been made, and where mining is currently active, no progressive rehabilitation is evident. This is completely unacceptable practice in a national park.

Threats

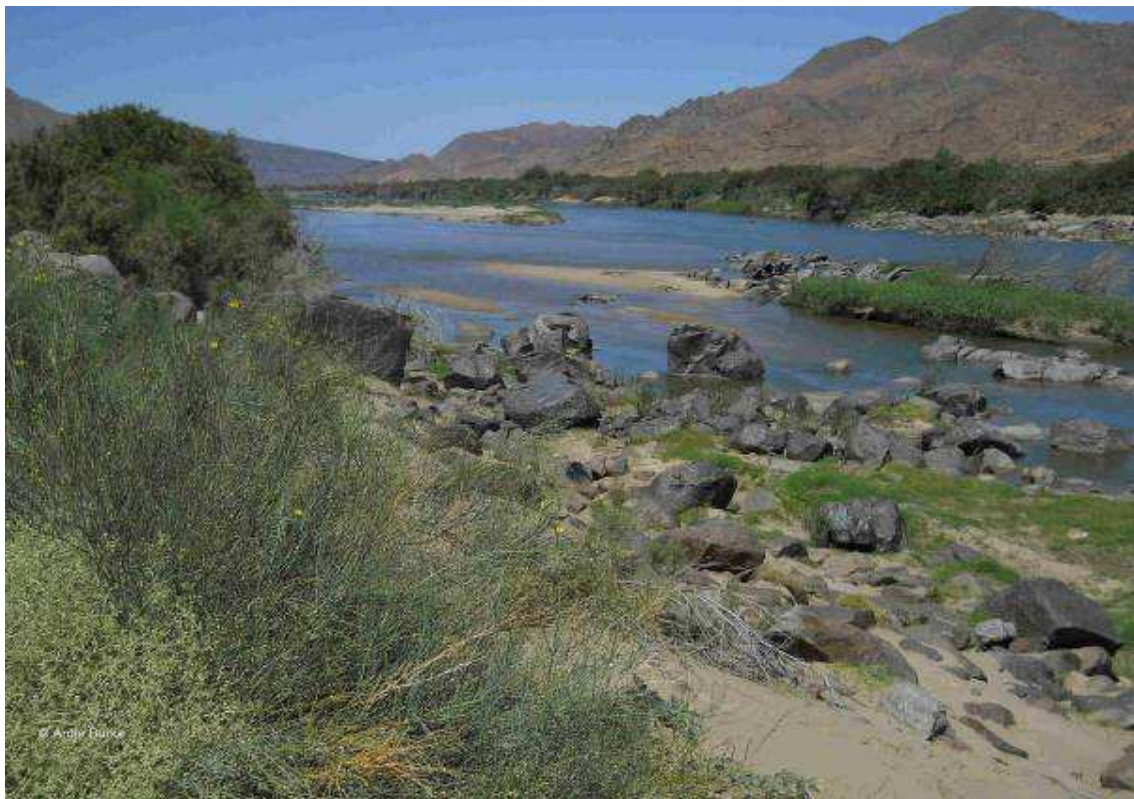
- Quarrying, mining and prospecting
- Irrigation and livestock farming
- Infrastructure developments
- Off-road driving
- Illegal plant collecting

Management

- Recommended management zoning: IUCN 2 (National Park)

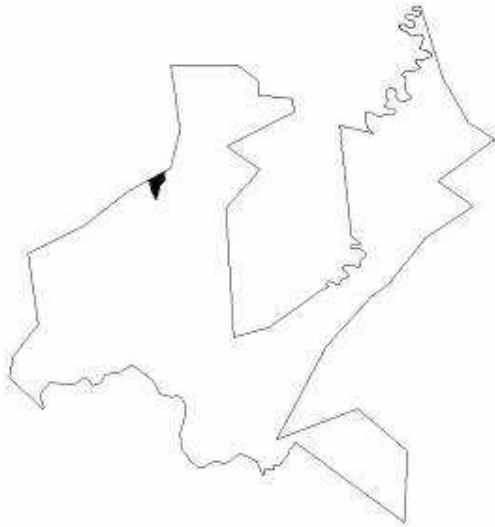
- Current ARTP zoning: low intensity development
- MET land use zoning: National Park (IUCN 2) and strict nature reserve (IUCN 1a)
- Rigorously enforce Environmental Management Act for all prospecting and mining activities (i.e. environmental assessment, management and rehabilitation plans (EMP) and regularly check compliance with EMPs.
- Prohibit off-road driving
- Controlling all invasive alien plant species along the Orange River is a formidable task, and not possible without collaboration of all upstream users. MET's efforts should thus focus on supporting currently on-going projects in the river basin (e.g. *Prosopis* control) and prevent the further spread of invasive from the river into adjoining habitats. All tributaries to the river are therefore high priority for invasive alien control.

Research needs Field-based Red Data assessments of range-restricted species, e.g. on the gravel banks, are important. Practical rehabilitation and biodiversity restoration methods have to be developed for disturbed areas.



The picture deceives – the Orange river is ecologically one of the least healthy rivers in southern Africa – due to upstream water abstraction, dams and pollution from agriculture, industry and towns.

Arimas plains



Locality Extending only marginally into the AHGP, the Arimas plains are situated in the north-western section of the park.

Extent 11.04 km² (0.25 % of the AHGP)

Habitat and environmental parameters Part of the open valley and plains between sections of the Huib Hoch plateau and the Huns mountains, these gravel plains are at approximately 1000 m

m (amsl). They may form a transitional area between the Succulent and Nama Karoo biomes.

Description The plains support moderately dense dwarf shrubland, while taller shrubs line drainage channels.

Key plant species *Zygophyllum decumbens* is the dominant shrub on the plains, with *Zygophyllum rigidum* locally abundant. *Sisyndite spartea* and *Rhigozum trichotomum* are abundant in drainage lines.

Conservation importance: MODERATE

Alien plant species None recorded

Resource use and other aspects This area was previously used for livestock farming.

Threats

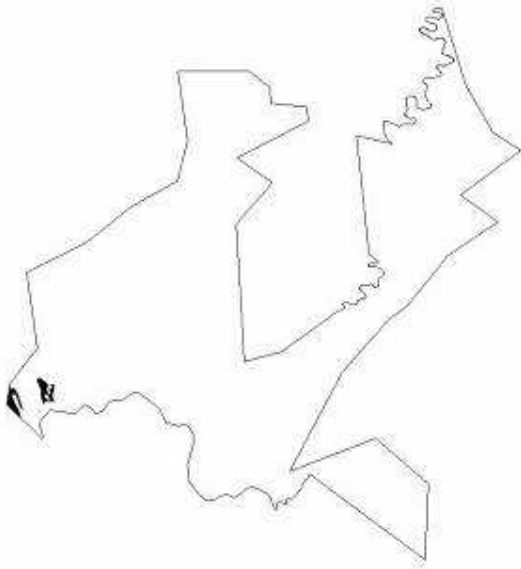
- No current threats.

Management

- Recommended management zoning: IUCN 2 (National Park)
- Current ARTP zoning: wilderness
- MET land use zoning: wilderness (IUCN 1b)

Research needs A more detailed plant inventory of this landscape unit is required.

Dreigrat plains



Locality The plains in between and to the west of the Namus mountains are here combined.

Extent 12.5 km² (0.3 % of the AHGP)

Habitat and environmental parameters Mostly sandy, these plains are framed by mountains and ridges. They are within the extended coastal influence area along the Orange river and experience occasional fog and strong southerly winds.

Description Grasses, dwarf – and taller shrubs are present, providing sparse perennial plant cover. Drainage lines are more densely vegetated, mainly by tall shrubs.



A combination of various *Stipagrostis* grasses and the tall succulent shrub *Euphorbia gummifera* characterise the Dreigrat plains in the western part of the park.

Key plant species The western plains are characterised by large *Euphorbia gummifera*, accompanied by *Calicorema capitata* and *Brownanthus arenosus*. *Sisyndite spartea* and *Zygophyllum prismatocarpum* are dominant in drainage lines. Bushman grass (*Stipagrostis ciliata*), *S. obtusa* and *S. subacaulis* dominate on the more sandy areas.

Conservation importance: HIGH Species of conservation importance include the southern Namib endemics *Dracophilus dealbatus*, *Eberlanzia sedoides* and the Gariiep endemics *Sarcocaulon patersonii*, *Zygophyllum prismatocarpum* and *Z. pterocaula*.

Alien plant species None recorded

Resource use and other aspects These plains are some of the few accessible areas in the park and thus suffer from recreational usage. Tracks made by off-road driving are the most obvious impact, but illegal plant collecting and prospecting and mining activities take their toll on biodiversity. Disturbances from abandoned mines, such as the one at Lorelei, have not been rehabilitated.

Threats

- Off-road driving
- Illegal plant collecting
- Quarrying, mining and prospecting
- Infrastructure developments

Management

- Recommended management zoning: National Park (IUCN 2)
- Current ARTP zoning: primitive
- MET land use zoning: National Park (IUCN 2)
- Prohibit off-road driving and implement control measures
- Rigorously enforce Environmental Management Act

Research needs Field-based red data assessments and monitoring of range-restricted plant species is critical in this landscape unit.

Eastern sand plains



Locality A small section of these extensive sand plains extends into the very north-east of the park.

Extent 10.95 km² (0.25 % of the AHGP)

Habitat and environmental parameters The eastern sand plains are at about 800 m m (amsl) and they are in the hotter part of the park (maximum temperatures during hottest month 34-36° C).

Description Grasses dominate the vegetation, reaching about 10-20 % plant cover.

Key plant species The sandy plains are dominated by *Stipagrostis cf hochstetteriana* (no inflorescences were present during the site visit to verify identification), accompanied by *Stipagrostis cilia*, *S. obtusa* and *Schmidtia kalahariensis*. *Rhigozum trichotomum* is locally also co-dominant and *Sisyndite spartea* is dominant in drainage lines.

Conservation importance: MODERATE No plant species of formal conservation importance were recorded, but they were very dry and some remnants of plants could not be identified. The grasslands are an important food source for antelope and other game.

Alien plant species None recorded

Resource use and other aspects These grasslands are grazing areas for wildlife.

Threats

- None evident

Management

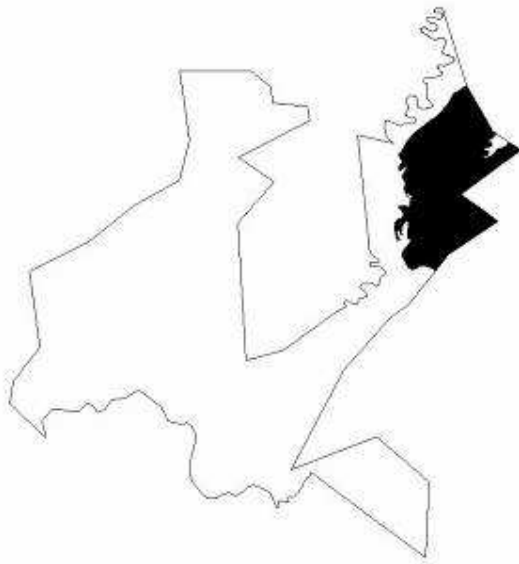
- Recommended management zoning: IUCN 2 (National Park),
- Current ARTP zoning: primitive
- MET land use zoning: National Park (IUCN 2)

Research needs A more detailed plant inventory is required during the peak of the vegetation season.



Sandy plains in the north-east of the park show a dense cover of perennial *Stipagrostis* grasses. Isolated quiver trees also grow on these plains.

Eastern undulating plains



Locality The eastern undulating plains cover the greatest part of the a sizable north-eastern section of the park. Due to more rugged topography, the southern sections have been included in the “canyon slopes”.

Extent 525.3 km² (12.1 % of the AHGP)

Habitat and environmental parameters Open, level plains, small hills and undulating ridges, dissected by drainage lines and small ephemeral rivers comprise this landscape unit. The area is positioned at approximately 600-700 m m (amsl), with most drainage lines running in a south-westerly or westerly direction into the Fish river and its tributaries.

Description The vegetation is sparse shrubland, and hardly reaches 5% plant cover. Isolated trees line the ephemeral rivers.



On the plains east of the Fish River *Euphorbia gregaria* and various grasses comprise the main part of the vegetation.

Key plant species The tall stem-succulent *Euphorbia gregaria* is undoubtedly the most conspicuous plant and dominant in most parts of this landscape unit. The dwarf shrubs *Zygophyllum decumbens* and *Salsola cf barbata* are locally dominant, particularly on slopes and more rocky surfaces. Isolated quiver trees (aloe dichotoma) dot the landscape, and the stem-succulent *Euphorbia avasmontana* is conspicuous on some slopes. The ephemeral rivers and some drainage lines support camel thorn (*Acacia erioloba*), *Acacia mellifera*, *Pappaea capensis* and buffalo thorn (*Ziziphus mucronata*).

Conservation importance: MODERATE Some plant species of conservation importance, such as the southern Namibian endemic *Petalidium linifolium* and the protected *Aloe dichotoma* occur and this landscape unit is important for wildlife.

Alien plant species None recorded during rapid survey, but likely present in some areas, particularly where adjoining tributaries to the Fish river and around the camp at Hobas.

Resource use and other aspects Next to the camp at /Ai-/Ais, this is the most frequented landscape unit with the Fish river canyon view point and associated access roads.

Threats

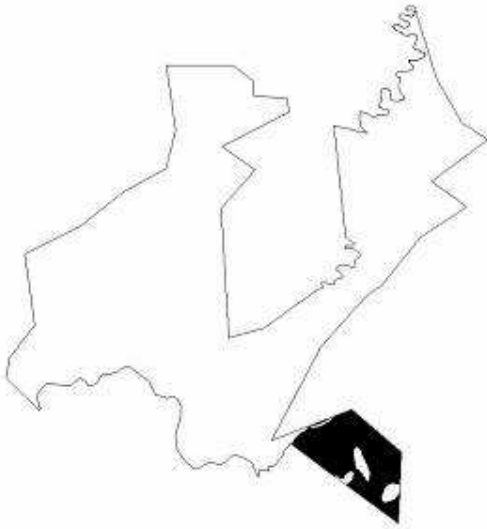
- Infrastructure developments
- Locally noise (generator at Hobas camp and road traffic)
- Collisions with wildlife along main tourist routes

Management

- Recommended management zoning: IUCN 2 (National Park)
- Current ARTP zoning: primitive, quiet, and low and high density development
- MET land use zoning: National Park (IUCN 2)
- Monitor wildlife accidents and, if necessary, introduce speed bumps in critical areas.
- Monitor occurrence of invasive alien plant species around tourism developments.

Research needs The impact of noise and traffic on wildlife need to be better understood, as well as effective measure to curb habituating tendencies in some animals (such as baboons).

Gamkab plains



Locality This is the most recent farm (Assenkjer 147) added to the park in the south-eastern corner.

Extent 275.4 km² (6.3% of the AHGP)

Habitat and environmental parameters

Extensive, gently south-west-sloping plains dissected by a network of drainage lines to the Gamkab river characterise this landscape unit. The area descends from approximately 370 m to 280 m m (amsl). This area is in the hottest and driest part of the park (largely due to being positioned in the rain shadow of the Richtersveld and Huns mountains) and has by some scientists been characterised as the Lower Orange River Desert Biome Outlier (Irish 1994).

Description Most times almost barren, except for the drainage lines, annual herbs and grasses can be present in abundance after good rains. Perennial plant cover is no more than 1%, but annual cover can reach 20% locally in good rain years.

Key plant species The tall shrub *Sisyndite spartea* is always present, mostly in drainage lines, but the striking succulent creeper *Mesembryanthemum garusianum* carpets these plains presently, after the good rains of the 2011 season. The herbs *Myxopappus acutilobus*, *Sesuvium sesuvioides*, *Trianthema parvifolia* and *Zygophyllum simplex* are also present, as is the grass *Stipagrostis obtusa*. The dwarf shrub *Calicorema capitata* is locally present.

Conservation importance: MODERATE The southern Namibian endemic *Tetragonia schenkii*

grows in some drainage lines. This area appears to be an important corridor for wildlife as evident by many game trails crossing these plains.

Alien plant species None recorded



After good rains the usually barren plains of the Gamkab basin are covered in carpets of the stunning succulent creeper *Mesembryanthemum garusianum*.

Resource use and other aspects This is a former livestock farm and an abandoned quarry is present in this unit.

Threats

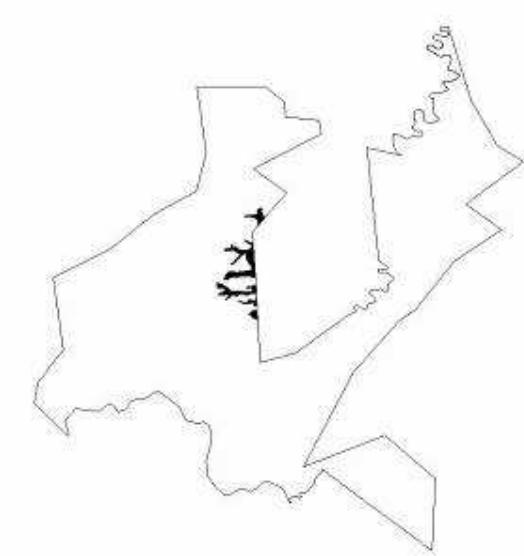
- Off-road driving

Management

- Recommended management zoning: IUCN 2 (National Park)
- Current ARTP zoning: remote
- MET land use zoning: Managed resource protected area (IUCN 6)
- Prohibit off-road driving and implement effective control measures.

Research needs The former quarry may require investigation to assess rehabilitation needs.

Konkiep plains



Resource use and other aspects No field data

Threats

- None expected

Management

- Recommended management zoning: wilderness (IUCN 1b)
- Current ARTP zoning: wilderness
- MET land use zoning: wilderness (IUCN 1b)

Research needs A plant inventory is required for this mapping unit.

Locality These plains form the transition between the northern Huns Mountains and the Konkiep River.

Extent 40 km² (0.9 % of the AHGP)

Habitat and environmental parameters These plains are dissected by largely shallow drainage lines draining east into the Konkiep river.

Description There are no field data for this landscape unit is landscape unit which prohibits a proper description.

Key plant species No field data

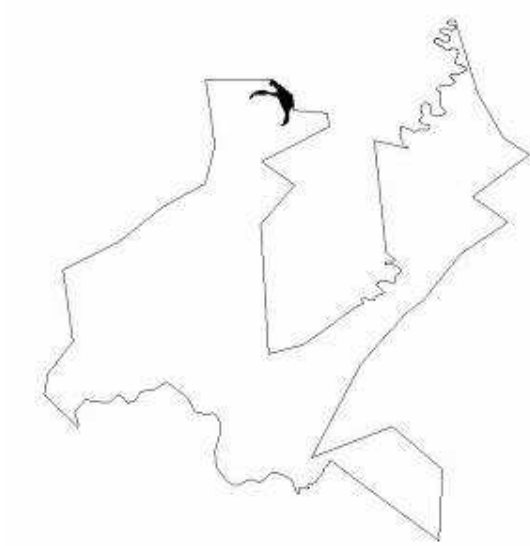
Conservation importance: HIGH Based on importance for wildlife and ecological functioning.

Alien plant species No field data



Access along the Konkiep river can be a treacherous affair...

Moedhou plains



Locality The open plains surrounding the Konkiep river in its upper reaches on the farm Moedhou marginally extend into the north-western section of the AHGP.

Extent 21.7 km² (0.5 % of the AHGP)

Habitat and environmental parameters The open plains are positioned at about 700-750 m (amsl).

Description The vegetation on the plains is very sparse dwarf shrubland, with vegetation largely concentrated in drainage lines and ephemeral rivers. Here vegetation cover can reach 20%.

Key plant species *Calicorema capitata* is the dominant shrub on the plains, accompanied by *Rhigozum trichotomum* in shallow drainage lines and *Zygophyllum decumbens* is locally dominant or co-dominant. Larger drainage lines and rivers support trees such as *Pappea capensis* and *Euclea pseudebenus* and larger shrubs, for example *Sisyndite spartea* and *Grewia tenax*.

Conservation importance: HIGH Although generally not as diverse in plant species as the adjacent mountainous areas, a number of endemics occur in the rivers and drainage lines, such as *Justicia guerkeana*, *Polygala guerichiana*, *Ruellia asperifolia* and *Tetragonia schenkii*.

Alien plant species None recorded

Resource use and other aspects This part of the park was formerly used for livestock grazing.

Threats

- None known presently

Management

- Recommended management zoning: IUCN 2 (National Park)
- Current ARTP zoning: primitive
- MET land use zoning: IUCN 2 (National Park)

Research needs None presently



Drier than the southern part of the park, the plains north of the Huns Mountains provide a typical Nama Karoo aspect with widely scattered dwarf shrubs, such as *Calicorema capitata*. Only drainage lines (foreground) support more dense and diverse vegetation.

CONCLUSION

True wilderness, meeting point of several southern African bio-geographical zones (biomes), within a centre of plant endemism, position at the margin of a global biodiversity hotspot, and complex geology and landforms have made the /Ai-/Ais Hotsprings Game Park an unique asset to Namibia's Protected Area Network.

As major parts of this mountain area are inaccessible, biodiversity has been well protected. A blessing in disguise, it does mean that biodiversity inventories for the park are fragmentary and only reasonably adequate for plants in the accessible areas at the outskirts of the park. Fauna data are even more fragmentary. This provides challenges for biodiversity management to the extent that major southern African biome boundaries are still debated. As precisely these are predicted to be most affected by climate change, and two endangered and iconic plant species – the halfmens (*Pachypodium namaquanum*) and giant quiver tree (*Aloe pillansii*) – have found a refuge in the almost inaccessible mountain, a concerted effort to improve biodiversity baselines is called for.

Human impacts on biodiversity are restricted to the few accessible areas, but here they can be severe. Mining and quarrying on the gravel banks of the Orange river threatens range-restricted plant species, some of which grow on these terraces only – aside from the negative visual impact these mining operations pose along one main tourist route through the park. To date no attempts to rehabilitate abandoned mines has been made.

The impacts of tourist developments on biodiversity are largely localised, but most of these can be significantly reduced by implementing simple measures such as reducing excessive light and noise at camps, switching to solar energy where generators are used, demarcating trails near camps to prevent unnecessary disturbance of fragile mountain slopes and restricting quarrying for road material to few managed borrow-pits.

In order to re-establish historic migration routes, which are essential for healthy wildlife populations, wildlife needs to be managed jointly with conservation-minded park neighbours. Good information exchange and joint management of wildlife and related data will facilitate this process.



Discovery of new plant species is still possible in the Huns mountains. This strange bulb has been preliminarily identified as *Oxalis ambigua*, but there is a possibility that this is a new species, which can only be confirmed once flowers are found.

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During the rainy season framed by a their own delightful rock gardens, the rock overhang of the famous Apollo 11 cave is located in the picturesque Goachanas gorge.

