TAKING STOCK OF PARKS IN A CHANGING WORLD

The SANParks Global Environmental Change Assessment

2016

South African
NATIONAL PARKS

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The SANParks Global Environmental Change Assessment was initiated by Melodie McGeoch in 2009 and continues to be managed and led by Nicola van Wilgen.

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Contents

The challenge of global change is well summarised below, albeit with a climate change focus, the issues highlighted are relevant to all aspects of global change:

"The sheer number of people alive today is partly responsible for the size of our footprint on the planet, but the dominant cause is the dramatic increase in modern times of per person consumption of resources and production of waste. The lifestyles to which many people in the developed world have become accustomed, and to which the less fortunate legitimately aspire, come at large cost to the environment. Most of the debt will be borne by future generations: our comfort and luxury create future disadvantage. This raises profound ethical issues as well as practical difficulties in persuading the current generations that the problem is real and urgent. The combined inertia of the global climate system, the political systems which govern our actions, and the technology systems that satisfy our demands for energy and mobility mean that, by the time everyone feels the heat, we are likely to have overshot the climate 'comfort zone' in which modern civilization evolved. This will place humans and the millions of other species with which we share the planet in jeopardy."

Scholes, R., Scholes, M. & Lucas, M. 2015.
Climate change: Briefings from Southern Africa. Wits University Press, xv + 199 pages.

Part 1 of this report provides an overview of how six drivers of environmental change affect all the national parks and recommendations of the way forward.

Part 2 of this report provides more detailed information on the impact of each of these drivers in each of the parks.

The six drivers are:

- Climate change
- Land-use change
- Disease
- Alien species
- Change in freshwater systems
- Resource use

Acronyms

AHS	African Horse Sickness
BSP	Biodiversity Social Projects
CDV	Canine Distemper Virus
CFR	Cape Floristic Region
CRC	Cape Research Centre
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DCA	Damage Causing Animals
DoA	Department of Agriculture
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
EDRR	Early Detection Rapid Response
EVI	Enhanced Vegetation Index
FEPA	Freshwater Ecosystem Priority Area
GEC	Global Environmental Change
GIS	Geographic Information Systems
GRNP	Garden Route National Park
IDP	Integrated Development Plans
KPA	Key Performance Area
MPA	Marine Protected Area

NDVI	Normalized Difference Vegetation Index
NEM: BA	National Environmental Management: Biodiversity Act
NFEPA	National Freshwater Ecosystems Priority Assessment
NGOs	Non-Governmental Organisations
OIE WAHID	World Organisation for Animal Health World Animal Health Information Database
PA	Protected Area
PCR	Polymerase Chain Reaction
P&C	People and Conservation
SAFCOL	South African Forestry Company Limited
SANBI	South African National Biodiversity Institute
SASS	South African Scoring System [for River Health monitoring]
SAWS	South African Weather Service
SMA	Special Management Area
TFCA	Transfrontier Conservation Area
TMNP	Table Mountain National Park
TPC	Threshold of Potential Concern
UCT	University of Cape Town
VWS	Veterinary Wildlife Services
WfW	Working for Water
WWF	World Wildlife Fund

THE WORLD IS CHANGING
HOW SHOULD WE RESPOND?

GLOBAL CHANGE
The collective way in which modern living, travel, trade, resource consumption and waste generation impact on the planet's ecosystems and their function

We assessed the status and possible future trends in **6 drivers** of change in each park

Global change drivers do not stop their impact at the park fence

1 Climate Change

Temperatures are increasing everywhere

EXAMPLE: Average maximum temperature has increased by **2°C** in Kalahari **90%** of summer days are now **> 35°C**

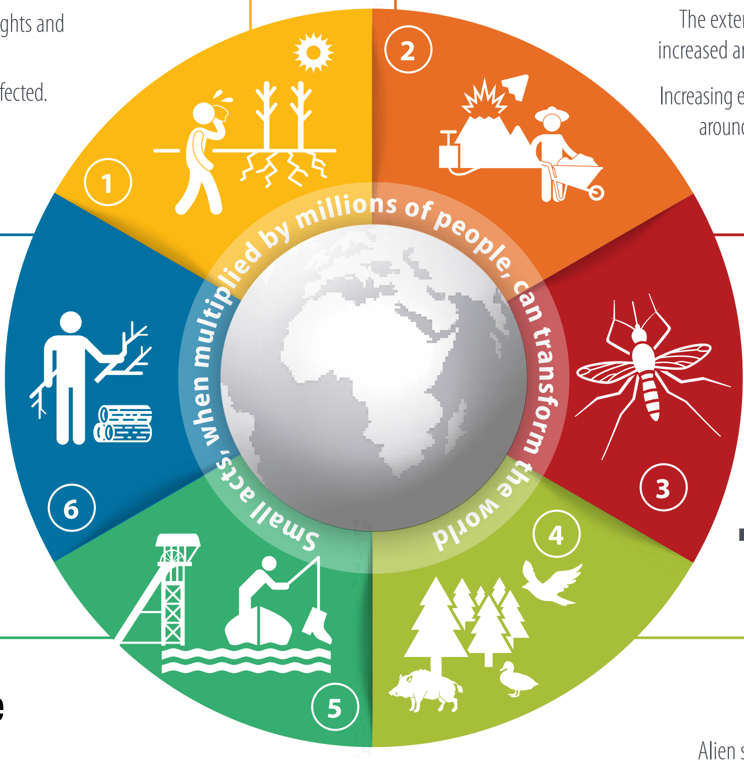
- Rainfall will become less predictable and droughts and floods more common.
- Several parts of the country are already being affected.

2 Habitat change & land-use change

The total area covered by national parks has increased dramatically since the first national park (Kruger NP) was declared in 1926. Along with the expansion of park area, the number of habitat types conserved within national parks has also increased to nearly **150**

The extent of urbanized area and cultivated land has increased around many of the parks in the last 20 years

Increasing environmentally friendly practices in the areas around parks assists species in adapting to changes



6 Resource use

- Poaching of high value species is a problem in some areas
- Sustainable resource use projects and initiatives provide tangible benefits to several neighbouring communities
- Game off-takes and use of abiotic materials such as water and gravel also constitute resource use and require monitoring

3 Disease

- Disease has a natural positive function in regulating animal populations but can also threaten species and is closely linked to ecosystem health
- Climate change can affect the emergence and distribution of disease vectors as well as susceptibility of animals and plants to disease
- More research is required on plant diseases

5 Freshwater change

South Africa has:

177 276 km of rivers

47% are in good condition

2.9% are in national parks of which **76%** are in good condition

8.2% are in protected areas of which **64 %** are in good condition

4 Alien species

Alien species are here to stay and prioritization of target species is becoming increasingly important

- Alien species pose a major threat to indigenous species and water
- A total of **869** alien and extralimital species were recorded across the parks

SANParks is in an excellent position to advocate for greener and healthier living and lifestyles

INTRODUCTION

Project background

The Millennium Ecosystem Assessment (2005) was a United Nations project designed to assess the consequences of ecosystem changes for human well-being at a global scale. It used available information to identify and assess the consequences of a number of drivers of global environmental change. The Assessment raised questions about the role of protected areas in buffering ecosystem change, as well as the possible impacts on, and actions required to allow protected areas to contribute to sustaining ecosystem services and human well-being. The questions raised in this global project were of interest and concern to SANParks and triggered an assessment at the local scale, with SANParks launching its own assessment of the state of environmental change in all parks in 2009. It was conducted largely by the Conservation Services Division, with inputs from several researchers from other institutions. It focused on the impacts and trends in six major change drivers: climate change, habitat and land-use change, disease, alien species, change in freshwater systems and resource use. Pollution, another recognized driver of change, was only indirectly considered by assessing the status of freshwater systems in parks as well as by identifying the role of pollutant bacteria in causing disease. The original objective was to conduct a quantitative assessment of the current status and projected future trends and impacts of global change on parks, and to use this as a basis for providing policy directives and management recommendations. It was not possible to do this for all drivers and trends as information was not available uniformly across parks. Nonetheless this report reflects the state of information available in each of the parks for each of the drivers. These change drivers should however not be viewed in isolation as they also influence and interact with one another. These interactions are critically important, and although not included in the current study, should remain a consideration and be prioritised in future research.

Defining global environmental change

People's association with the words 'global change' is often restricted to 'climate change', which conjures up pictures of stranded polar bears. However global change is more than climate change and it is not just polar bears that are affected but all plants, animals and ecosystems all over the world. According to the Millennium Ecosystem Assessment virtually all of our planet's ecosystems have been significantly transformed through human actions, with the biggest and fastest changes taking place in the second half of the past century. Known as GLOBAL ENVIRONMENTAL CHANGE, this syndrome of change is defined as the processes that alter the Earth's land, oceans, and atmosphere at a planetary scale. This includes drivers that act on a global scale (such as ozone depletion and chemical changes in the earth's atmosphere leading to climate change), as well as those that occur locally, but are so widespread that they are experienced globally (such as alien species invasions, urbanization and land conversion). That is, global change is the collective way that modern living, travel, trade, resource consumption and waste generation impact on the planet's ecosystems and their functioning. The factors that drive global change include climate change, alien species, disease, habitat change (including habitat conversion, urbanization and fragmentation), unsustainable harvesting of natural resources (overharvesting), pollution and waste generation.

Global change has consequences for biodiversity, ecosystems, the services they provide and thus for human well-being. Traditionally protected areas were imagined as parcels of untouched land, seemingly immune to the drivers of change acting in the landscapes around them. This is no longer the case both because the notion of protected areas has changed, becoming increasingly inclusive of social perspectives and people's role in natural ecosystems; and the realization that the global drivers of change do not halt at the park fence. Biodiversity losses have been recorded in protected areas all over the world as a result of climate change, the fragmentation and destruction of habitats inside and outside of parks, disease, alien species, freshwater change, overharvesting and pollution.

While climate change may be a contributing factor in species declines and ecosystem change, understanding all the potential drivers impacting a species or area may result in varied management responses depending on the number of drivers and magnitude of their impacts. For example climate change might threaten the last population of species x on the West Coast, because this species is not able to survive temperatures of above 25 degrees for sustained periods and recent temperature increases could mean that temperatures remain above 25°C too frequently. In contrast, the decline in species y from Table Mountain might be attributed to several global change drivers, including harvesting for medicine to support a growing urban population, pollution of the river that feeds its habitat, competition from alien species and hotter fires that have resulted from dense alien species and warmer average temperatures that are being experienced in fire season. In this instance it would be very important to distinguish climate change from global change to apply the correct management action. In the first example, aside from finding alternate suitable habitat (probably at a higher, cooler altitude) and creating an appropriate corridor or actually moving the species, there is little that management could do to prevent loss of species x, whereas loss of species y might be halted or slowed by improving water quality, removing alien species and working on alternate harvest practices to assess whether this alleviates the pressure of a changing climate.

Methodological notes

For each of the parks, we endeavoured to gather data and assess the status and trends in climate change, land-use change, disease, alien species, freshwater change and resource use. Certain information was not accessible or did not exist. The data that were available and used for each of these 'drivers' are summarised in the table on p. 3. Further details of the approach used for particular drivers, including the limitation of the methods, is provided in the appendix.

Note that the report uses modelled scenarios to illustrate the range of future climate change regimes so that SANParks can prepare for change. Scenario planning is that part of strategic planning that relates to managing the uncertainties of the future. It involves a process of visualising or modelling 1) what future conditions or events are probable, 2) what their consequences or impacts are likely to be.

Summary of what was assessed at park level

Driver	What was assessed	Distribution and reliability of information across parks
Climate change	■ Analysis of trends in temperature and rainfall from weather station data available from the South African Weather Service (SAWS) up to 2009. The information was sourced from SAWS in bulk, but in some instances additional data were obtained directly from parks following the initial assessment. ■ Predictions for future climate change from a study conducted by SANBI, the CSIR and collaborators, including SANParks scientists.	The availability and quality of weather station data varied markedly between parks. For several parks no long-term historical temperature data were available and in several other instances the assessment relied on data from a town nearby the park. Information on the possible future climate was available for all parks at the same resolution. The methods used to generate the predictions are outlined briefly in the appendix.
Habitat change and land-use change	■ A comparison of land-cover classification, using data form 1990 and 2014 was undertaken to assess changes in external pressures within a 20 km radius of national parks. ■ Positive change was assessed by reviewing park expansion for each park and the resultant increase in the number of habitats conserved was assessed per park. ■ An initial assessment used trends in herbivore numbers to assess the status of veld condition, but these data are now outdated and cannot be used in isolation to assess veld condition because management actions (e.g. the off-take of game) also influence these numbers. ■ Repeat vegetation survey data were not consistently available for all parks, and where available, expert opinion was used to describe habitat and veld condition in particular areas.	Land-cover information was consistent between parks, but the expert opinion required to interpret these changes varied between parks. Additional expert opinion was required to determine the threats associated particularly with mining, and the level of information varied at park level. The information available on park size and the increase in habitats conserved was consistent. Information on the state of habitats within parks was not requested per se for all parks, but in some instances expert opinions have been included. Note that additional tools are becoming available and future assessments could include information from satellite imagery such as EVI (enhanced vegetation index).
Disease	■ The presence and impact of 15 notifiable diseases was assessed in all parks by veterinary experts. ■ Data from 3 sources: state vet reports where available, OIE WAHID database and the DoA Handistatus database were assessed. ■ Information from lower level plans (which form part of Park Management Plans) was considered where available.	The only information available across parks was expert veterinary opinion and the availability of expertise varied markedly between parks. Lack of internal plant disease experts meant that plant diseases were excluded although anecdotes are available from some Cape parks.
Alien species	■ The presence of alien species within each park (based on project and cybertracker data, published information, grey literature and expert knowledge) was assessed. ■ Known impacts and pathways of introduction for each of the species was assessed generally but not at individual park level. ■ The NEM: BA status of species present in parks was determined. ■ Work conducted by BSP on species present in parks was assessed between 2002 and 2016.	Sources of information used to list the species present in each park varied widely depending on the history of clearing programmes in the park and the availability of published data on aliens in a particular park (see appendix). NEM: BA and BSP data were available for all parks.
Freshwater change	■ The level of impact on freshwater systems (including groundwater, wetlands, lakes and rivers and estuaries) in parks, was assigned based on information on water quality and flow regimes, the use of rivers as a park boundaries, the impact of upstream/adjacent land-use as well as the results of the National Freshwater Ecosystems Priority Assessment (NFEPA) of river health. ■ National information for wetlands was deemed unreliable, but fieldwork has been conducted in some parks to survey wetland distribution and status.	The NFEPA data is presumed to be consistent throughout the country, in reality however, data inputs are better for well-known areas. In addition, data are averaged across all systems in a park and in large parks (e.g. Kruger), the apparent natural state across most of the small river systems may mask the impacts within particular systems. Wetland information was only available for parks where field work has been conducted.
Resource use	■ Park staff were interviewed (by email and/or telephone) using a standard template regarding authorised and unauthorised resources use in parks. ■ Submissions to DEA on the authorised use of biological resources between 2013 and 2015/16 were reviewed. ■ Additional information was gathered from project managers and SANParks scientists following the interview survey. ■ Information from lower level plans was included, where available.	Where direct contact was made with park staff, more resource use was reported than in parks where direct (face to face) follow-up was not possible. Availability of published information on resource use projects was not consistently available for all parks.

How to read this report

Part 1 provides an overview of the results of the SANParks assessment at a driver level and an overview of the results within each of the parks. We also provide some generalised recommendations, cautions and opportunities for action.

Part 2 unpacks the results of the assessment park by park. For each park we report the key findings under the broad headings of Climate change, Land-use change or change in habitat quality, Disease, Alien species (dealt with separately for plants and animals), Freshwater Change and Resource Use. Parks are reported on in alphabetical order. We have reported the information available for each driver separately and in a consistent order across parks. In instances where the interaction between drivers was evident or well-understood for a particular park, results for these drivers have been combined to demonstrate these links.

To make the information that we have on each of these global change aspects useful, we have provided some direction on what to do next in the face of these often seemingly insurmountable problems. While some of the suggestions may appear radical, the nature of the changes we face will require very different thinking and often novel solutions. We hope that the expert opinion and suggestions provided will encourage broader and more creative thinking.

We have provided this direction in a number of ways. We highlight messages of particular importance relating to management (what can be done about a problem), research (what do we still need to learn), positive outcomes (where interventions have been helpful or progress has been made in combatting a problem) and red flags. We have also highlighted 'red herrings', that is, those management interventions that might sound appealing, but may actually do more harm than good or are doomed to fail because the circumstances are inappropriate. These 'red herrings' are areas where we can learn from our mistakes or the mistakes of others, or situations where fruitless expenditure can be avoided. The following symbols and colour codes have been used throughout the report to convey these different types of messages:

- Management recommendations (what can be done about a problem)
- Research requirements (what do we still need to learn)
- Green flags (positive outcomes where interventions have been helpful or progress has been made in combatting a problem)
- Red flags
- Red herrings
- Quick facts and research results
- Fun facts

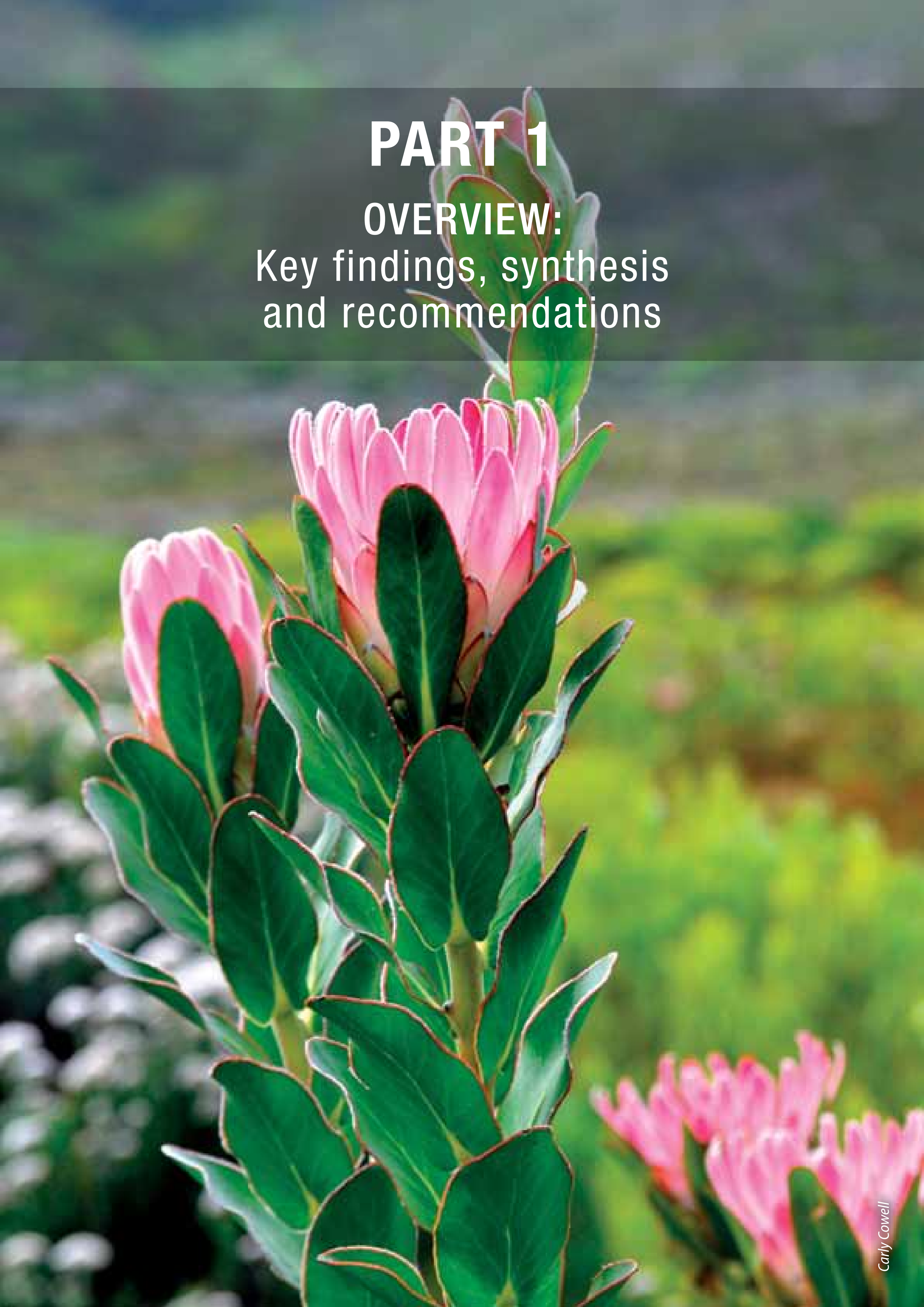
It is important to note that while we tried to collect similar information for all parks, there were certain parks (Table Mountain, Garden Route and Kruger in particular) where, because of historical levels of research or the age of the park, there is much more information than for others. As such, the management recommendations, key concerns and learnings were easier to derive for these parks. We have however tried to keep the recommendations generally relevant, so when you read this report it may be useful to refer to parks where more detailed information was available as there may be anecdotes or recommendations relevant to your park of interest.

We invite you to join us in a mind-shift that will be necessary to align our thinking and actions beyond what is required for today, towards what is required for a better tomorrow.

Let's fix the tap today so that there is water in the dam tomorrow.

PART 1

OVERVIEW:
Key findings, synthesis and recommendations



Carly Cowell

Summary assessment from all the parks

In general, there was more data available for older parks and parks with a long history of research such as Kruger, Table Mountain and Garden Route. One of the major concerns is that for many of the parks (including Augrabies Falls, Camdeboo, Golden Gate Highlands, Karoo and Marakele) there is insufficient information available to determine the status and impacts of change drivers. However increased awareness of issues relating to global change generated by this assessment has seen increasing awareness of data for these parks which bodes well for future assessments. Despite data challenges, global change in some form was found to be acting in all 19 national parks. Here are some of the key findings:

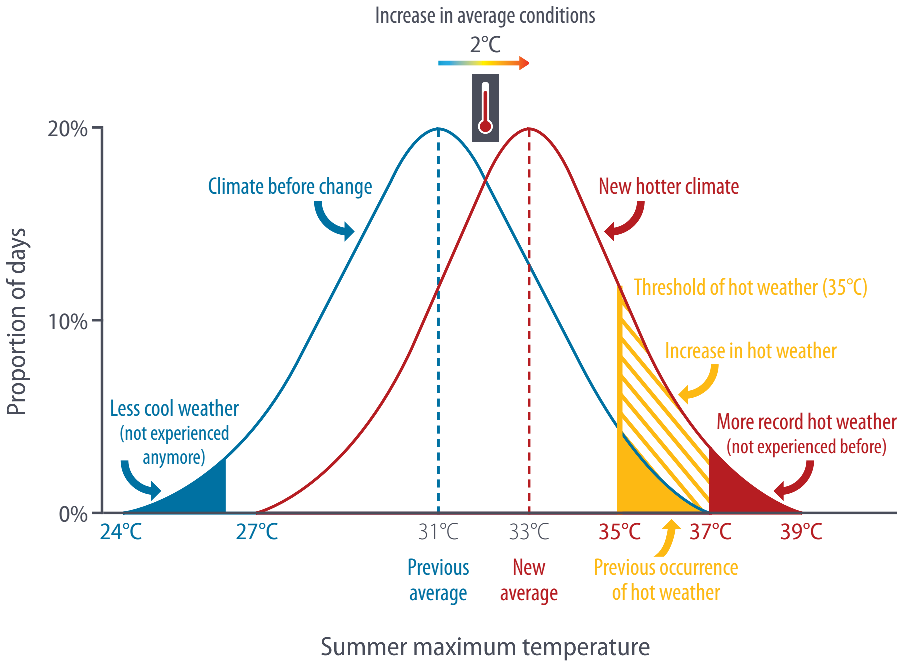
Climate Change

Significant temperature increases (on average 1.25°C over 50 years) have already been observed in several parks, and future climate scenarios predict ongoing temperature increases for all parks over the coming decades. Rates of temperature increase were highest in the north-western parks (Kalahari Gemsbok and Richtersveld). Of concern is that the changes that have already taken place approximate the changes predicted for the next decades, meaning that future predictions may be too conservative. While an average change of a degree or two might sound insignificant, it has profound implications for what temperatures will be like on a day to day and seasonal basis. For example, the average maximum temperature at Twee Rivieren increased by about 1.95°C between 1960 and 2009, with further increases detectable in more recent data. Under these hotter average conditions, nearly 90% of summer days in the last two years reached or exceeded 35°C, compared to about 64% of summer days in the 1960s. This will impact on plants and animals, but also tourist and staff comfort (see park write-up in Part 2 for details). At the same time, increasing minimum temperatures might mean that it no longer gets really cold in certain areas. For example, it drops below 0°C less frequently in Kalahari and Mokala than it used to. This might have implications for pest organisms and alien species that were previously kept from spreading by cold temperatures in the winter.

Additional, dedicated personnel to properly deal with climate-change-related adaptation work is urgently required. The focus of required work includes the development of robust park-scale climate change adaptation and mitigation options that can be incorporated into planning, management and park expansion guidelines. Particular recommendations are made at park level in the park summaries that follow the introduction.

Data is currently being archived from 76 weather stations across SANParks (some of these are not in the parks but adjacent to them). The majority of these stations were identified and added to the archives following renewed interest and awareness of the need to archive weather data stimulated by the Global Environmental Change project.

Parks should continue to collect and submit daily / hourly weather data for archiving as this is a valuable source of information for a wide variety of future research and management applications.



This figure shows the range of summer temperatures for a hypothetical situation where the historical average maximum summer temperature was 31°C, compared to what the range of summer temperatures might look like if average conditions increased by 2°C. Under the previous climate there would be an average of 4 days per summer that get to 35°C or hotter and it would never get hotter than 38°C, whereas there are about 17 days over 35°C under the new climate that has warmed by 2°C and 3 days reach 38°C or more – conditions not experienced under the previous climate.

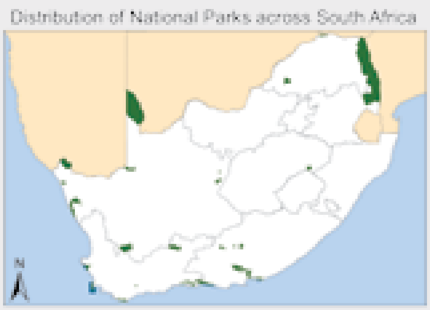
Rainfall patterns are far more variable and projected rainfall trends similarly uncertain, although under the intermediate scenario of future change by 2050, most parks are expected to experience a minor reduction in rainfall. Trends in several southern parks (Addo Elephant, Bontebok and Garden Route) indicate that this reduction is already taking place. Mokala and Karoo were the only parks where a rainfall increase was detected in the historical data, while the intermediate risk scenario of conditions by 2050, predicted no change or a very slight increase in rainfall for Mokala, Mountain Zebra and Camdeboo. Rainfall intensity, which can be linked to flood risk, has also increased in several parks and is generally predicted to increase across the country. In terms of biomes, parks in the Nama-Karoo biome (e.g. Augrabies Falls) are expected to change considerably. Short time series, poor quality or lack of data in some parks meant that patterns and trends remain unknown, which may lead to lack of awareness and readiness for the inevitable change. New approaches to monitoring and sufficient resources will be required to detect the impacts that the changing climate is having on biodiversity.

Research into the impact of the changing climate on tourism (which impacts on revenue available for management), including not only human response to increased extreme hot days, but also impacts on water availability and the sustainability of infrastructure is required. For example, more frequent flooding causes significant damage to tourist camps and alternate locations may need to be investigated. International adaptation funding may be available for this type of intervention.

Tankwa-Karoo and Table Mountain have already included climate change objectives in their park management plans and several other parks are following suite.

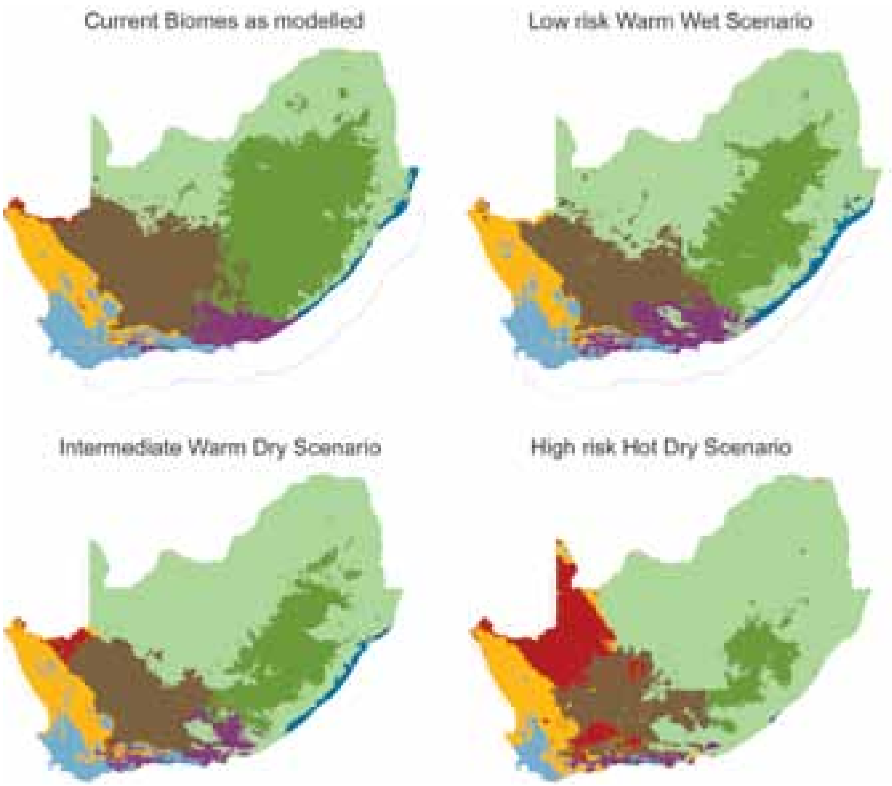
The climate within protected areas in the future may no longer be suitable for conserving the species or features that the protected area was designated to conserve. Strategies beyond protected areas and new ways of thinking about the role of the current parks will be required.

An impact of climate change that is seldom considered is the impact of increasing temperatures on people who work outdoors: Under hotter conditions, people's work rate will be reduced and in some instances people may not be able to do much outdoor work at all. This has dramatic implications for several of the northern parks where summer temperatures are predicted to become unbearably hot.



- SANParks: 19 Parks
- Marine Protected Area
- — Provinces of RSA

The distribution of the different SANParks across the country



- Coastal Belt
- Forest
- Fynbos
- Albany Thicket
- Grassland
- Savanna
- Desert
- Nama-Karoo
- Succulent Karoo

We do not yet know how biomes, and the ecosystems and species that make them up, are likely to respond to the new climatic conditions. The series of maps show where biomes are most at risk by 2050 from different degrees of climate change. Note that the grassland and northern parts of the Nama-Karoo are at risk under all scenarios of future conditions.

Alien species

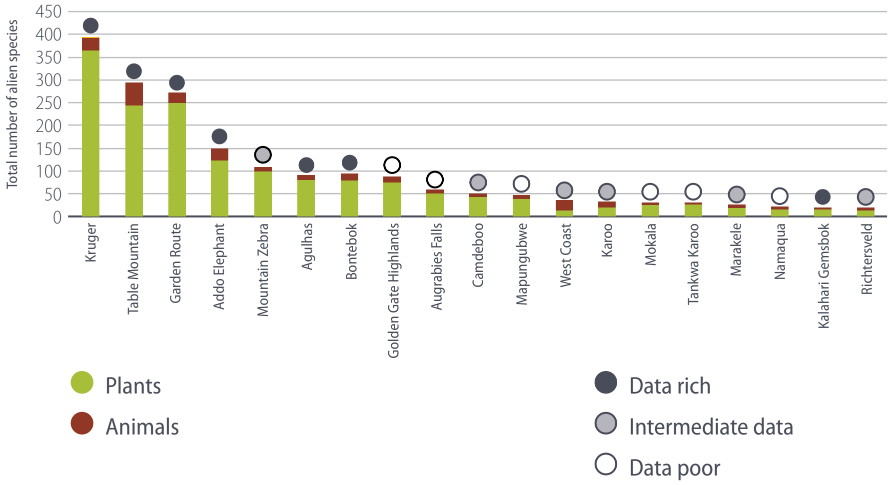
Alien species pose a major threat to indigenous species and water. A total of 869 alien and extralimital species were recorded across the 19 parks. Fynbos parks are likely to experience the highest impacts while parks in the drier parts of the country had the least invasive species. However, species such as *Prosopis*, which invades river beds, uses significant quantities of water and could worsen the climate-change-related impacts in these areas. Basic information on the presence or absence of alien species is still required for about one third of the national parks to make good management decisions.

The Working for Water (WfW) programme in the Biodiversity Social Projects (BSP) plays a critical role in managing alien plants. Recent cuts in the budget of the programme are of concern to maintaining gains made thus far. Although trend data were limited, it is likely that alien species introductions will increase in most parks in the future. Rivers, roads and the intentional introduction of ornamental species (either into the park or adjacent areas where parks are in close proximity to urban gardens or wildlife farms) have been identified as prominent pathways of entry for aliens into parks. The importance of roads and rivers in introducing alien plants has significant implications for the planning and opening of new tourism and management routes, which should carefully consider unintended impacts on the movement of alien species. Two key processes that require greater attention are outcomes- or ecologically-based monitoring and standardised operating procedures or guiding frameworks to assist in assessing and managing aliens. Despite numerous

Increases in the number of alien species that are mandated to receive attention under NEM: BA mean that difficult decisions are required to determine optimal allocation of available funds. Additional funding streams are needed to maintain the status of areas currently being managed, and to provide sufficient resources for the new species and areas that are prioritised.

Accurate identificton of species is essential and can be challenging. Sufficient expertise and strict control of data will ensure rapid and accurate identification of new emerging species, enabling management to act faster.

challenges, the need to revise and align management plans with the National Environmental Management: Biodiversity Act (NEM: BA) regulations of 2014 and 2016, along with improved species lists, increasing distribution data on key species and assessments of past programmes, provide the opportunity for the much-needed prioritization of targets and strategic planning for future directions.



The total number of alien species present in each of the parks. Data availability in each of the parks is indicated by a shaded circle above the bars.

Resource Use

Promoting resource use and the equitable sharing of benefits from parks are growing priorities for the future sustainability of conservation. However these processes, including distinguishing between subsistence and commercial use, present considerable challenges. The assessment reported here did not address social aspects of harvesting but rather attempted to quantify all forms of resource use in parks. Responses were not uniform across parks. Although 381 unique resources were identified as harvested from national parks, many harvested resources were deemed to have been overlooked and very little information was available on the quantities of harvested resources. Concerns include the challenge of unauthorized, illegal and uncontrolled harvesting: 42% of all harvested resources were harvested without permission, while the conservation status (e.g. IUCN Red List) has not been determined for a large proportion of harvested resources (81% in the case of marine resources). Knowing the full extent of resource harvesting enables informed management decisions. Incorporating a resource use biodiversity objective into park management plans (as was done in the 2015 revision of the Table Mountain plan) could assist in informed decision making.

It is apparent that there is significant demand for access to natural resources: 36% of resources were harvested for food and a further 34% for medicines. This report has not considered the many other ways in which benefits are and may be shared from national parks. It is however apparent that resource use requires context-specific planning and implementation.

Implementing ground-level monitoring strategies is of primary importance to ground-truth and add to the data collected to date on resource use. Sufficient resources (skilled personnel and funds) will be required to do this. It is recommended that parks continue to annually submit up to date information on resources harvested in each park both legally and illegally. While monitoring is essential, management strategies to stop unsustainable harvesting are equally necessary and should be captured in park management plans.

NEM: BA regulations, in conjunction with improved species lists and increasing distribution data provide the opportunity for strategic planning and prioritization. In response, SANParks is developing an Alien Plant Management Strategy and is revising clearing priorities and requirements within each park. These interventions will, in turn, increase the impact of money being spent.

The collection of baseline data on species distribution and abundance at a fine scale has been initiated in some parks, providing valuable data for planning and use in monitoring the impact of management interventions. Baseline data collection in additional parks and ongoing monitoring will require sustainable funding and dedicated personnel, which should be accounted for in future budgeting and funding applications.

The threat posed by ornamental species in Kruger has previously been recognised and a policy on the planting of species in Kruger camps and gardens was published in 2015. It is already having a significant positive impact on the management of plants used in camps and staff gardens. Similar policies should be implemented in all parks.

All protected area agencies are required to report annually to the minister of Environmental Affairs on all authorized cases of resource use within the protected area. SANParks submits this report annually in June.

Social and political drivers were not considered in the current assessment, but could form the basis of very important future assessments of the impact and response possibilities for dealing with the drivers of global change.

Rangers should be involved in field assessments to improve overall water awareness, especially related to wetlands. Freshwater ecosystems are often appreciated only for their functional utility such as providing water for game watering or acting as attractive locations for tourist lodges. This needs to change to acknowledge freshwater ecosystems as biodiversity features in their own right and a central part of the park's conservation mandate.

To ensure that rivers are well managed within protected areas, quality objectives and monitoring requirements should be incorporated into management plans, and actions taken to enable them to recover from the impact of activities upstream. In addition, use of rivers as a park boundary during park expansion, and the development of visitor infrastructure on priority freshwater ecosystems in protected areas should be avoided.

SANParks must actively engage with upstream users, Catchment Management Agencies and Water User Associations, since most catchment protection needs to take place upstream or downstream to protect rivers within parks. Scientists and managers should continue to build multi-stakeholder relationships and contribute to the development of and engagement with Catchment Management Strategies.

The conservation estate is increasingly under pressure from land-uses perceived to better promote job creation and contribute to the country's GDP. Some of these adjacent or competing land-uses are more significant in terms of impacts on biodiversity and sense of place than others. Mining in particular will require holistic and sensitive trade-off decisions.

Disease, freshwater and habitat change

Disease, freshwater change and land-use and habitat change proved more difficult to evaluate as drivers, as these aspects of global change are very often a response to other drivers and one another. However, understanding their status and related threats is critically important and requires that we look beyond the boundaries of protected areas. This underlines the importance of SANParks being involved in forums and initiatives outside of the parks, as many of these proceses act out at regional scales.

Freshwater change

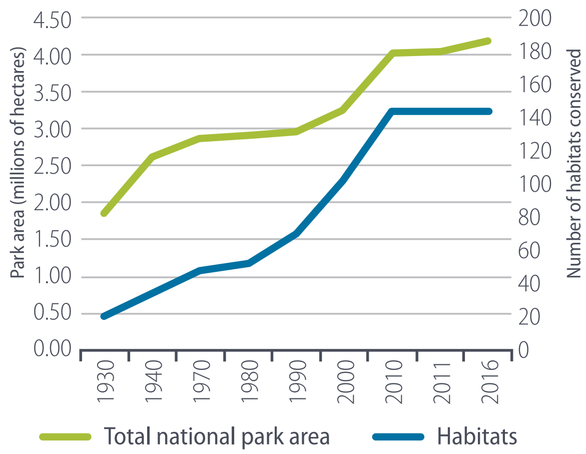
Despite freshwater being paramount to our well-being, approximately half of South Africa's rivers, wetlands and lakes are ecologically modified and degraded and half of the river ecosystem types in South Africa have no protection in formal protected areas at all. Of South Africa's 177,276 km of rivers, 2.9% run within national parks and 8.2% in all forms of formally protected areas. Within protected areas 64% of rivers are in good condition. This percentage of rivers in good condition rises to 76% in national parks, which is significantly better than rivers outside of protected areas where less than half of river lengths are in good condition. There are 223 river ecosystem types in South Africa of which 84 occur within national parks. Only six of these have the majority of their length (> 50%) in the national parks. National scale wetland data were deemed inappropriate to interpret and use at park level. Work (including ground-truthing and wetland mapping) to improve this situation is underway in several parks, but needs to be expanded.

Tourism and infrastructure along rivers as well as impacts upstream and adjacent to protected areas result in degradation of freshwater systems in protected areas. An example of this is where rivers are used as park boundaries and where only one side is protected. This practice should be avoided. Going forward, it will be essential for SANParks to nurture strategic relationships beyond its boundaries and to continue with identified research priorities to provide adequate information for decision making.

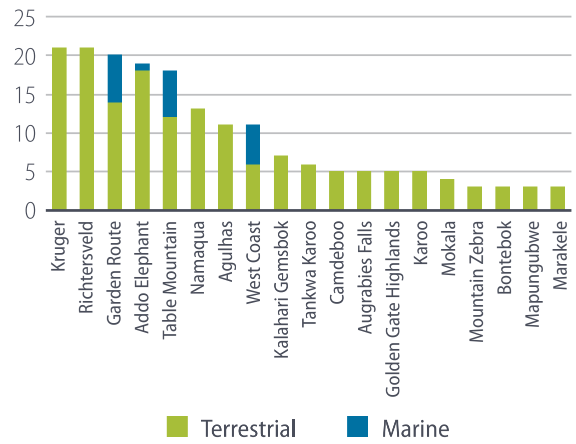
Land-use and habitat change

Habitat change was assessed both in terms of habitat quality as well as land-use change in areas surrounding parks. The habitat quality assessment revealed limited opportunities for assessing change in vegetation indices due to scarcity of adequate data. However, recent innovations with satellite and aerial imagery provide opportunities for tracking habitat quality and condition in the future. Protected areas are embedded in matrices of different land-uses, all of which may have different consequences for the environment. While for many of the more isolated parks, little change has taken place in the broader landscape since 1990, urban expansion is seen in most areas, which will place additional pressures on all parks. In addition the number of applications for mining and prospecting within and adjacent to national parks continues to increase. Mining, both off-shore and terrestrial, can potentially have consequences for soil and water quality, biodiversity, and human health. Thorough and objective assessments of the short and long-term costs and benefits of initiating new mining operations and rehabilitating old ones are important.

On the positive side, most parks have increased in size since proclamation and the number of habitats currently being conserved has increased from 69 in 1990 to more than 145. Further work is required to assess landscape level linkages and corridors for plant and animal species movement beyond and between protected areas. This will require collaboration with external agencies and private land-owners.



The total area covered by national parks has increased dramatically since the first national park, Kruger, was declared in 1926. Along with the expansion of park area, the number of habitat types conserved within national parks has also increased to nearly 150.



The number of unique habitat types within each park. Most of these habitats only occur in one or two parks.

Disease

Diseases have natural regulatory functions and can be positive for wildlife populations as well as posing threats. The health of wild animals is closely linked to the ecosystems in which they live and influenced by the environment surrounding them, and even minor disturbances can have far reaching consequences on what diseases wildlife might encounter and transmit as climate changes. For example, increasing urbanisation and urban waste generation has been linked to outbreaks of leptospirosis and plague, both due to increases in rodent populations, which can have major impacts on the public health system. The pathogens that originate from or move through wildlife populations can destabilize international trade and cause significant economic damage. Monitoring wildlife health will help predict where trouble spots will occur and enable better preparation.

Reliable data on wildlife disease distribution, presence and impacts are scarce, making trend determination difficult. However, we know that increasing temperatures and fluctuating rainfall will change the distribution of pathogens and their associated vectors, which can have cascading effects on surrounding human populations. The reason for this is that most of the endemic vector-borne diseases are tropical so global warming and intensification of water storage and irrigation will tend to expand their range into temperate zones as well as increase the rate of reproduction of vectors in cooler parts of the range. These tendencies will be exacerbated in some cases by increased rates of dispersal of the pathogens and vectors with human-mediated global transport. Intensification of transmission is also expected to increase as human population densities increase.

As development increases globally, new ideas will be necessary to reconcile conservation ideals and development needs. International experience has suggested one useful model whereby tourism and related developments are initiated predominantly outside of national parks and run by local residents and communities, while accommodation and development of facilities within parks are kept to a minimum. This model allows for conservation oriented development in park buffer areas, while also increasing the distribution of benefits beyond park boundaries.

Within parks there is also a measure of habitat alteration through development and management actions. It would be useful for parks to more explicitly consider and evaluate their impacts.

Total park area has increased by over a million hectares since 1990, resulting in at least 76 additional habitat types being conserved.

SANParks needs to implement buffer strategies and be part of integrated land-use planning outside of the parks.

If SANParks is part of integrated land-use planning there may be ways of promoting alternative methods to expand the conservation estate and conservation friendly developments beyond the acquisition of new land. SANParks can play a role in ensuring that fragmentation is limited and that the broader bioregional socio-ecological survival of our parks is enhanced by aligning bioregional management and zoning.

Assessing links for the movement of plants and animals between parcels of conserved land will be increasingly important as land-uses change and habitats are fragmented outside of parks.

A broad surveillance network for detecting wildlife disease within SANParks, accompanied by a depository for disease data and mortality reports where incidents can be assimilated centrally should be developed. Close collaboration and data sharing between SANParks and the State Veterinary Services of the Department of Agriculture is required.

A biobank has already been started, where veterinary samples can be stored. This provides a great resource for future studies. Due to costs associated with prospective disease studies, all opportunities should be taken to collect and store appropriate tissues, blood samples and ectoparasites from any animal that is immobilized or handled for veterinary or research purposes. Training of park staff to identify disease syndromes and equipping them with sampling kits has started in some parks and should be rolled out across parks.

Long term disease data remain difficult to collect for various reasons including costs, diagnostic test validation and interpretation, the stoic nature of wildlife and difficulty in obtaining fresh diagnostic material. Diseases that are transferable between domestic animals, livestock and wildlife as well as people are particularly important. This type of disease is usually controlled by the state with implications for wildlife translocation and management. For instance South Africa does have a number of controlled and notifiable animal diseases linked to the livestock industry and trade that are monitored nationally. Intensifying surveillance of diseases in wildlife could serve various functions including that wildlife disease may be a sensitive indicator of underlying environmental pollution (especially the case in marine environments) and diseases that could be a threat to wild species population persistence could be detected. Regular scenario planning has been suggested as a tool to predict the possible impacts of disease on people, plants and animals as the distribution of various diseases change and new pathogens emerge.

Priorities

The parks for which the highest global change impacts have been identified include Garden Route, Kruger, Addo Elephant, West Coast and Table Mountain. The threats in each of these parks differ, but centre around increasing urban populations and land-use change in park surroundings, which exacerbate problems associated with alien species, unauthorised resource use and degradation of freshwater quality. The priority parks for action under each driver are detailed in the Table p. 13.

In general the more isolated parks experience lower threats from land-use change, alien species and resource harvesting, while the parks closer to urban centres experience greater threats. The increase in mining and prospecting applications across the country may however change this. Freshwater systems are impacted in most parks and aside from the few parks that protect mountain catchments like Golden Gate, Marakele and Tankwa-Karoo, all suffer from various levels of outside influence. Climate change will have impacts regardless of a parks' position in the landscape, although parks in more rural settings have the advantage of having greater opportunities for expansion, preferably across gradients, and adaptation. Disease and resource use are two areas where additional research and creation of awareness is required to improve our understanding of the threats and opportunities posed, while alien species are a key priority where improved management and planning in the short to medium term can have a positive impact. The impacts of each of the drivers in each of the parks are detailed on page 14.

Looking at the key priorities across parks, it is clear that tackling global change issues will require that we think outside of the parks and consider each park's position within its landscape and local context

The priority parks requiring action or monitoring for risks relating to each of the six drivers. Parks are listed in loose order of priority

Driver	Priority parks	Comments
Climate change	Terrestrial: Kalahari Gemsbok, Richtersveld, Garden Route, Addo Elephant, Bontebok, Augrabies Falls Marine: West Coast	Observed and predicted temperature increases are particularly dramatic for the parks in the north-west of the country, while rainfall declines and potential biome shifts could be a reality in the southern coastal parks. Marine climate change is predicted to be particularly problematic for West Coast fish and shellfish.
Habitat and land-use change	West Coast, Karoo parks (fracking), Mapungubwe, Bontebok, Garden Route, Namaqua, Table Mountain, Kruger	Mining prospecting and fracking are potential concerns for the Karoo parks, Kalahari, Kruger, Mapungubwe, Namaqua and West Coast. Garden Route, Table Mountain and Bontebok are constrained by the hard boundaries of urban expansion.
Disease	Kruger is a priority, although there is too little information to properly prioritize other parks Bontebok, Garden Route, Agulhas and Table Mountain could be at risk from plant and bird diseases, although research is required	The threat is thought to be increasing in several parks, but information is limited. Plant diseases were not evaluated per se, but anecdotes suggest that the Cape parks (including Garden Route) might be particularly vulnerable. Marine and bird diseases were not evaluated but are thought to be a concern and necessary to monitor.
Alien species	Terrestrial: Table Mountain, Garden Route, Agulhas, Addo Elephant, Kruger, Marakele, Camdeboo Mountain Zebra requires information review Marine: West Coast, Table Mountain	The Fynbos and forest parks experience the highest diversity and impact from alien species. Several parks also experience problems with domestic and extralimital animals as well as alien fish and marine invaders.
Freshwater change (including groundwater, wetlands, lakes and rivers, estuaries)	Augrabies Falls, Camdeboo, Mapungubwe, Kalahari Gemsbok, Garden Route, West Coast, Mokala	Impact classes have been assigned based on information on water quality and flow regimes, the use of rivers as a park boundary, the impact of upstream/nearby land-use as well as the results of the National Freshwater Ecosystems Priority Assessment of river health. Freshwater conservation should be a priority for all parks. The current priorities need further interrogation as for some parks only information from the national freshwater assessments were available, but there may be additional concerns at park level. Where only small portions of a river are contained in a park or where the river forms part of the park boundary, SANParks may have limited say in their management and the implementation of ecological reserves. In some instances however, successful relationships have been built. For example, lessons learned from multi-stakeholder and catchment-wide engagement in Kruger can be applied elsewhere.
Resource use	Table Mountain, Garden Route, Kruger, Camdeboo The impact of livestock grazing and adherence to herd size in Richtersveld requires further investigation Marine: Addo Elephant	Better data required for all parks, but generally parks in closer proximity to large human settlements experience greater threats from illegal resource use. A possible exception is Richtersveld, where although the community is not that large, large numbers of livestock may still have significant impacts.

The estimated impact of each driver within each park and the degree of confidence in the assessment.*

Park	Climate change	Habitat and land-use change	Disease and factors that impact animal/plant health	Alien species	Freshwater Change (groundwater, wetlands, rivers, lakes, estuaries)	Resource use
Addo Elephant	L (orange)	Terrestrial L (yellow) Marine H (red)	M (orange)	H (red)	L (orange)	Terrestrial L (yellow) Marine M (red)
Agulhas	M (orange)	M (yellow)	L (orange)	H (red)	H (orange)	H (yellow)
Augrabies Falls	L (red)	L (orange)	M (yellow)	L (yellow)	H (red)	L (yellow)
Bontebok	M (red)	H (red)	M (orange)	H (orange)	H (orange)	H (yellow)
Camdeboo	L (orange)	L (orange)	L (yellow)	H (red)	M (red)	H (red)
Garden Route	M (red)	H (red)	L (orange)	H (red)	H (red)	H (red)
Golden Gate Highlands	L (orange)	H (orange)	L (yellow)	L (yellow)	H (yellow)	H (orange)
Kalahari Gemsbok	H (red)	M (orange)	L (orange)	H (yellow)	H (red)	M (yellow)
Karoo	L (orange)	L (orange)	L (yellow)	M (yellow)	L (orange)	L (yellow)
Kruger	M (orange)	H (red)	M (red)	H (red)	H (red)	H (red)
Mapungubwe	H (red)	H (red)	M (yellow)	L (orange)	H (red)	M (orange)
Marakele	M (orange)	L (yellow)	M (orange)	H (red)	H (yellow)	L (dark grey)
Mokala	L (orange)	M (yellow)	M (orange)	H (orange)	H (red)	L (yellow)
Mountain Zebra	M (orange)	L (orange)	L (yellow)	L (orange)	M (orange)	L (yellow)
Namaqua	L (orange)	H (orange)	M (yellow)	H (yellow)	L (orange)	M (orange)
Richtersveld	H (red)	L (yellow)	M (yellow)	M (orange)	L (orange)	L (orange)
Table Mountain	M (orange)	H (red)	M (orange)	H (red)	M (orange)	H (red)
Tankwa-Karoo	M (orange)	H (yellow)	H (yellow)	M (yellow)	M (yellow)	M (yellow)
West Coast	Terrestrial H (orange) Marine H (red)	H (red)	L (orange)	Terrestrial H (orange) Marine H (red)	M (red)	Terrestrial L (yellow) Marine M (orange)

- (dark grey) Not enough information available to make an accurate assessment
- (red) High degree of impact
- (orange) Moderate impact
- (yellow) The driver is of less concern than others but may still have an impact
  Note that this does not mean that the driver is having no impact in that park, the driver is merely of less concern than others.

In addition, we have provided an estimate of our confidence in the assessment using one of the following symbols:

- H High confidence
- M Medium confidence
- L Low confidence

*** Notes on scoring:**

- The impacts indicated in this table ARE NOT an indication of how well management are doing, but rather a summary of the largely external threats to a park
- This table provides an estimate of the degree and number of impacts on the state of biodiversity, rather than the state of biodiversity itself
- This table is not intended as a monitoring tool, but rather for prioritization of the parks and aspects of global change which need the most immediate action.
- For climate change, the possibility of adaptation within parks has been rated under climate change, while the requirement for external corridors is rated under land-use (e.g. where hard boundaries will prevent species from moving beyond the park)
- For parks that have both terrestrial and marine components, the threat posed by each driver has been scored separately (split cells) in instances where the threat or levels of certainty differ between these environments
- The impact ratings for disease include known diseases as well as any factors that could potentially impact on plant and animal health (e.g. environmental pollutants)
- For freshwater (which includes groundwater, wetlands, lakes and rivers, estuaries), the impact classes have been assigned based on information on water quality and flow regimes, the use of rivers as a park boundary, the impact of upstream/nearby land-use as well as the results of the National Freshwater Ecosystems Priority Assessment of river health.

Also see: Improving Parks Viability – Outcome of a work session (August 2013) SANParks internal report. By: Nomvuselelo Songelwa, Harry Biggs, Antionet van Wyk, Jill Bunding-Venter, Marna Herbst, Stefanie Freitag-Ronaldson

Conclusions and recommendations

Global change is upon us and new approaches to management are and will become increasingly necessary. A SANParks-wide response to the assessment is essential to ensure resilience to drivers of change. It will be important for SANParks to carefully consider how the identified research and communication gaps are incorporated into annual plans of operation and revision of park management plans. Departments and divisions will need to work together to better understand and increase overarching awareness of how the change drivers act and interact to impact on SANParks' multiple objectives.

Combating global change is not something that can be done on an individual basis or by an individual park or division. Finding solutions will require that everyone begins to think further than the tasks that require urgent action today, and to prioritize research, management and actions that influence processes over a longer term. Adaptations to cope with a changing world will require team-work and changes at an organizational level. One of the key challenges to address is to standardize the collection and storage of data so that information is readily available across the organization. Holistic planning can save money, resources and increase the impacts of management interventions, but will require consistent application of protocols and strategies and access to standard up-to-date datasets as source information for transparent, comparable and well-prioritized park planning. This will become increasingly important as parks face similar and linked challenges relating to land-use, mining and climate change.

While many of the anecdotes and situations may appear negative or dire, there are significant funding and collaborative opportunities available if we endeavour to be transparent and proactive about the issues that we face. Better communication and engagement internally, with funders, other government departments and broader society could garner significant public support and opportunities for funding and will lead to positive outcomes. Flexibility in the allocation and use of funding would be prudent, for example allowing for special projects with ring-fenced funding. The links between objectives in park plans and KPAs as well as dedicated budgets to carry these out need to be developed.

Nicola van Wilgen

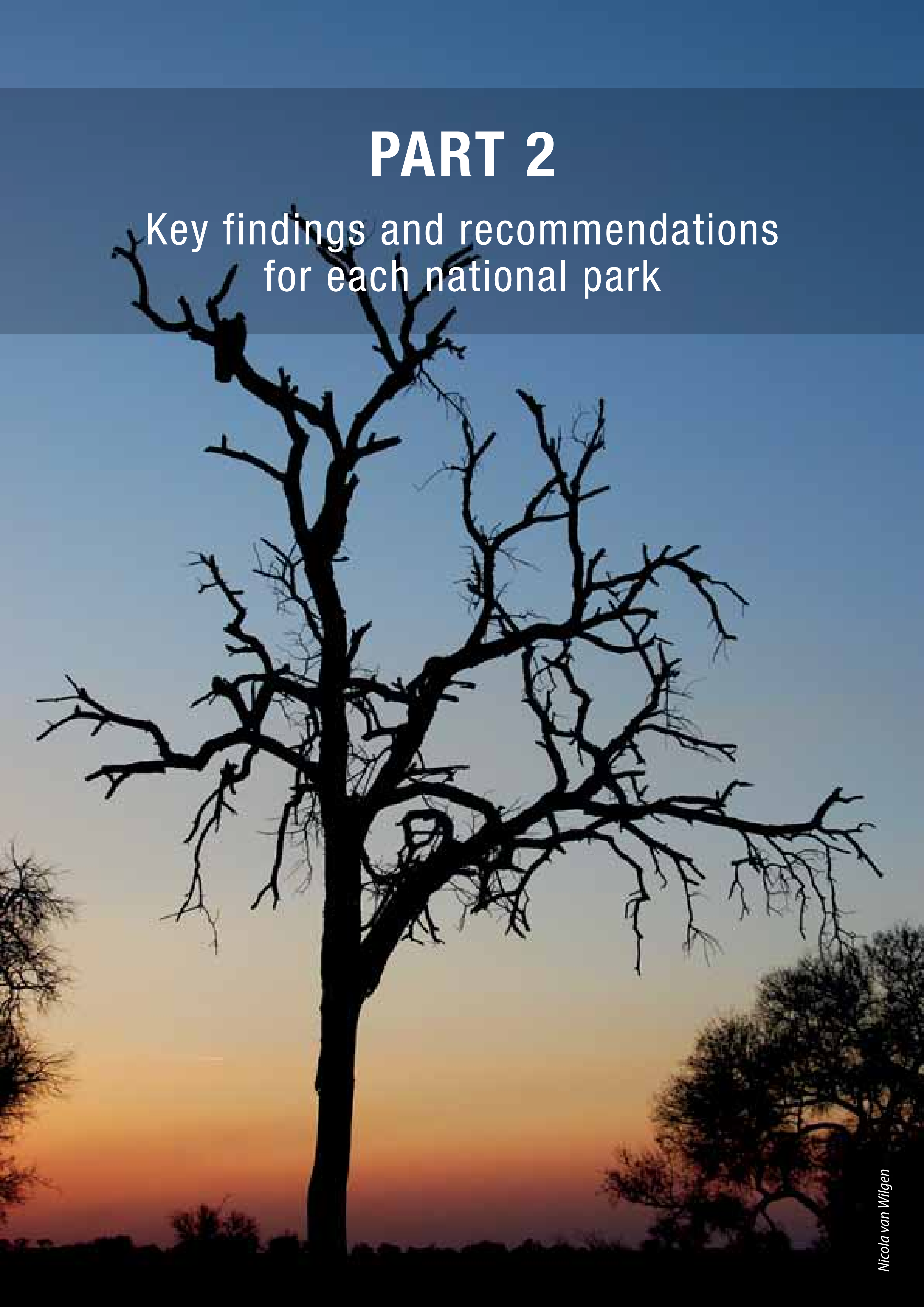
Raw data generated through daily research and technical activity is now being captured and stored electronically on the SANParks Data Repository System. A database of monitoring that is currently ongoing across parks is available and could be used to identify gaps between priorities and current activities as well as funding and capacity shortfalls. Benchmarks for how frequently the analysis of particular data is required to detect trends should be set and incorporated into planning and science management feedback.

- Many aspects of global change and the findings in this report have implications for policy development or changes, park management action or the potential for tourism and/or future income generation. Considering global environmental change in a risk audit framework could be a useful exercise to identify the ecological and financial risks and costs of changes and possible actions that can be taken to mitigate these.
- Strengthening capacity and improved communication between divisions in SANParks would allow for improved interpretation of the implications of global change for SANParks' mandates. Work has begun in the following areas: data management, geohydrology, land-use planning, marine climate change, resource harvest dynamics, social research, tourism research, tourism trade-offs (and cost: benefit / risk analysis) research, disease ecology, plant disease, environmental pollution and waste management. We anticipate that this will need to continue and expand.
- Research requirements identified through this assessment should be prioritized and could be advertised at local and international research institutions to strengthen the prevalence of proactive rather than reactive research project management and supplement the expertise of our current teams. There are already some examples where co-supervision of students by SANParks staff, or the inclusion of field rangers in data collection has been successful in ensuring that data generated through such projects would remain with SANParks, while at the same time the capacity and knowledge of SANParks staff is grown.
- Continued data collection and archiving are critical, but need to be accompanied by a readily accessible platform where relevant and up-to-date information can be shared across the organization.
- The baseline data generated by this assessment should be incorporated into the Biodiversity Monitoring System and used to update priorities at a park level. Going forward it will be important to ensure that monitoring is set up in such a way that interactions between particular drivers can be detected.
- Policies need to be reviewed to ensure that waste is reduced. All aspects of SANParks' operations from a reduction in printed documents to the recycling of grey water need to be exemplary.
- Some regions and divisions experience high staff turn-over, whereas adapting to and living with global change requires sound understanding of local contexts. A method to capture information, data and institutional memory of individuals leaving or moving within the organization should be investigated. Proactive succession planning may also assist in transferring of knowledge between employees.
- SANParks is in an excellent position to advocate for greener and healthier living and lifestyles. Global environmental change is a global phenomenon and will have an influence on all species on earth, including people. Drastic change is necessary to conserve our environment and SANParks should take the lead and set an example.

Scientists and managers

PART 2

Key findings and recommendations for each national park



Nicola van Wilgen

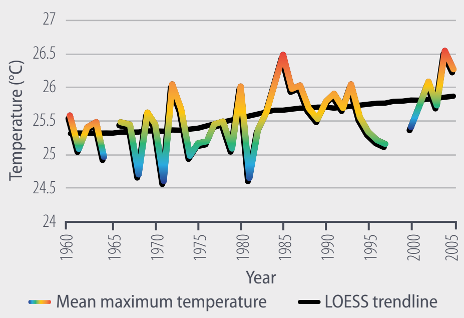
Dries de Wet

ADDO ELEPHANT
NATIONAL PARK


Dries de Wet


Dries de Wet


Dries de Wet



Annual average increase in maximum temperature at Addo between 1960 and 2006 (when this station was closed), showing a significant increase.

The Addo Elephant National Park (~172 000 ha, plus 7000 ha MPA) is situated in the Eastern Cape Province. It was initially declared in 1931 to protect eleven elephants and is still known for its elephant population although it has expanded to conserve a wide range of biodiversity, landscapes, fauna and flora. Its protection extends from the semi-arid plains around Darlington Dam, south and east over the Zuurberg Mountain range and into the Sundays River Valley down to the Sundays River mouth and then east along the coast to the Bushman's River mouth encompassing Bird and St Croix Islands in Algoa Bay.

The park faces several challenges: a decline in rainfall has been observed in coastal forested section of the park, there are alien species particularly in newer sections of the park, as well as prickly pear (*Opuntia* sp.) and Tamarisks (*Tamarix ramosissima*) in other parts. Warthogs (*Phacochoerus africanus*) and alien fish pose a continual threat and management challenge. Disease vectors are moving into the park in response to warming temperatures, while birds, particularly marine species are at risk from various diseases. The substantial expansion of the terrestrial portion and extending to the sea, has been labelled a success story for conservation. However illegal resource use in the marine environment poses a significant challenge and the new harbour at Coega poses serious threats to marine species. The park will need to engage with the development zone outside its boundaries to mitigate the impacts.

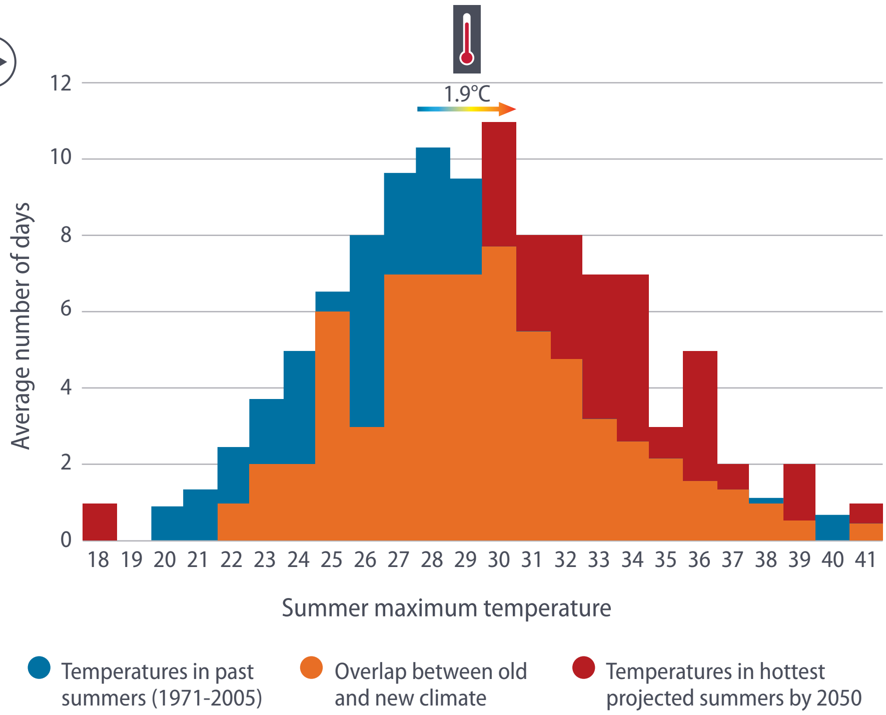
Climate change

L

Temperature

Over the last ~50 years (1960–2006), the absolute minimum temperature, average minimum and average maximum temperature have increased significantly at Addo by 0.8°C, 1.15°C and 1.35°C respectively. These increases also resulted in an average increase of 7 more days per year where the temperature exceeds 35°C, in the mid-2000s, compared to 1960. These increases also resulted in an average increase of 7 more days per year where the temperature exceeds 35°C, in the mid-2000s, compared to 1960. Further temperature increases of between 1.1°C (best case), 1.4°C and 1.9°C (worst case) are predicted by 2050. While the predicted changes seem small, we have demonstrated the effect that a 1.9°C increase in average summer temperatures would have on the relative proportion of summer days above 35 degrees in the figure on p. 20. Days above 35 degrees could double by 2050 under this worst case scenario (see figure).

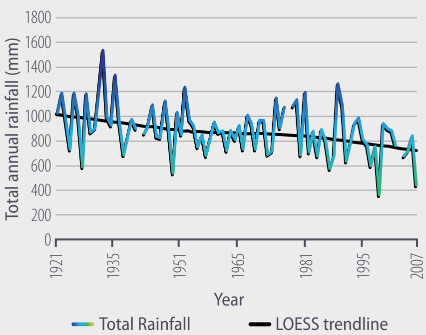
Increases in mean annual temperature of between 1.1°C (best case), 1.4°C and 1.9°C (worst case) are predicted by 2050.



The average number of summer days reaching between 18°C and 41°C at Addo in the past (1971-2005) compared to a hypothetical summer where temperatures have increased on average by 1.9°C, showing how this seemingly small shift impacts on warm extremes. In the past, an average of only seven summer days would have been 35°C or hotter, but if summer temperatures increase by 1.9°C, about 13 days in summer will be this hot (that is almost double). There will also be many more days hotter than 30 degrees (60% of summertime compared to 35% in the past), while temperatures below 25 degrees will occur less frequently than in the past.

Climate change adaptation (changing the way we do things in response to new conditions) and mitigation (trying to prevent further climate change) are very important for SANParks.	Addo can save water and electricity in a number of ways including low flow toilets, low pressure shower heads, solar geysers and geyser timers, rainwater harvest and tourist and staff awareness programmes.
Reducing waste and increasing opportunities for recycling are also critical.	Appropriate signage for tourists can increase awareness and support for water and energy management changes.

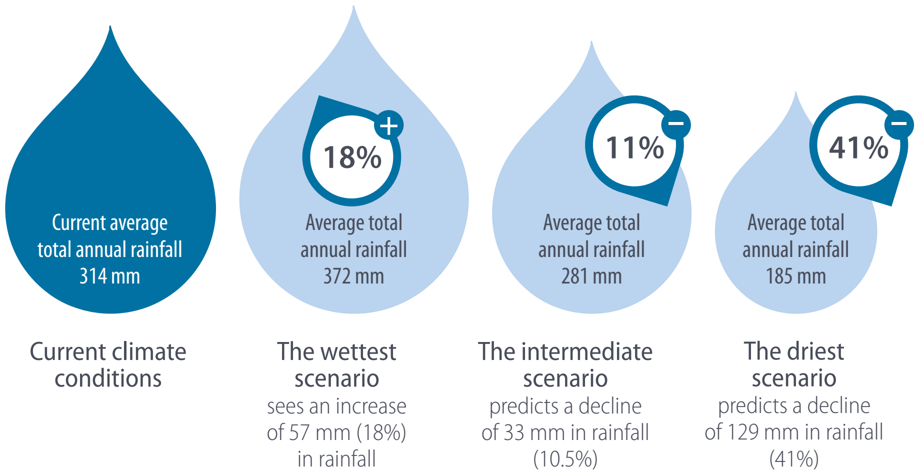
Actions to make a difference



Total annual rainfall at Alexanderbos since 1921, showing a significant decrease. Although further investigation is required to determine the accuracy of the data in the early part of the century, similar decreases were also seen at Bloukrans in Garden Route as well as Swellendam, near Bontebok and the park should begin investigating the possible impacts of a drier future.

Rainfall

A substantial decrease in rainfall was observed at the Alexanderbos station in the forested section of the park over the last 91 years. This decrease was associated with an increase in the longest span of consecutive dry days, as well as an increase rainfall variation. Rainfall decreases were not detected at the other drier stations in the park, although time series were shorter and missing data may have played a role.

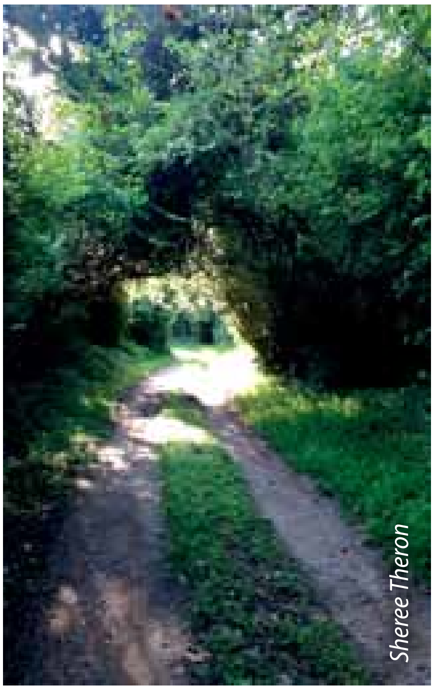


This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8 × 1.8 km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely for the southern part of South Africa, observed trends in the forested Alexanderbos region indicate that the wetter scenario is less likely. Also note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of smaller steadier rain events).

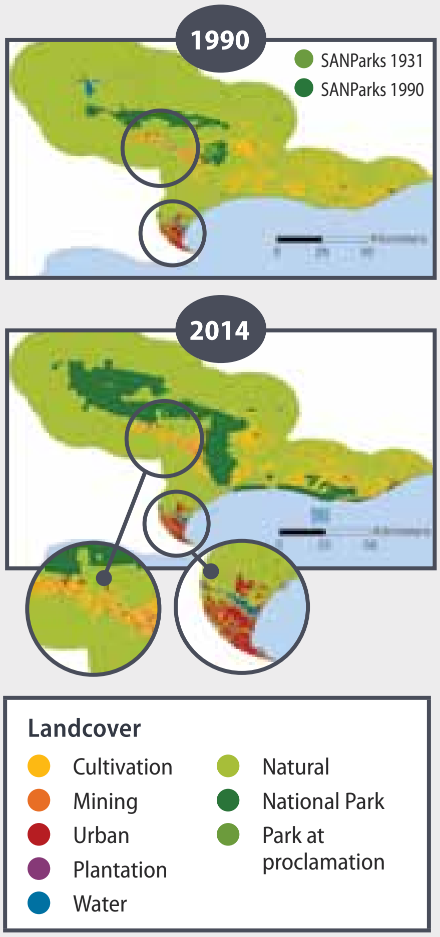
- The large decrease in rainfall along the coastal forested areas and the increase in temperatures throughout the park, mean that the park should urgently consider scenario planning for a variety of futures which are very different to current conditions. These likely futures have implications for disease, game management and tourism: The park's ability to maintain conservation targets for Sundays Spekboom Thicket, an important component of the Albany-Pondoland biodiversity hotspot may be reduced
- Addo is a water-poor area with very little natural water available for game and boreholes that produce less groundwater over time. A drier scenario would make it increasingly difficult to provide enough water for all the game in the park
- On the islands, bird mortalities increase with rising temperatures

Biome changes and impacts on vegetation types

Future conditions are closer to those currently associated with savanna, and under the hot/dry scenario the park is expected to be entirely dominated by conditions associated with savanna or Succulent Karoo, with small patches of Nama-Karoo-like climate.



Alexanderbos region



Expansion of the Addo Elephant National Park since 1990 and changes in land-use in the 20 km area surrounding the current park boundary. Inserts show the expansion of citrus farming to the west of the park and the expansion of the urban area around the Coega harbour development.

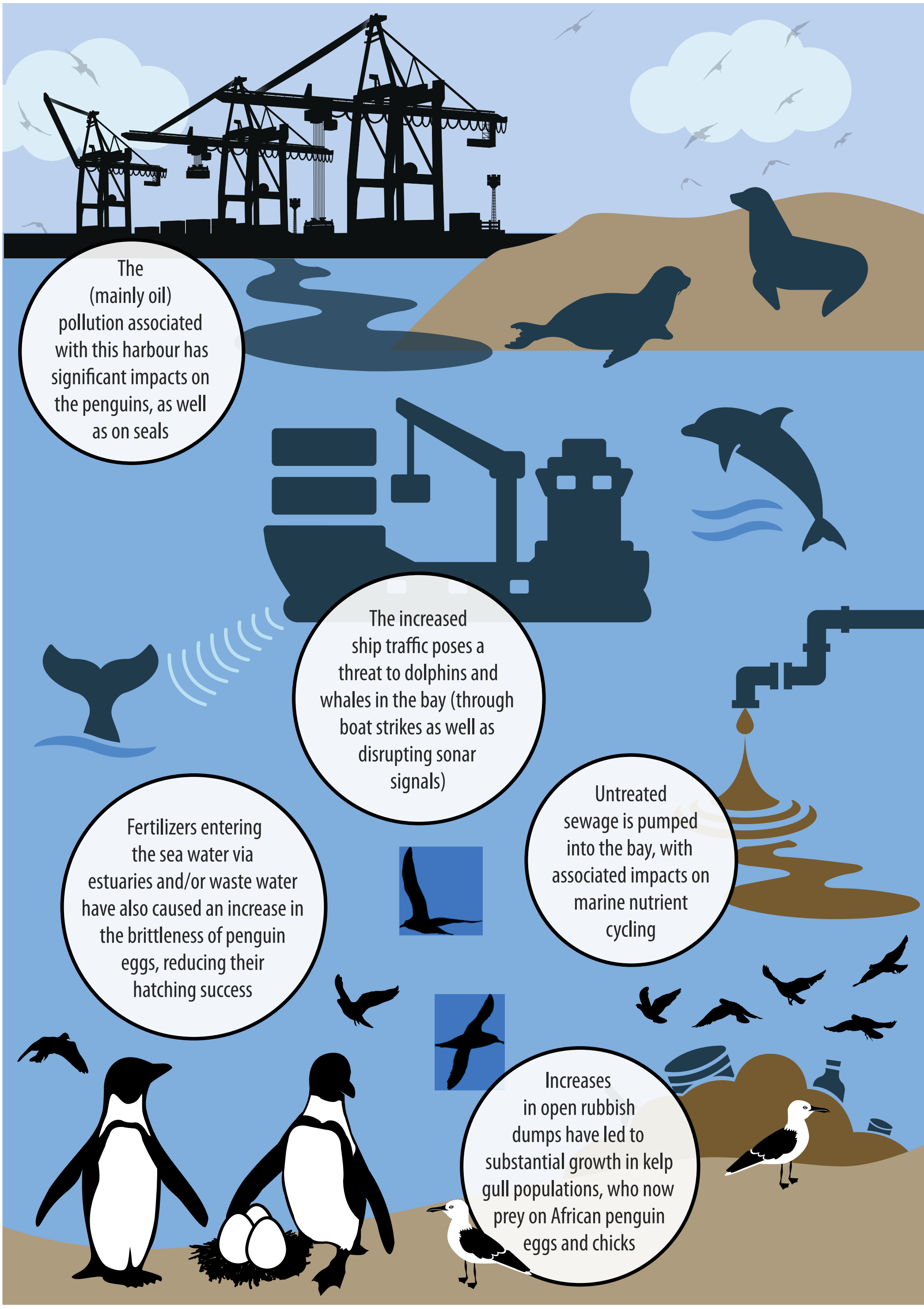
This infographic illustrates the profound knock-on effects that developments can have (shipping traffic, oil, sewerage and waste pollution) on marine wildlife (e.g. penguins, seals and dolphins). Often only the direct impacts of the initial development are considered (e.g. the impacts of the harbour itself), whereas it is the combined impact of the harbour and the associated urban expansion and waste generation which have the biggest environmental impacts. Other changes around the park include the expansion of citrus farming into natural thicket areas to the west of the park. Cultivated land in the rest of the buffer area has however remained quite stable.

Land-use change

Terrestrial **L** Marine **H**

Since the original main camp section was declared in 1931, the terrestrial park has expanded by a total of 167 000 ha, including both mountainous and coastal areas, while an additional 7000 ha MPA has also been declared. The park now conserves 18 terrestrial and one marine habitat type in comparison to just 3 habitat types conserved at proclamation.

The increase in urbanized/settled area across the 20 km surrounding the current park boundary is relatively small (16 km^2 in total between 1990 and 2014), however the major expansion is associated with the development of the Coega industrial harbour, situated near to three of the bay's islands which form part of the park and are home to the largest remaining breeding population of African penguins.



Influences on habitat within the park

Although the condition of thicket in the Main Camp section of Addo is steadily declining through the impact of elephants, the newly incorporated Colchester section retains vast stands of intact thicket. The elephant management approach in this section relies on the maintenance of a water availability gradient from north (Main Camp) to south (Colchester) to prevent elephants from thinning out this intact thicket. This variability in elephant landscape use has so far ensured the persistence of a variety of habitats with associated faunal species.

Elephant utilising thicket vegetation.

Disease

M

Being a park that straddles both marine and terrestrial ecosystems, with a diversity of land-use practices in neighbouring areas, the park presents substantial opportunities for potential disease transfer between wild and domestic animals. Diseases of veterinary importance such as African horse sickness and heartwater (which require reporting by the Animal Diseases Control Act) are endemically present in the park. The park has the largest relic population of 'disease-free' Cape buffalo: an important financial and conservation resource. The tick vector for Corridor disease, *Rhipicephalus appendiculatus*, is currently marginal in Addo and thought to be limited by temperature, rainfall and resultant vegetation structure. However climate change is likely to aid its expansion inland. Currently there is active surveillance of Corridor disease, Foot-and-Mouth Disease, Brucellosis and Tuberculosis in all buffalo that are sold or relocated from the park and this should be continued. Studies have shown that wildlife areas with buffalo in the eastern Cape have a greater diversity and abundance of tick species, and though they pose little risk to the co-adapted wild hosts, could pose risks (both real and perceived) to livestock farming in the area. Both local and introduced tick vectors are likely to increase in terms of the future climate change scenarios. In addition, diseases of marine animals could become a problem, especially for penguins (avian malaria), and seals (morbilliviruses, tuberculosis).

Ticks act as disease vectors (they play a role in spreading certain diseases). Monitoring changes in their distribution can provide insights into disease dynamics.

Disease-free buffalo in Addo.

The elephant management strategy (that makes use of the water availability gradient from main camp to Colchester and contraception in the Nyathi and Kuzuko sections) is minimizing further degradation of thicket and other vegetation.

It is important to keep water availability limited (or inaccessible to elephants) in the southern Colchester section in order to maintain the last remaining intact thicket.

BSP rehabilitation work has made significant and successful contributions towards combatting soil erosion that was inherited from farms procured for park expansion. This is an example of good science-management partnerships.

Fenced areas that exclude megaherbivores (i.e. buffalo, elephant and black rhino) have a duel function to play in AENP. These exclosures (i) protect plant species that are particularly vulnerable to megaherbivore utilization, and (ii) act as research platform to understand how thicket vegetation responds in the presence and absence of megaherbivores. Various important publications have emanated from work conducted in these exclosures, improving our understanding of megaherbivores as drivers in these systems.

The impact that changing climate will have on the ability to maintain Addo buffalo's disease-free status needs research.

Freshwater

L

With none of the rivers fully contained within the park it is difficult and often impossible to conserve large scale ecological processes associated with these systems.

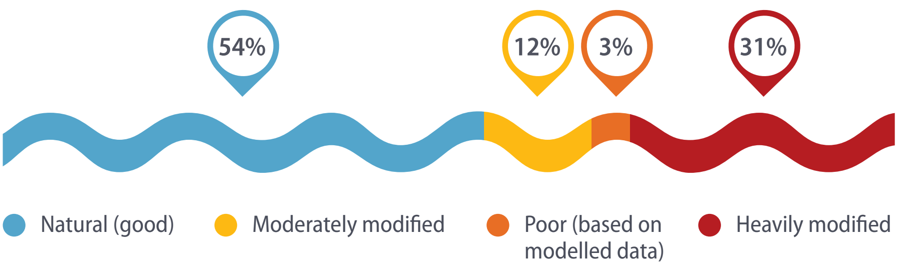
- Maintain and restore flow and sediment transport regimes of rivers where possible
- Avoid development of visitor and other infrastructure on or near priority freshwater ecosystems

- Compile an inventory of wetlands through a systematic mapping of wetland spatial delineation and a basic classification of the type of each (e.g. seep wetland or depression)
- Develop a social-ecological systems model and management plan for each of the rivers flowing through the park

QUICK STATS

- Total river length in park: **290 km**
- River Ecosystem types (of 223 in SA): **16**
- River length in good condition: **54%** (12% moderately modified; 31% heavily to unacceptably modified and 3% is in poor condition based on modelled data)
- The development of a wetland inventory is a high priority and the process for invetorying wetlands has already commenced with a rapid field assessment in 2014

Sundays River flowing out of the Darlington Dam



Condition of all rivers in Addo Elephant Mountain National Park (as per the National Freshwater Ecosystem Priority Assessment).

Rivers: The main river systems that flow through Addo Elepahant National Park are (from north-west to south-east): Sundays, Volkers, Kabouga, Uie, Wit, Krom and Courney Rivers. The Kabouga, Wit and Krom Rivers have been identified as national Freshwater Ecosystem Priority Areas (FEPAs). The Kabouga River is regarded as important for the protection of Eastern Cape Redfin (*Pseudobarbus afer*). The Wit River and its tributaries are regarded as important for the conservation of the Eastern Cape Redfin, Southern Goldie Barb (*Enteromius pallidus)* and Moggel (*Labeo umbratus)*, while the Krom River conserves Eastern Cape Redfin and Southern Goldie Barb. The Uie and Courney Rivers have been identified as national Fish Support Areas for the protection for Eastern Cape Redfin and Southern Goldie Barb. Neither of these rivers is fully contained within Addo.

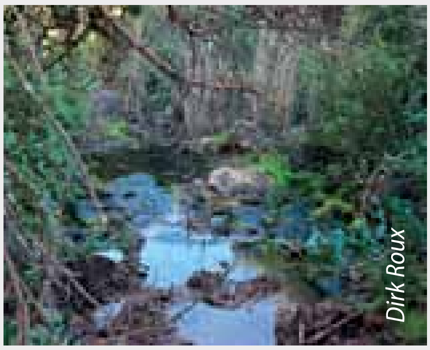
Freshwater fish species within Addo, the (i) Southern Goldie Barb (*Enteromius pallidus*).

(ii) Eastern Cape Redfin (*Pseudobarbus afer*).

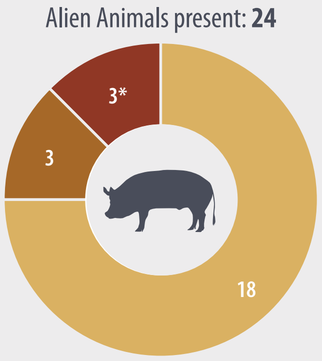
Wetlands: Because of its diversity in topography, geology and vegetation types, Addo potentially has a highly diverse spectrum of wetland types. A rapid field assessment during 2014 revealed a large floodplain wetland at the mouth of the Sundays River, seasonal depressions and a saline spring-fed seep in the Colchester section, mountain lakelets (depressions) in the Njati and Zuurberg sections, and seasonal pans in the Darlington section.

Sundays River Estuary in the Woody Cape Section.

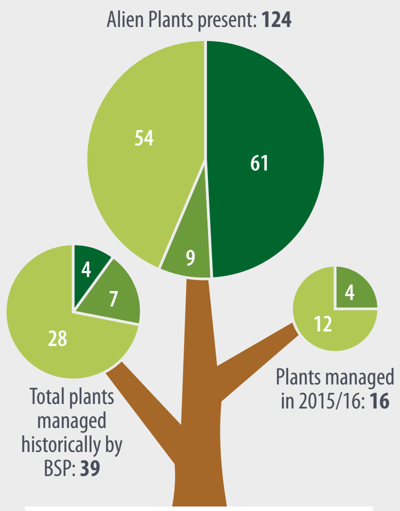
Wetland in Kuzuko Section maintained for grazing.



Zouten Fontein is a seep wetland with saline water in the Colchester section.



NEM: BA Category 1
NEM: BA Category 2 or 3
Species not on NEM: BA
*Mosquitofish, carp and feral pigs



NEM: BA Category 1
NEM: BA Category 2 or 3
Species not on NEM: BA

1 biocontrol agent has been used in the management of alien plants

Alien species

148 alien species have been recorded in Addo. This is the fourth highest total number of alien species across SANParks (Kruger, Table Mountain and Garden Route have more alien species recorded).

Animals

Extralimital species in the park including domestic animals, feral pigs (*Sus scrofa*) and warthog (*Phacochoerus africanus*) are currently actively being removed. Warthogs, which are not indigenous to the Eastern Cape, occur in high numbers in the park and may have significant impact particularly on bulbs. Annual warthog culling has been undertaken by rangers for the past several years, but has proved insufficient and in future will be carried out by professional culling operators. Several alien fish are established in the rivers and dams and there is little likelihood of eradicating them. Large numbers of carp in the Darlington dam and river have largely taken the place of indigenous species. A community fishing project was initiated involving carp, but was discontinued as the costs involved were too high compared to the income generated.

Warthogs are not indigenous to Addo, reach high population numbers and have a negative impact on the vegetation.

Plants

One hundred and twenty-four plants have been recorded in Addo. The jointed cactus (*Opuntia aurantiaca*) is a problem species that has implications for animal welfare given its aggressive ability to stick to their fur. This cactus is spreading rapidly, but the biocontrol recently introduced provides some optimism for long-term control. Elephants (*Loxodonta africana*) control the prickly pear species, *Opuntia ficus indica* really well, so there is no active control of it by BSP in the sections where there are elephants in Addo. BSP is focusing their attention on the jointed cactus and biocontrol. In the newer coastal dune sections of the park, rooikrans (*Acacia cyclops*) and Port Jackson willow (*Acacia saligna*) are a problem, while Black wattle (*Acacia mearnsii*), in particular, is not likely to be brought under control within the next few decades due to the large seedbank that is present and regrowth after clearing operations and fires. This is particularly problematic in the Zuurberg section. Tamarisk (*Tamarix ramosissima*) has spread down the Sundays River from Camdeboo into the Darlington section of Addo, and is a current focus of management attention. This case highlights how parks need to work together to manage alien species. Several other transformer plants such as eucalypts and *Solanum* species are also found in the park.

Biocontrol of jointed cactus relies mainly on a cochineal insect (*Dactylopius austrinus*), a native of Central and Western Argentina. It was obtained via Australia, where research into the host-specificity and impact of the insects was carried out. The cochineal exerts satisfactory control on jointed cactus, except in regions where it is too moist and cold for the insects to build up their populations sufficiently.

Sixty-three species are listed on the NEM: BA regulations and will require some form of management action. There is a significant shortfall between this requirement and current management capacity: work has been conducted on an average of 11 species per annum; 16 in the last year, with key focus on prickly pear (*O. aurantiaca*), black wattle (*A. mearnsii*) and lantana (*Lantana camara*).

A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

Resource use

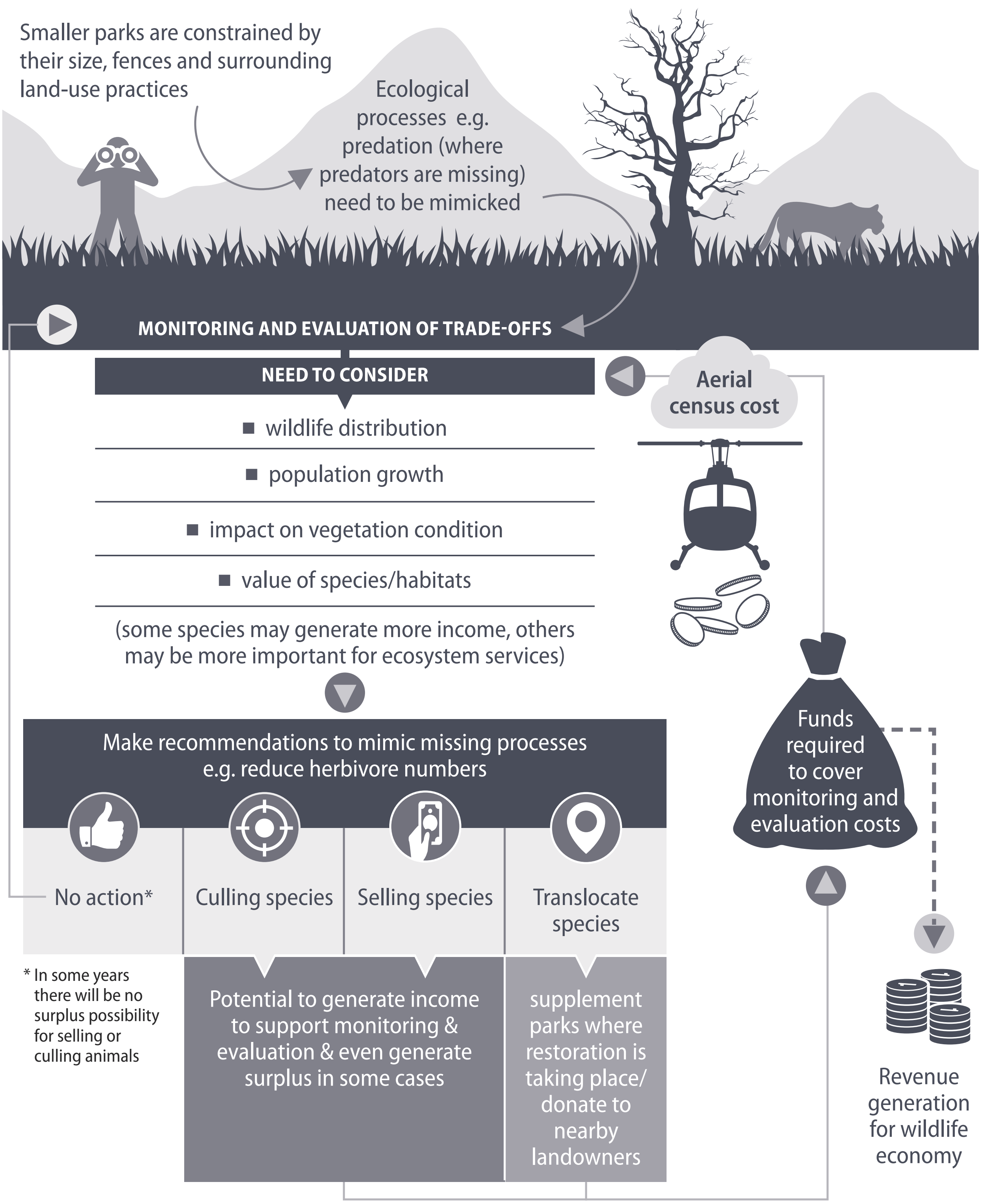
Terrestrial L Marine M

Initially only 5 resources (alien carp and catfish, warthogs, soil, sand and water) were reported to be used in the park, but the scope of resource use in the park is in fact broader. Game sales and the indigenous plant nursery provide an annual source of income and access to these resources for outside parties. Buffalo are sold annually on auction (see infographic on the next page on the importance of regular census surveys), while cuttings and seeds are collected to grow species in the nursery which are then used in rehabilitation, sold or donated (e.g. to schools). An average of 200 to 400 warthogs are culled annually and the meat is sold to cover the costs of culling. Initially SANParks conducted the culls and sold meat to staff at R6/kg to cover costs. Later an open tender was put out for warthog carcasses, which were sold at R12/kg. From 2016 an external operator has taken over the culling function.

While plants from the area are well known to be used in traditional medicines, the dense nature of the thicket, together with the presence of dangerous big game, largely deters illegal harvesting. However there are several poaching concerns, particularly of abalone in the Algoa Bay marine protected area. Although there is little potential for resource use projects in the park, the donation of game towards the community-based wildlife economy may be a feasible option if based on ecologically sound principles that ensure long-term ecological (as well as financial) sustainability (see infographic). A bee-keeping project suggested for the park did not gain support because of the high risk of alien bee species colonising the park. The community project involving the fishing of carp and catfish in Darlington dam was terminated as the financial costs involved significantly exceeded the income generated. Recreational and subsistence fishing does however still take place in the Sundays River outside of SANParks' jurisdiction. Other ways of including stakeholders particularly those who lost land to Addo must be explored.

Bee-keeping is not a viable option in the park due to the high risk of alien bees colonizing the park. Maintaining natural pollinator populations is a high conservation priority that will serve agriculture and food security and biodiversity. Declines in bee populations have been observed elsewhere in the world as a result of disease and pesticide use with potentially dire consequences for crops and biodiversity that require bee pollination.

The critical role of census and population status information in the wildlife economy



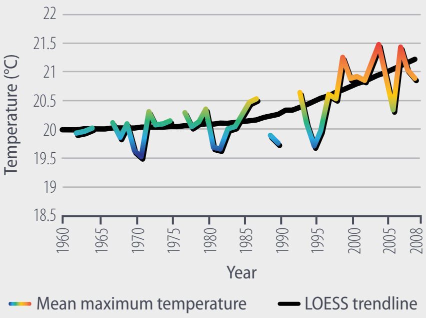
The critical role of census in wildlife economy and feedbacks between financial gains from game sales and funds required to continue census work.

AGULHAS
NATIONAL PARK

Nicola van Wilgen

Agulhas National Park (~22 000 ha) makes a key contribution to conservation of lowland Fynbos, being home to approximately 2000 species of indigenous plants including 100 which are endemic to the area and over 110 Red Data Book species. It also protects several types of wetland and represents the largest continuous lowland conservation area in this biome. Past land-uses have resulted in a high number of alien species being present in the park and have also altered the distribution of native species previously used in the cut-flower industry. Key threats to the area include the increasing temperatures that could lead to more frequent and/or intense fires, which are compounded by high alien densities in some places. Impacts on freshwater systems that result from management practices on adjacent properties as well as the abundance of roads through wetland areas are also a concern. Key opportunities in the area include continuation of the substantial work that is ongoing to rehabilitate rivers and wetlands in the park to combat erosion, restore the hydrological functioning and improve the conservation status of freshwater ecosystems. There might also be the opportunity to support local communities more, by for example, expanding the traditional harvesting of sour figs, an abundant resource. Research and monitoring are required on several fronts, including river health, species of special concern, the potential for the spread of diseases such as *Phytophthora* and avian botulism and options for climate change adaptation and mitigation.

Emmerentia de Kock



Annual average maximum temperature at Cape Agulhas station since 1960, showing a significant increase.

Further increases in mean annual temperature of between 1.1°C (best case), 1.5°C and 2°C (worst case) are predicted by 2050.

An increasing number of high fire danger days is already being experienced.

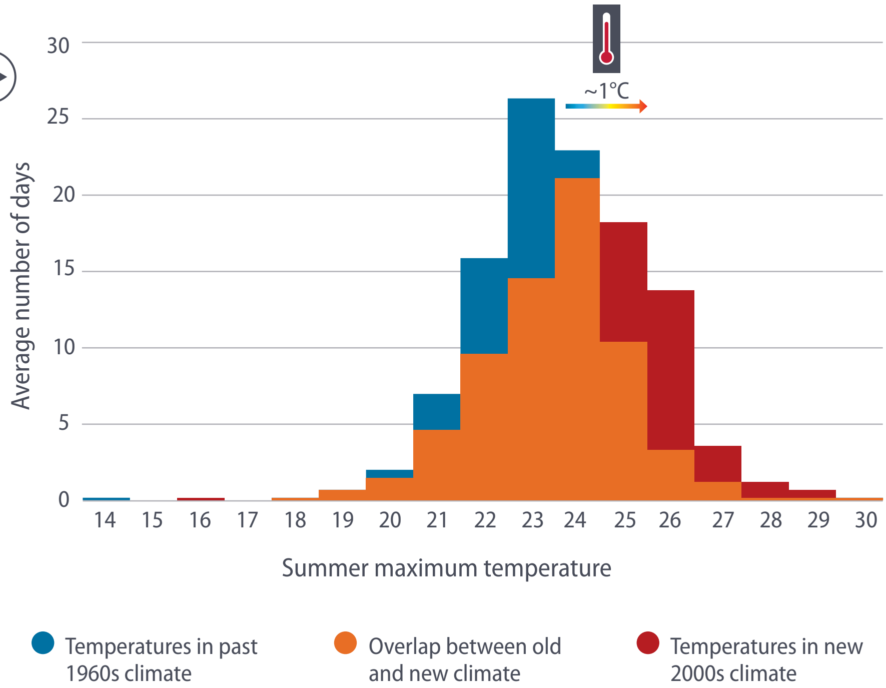
More frequent fires can lead to fire-induced soil hydrophobicity (i.e. soil water repellence). Ruth-Mary Fisher (SANParks) has monitored soil hydrophobicity in the park since the 2009 wildfires. Results indicate that soil hydrophobicity hampers the infiltration of water and may have negative impacts on plant growth.

Climate change

M

Temperature

Over the last 50 years (1960–2009), average minimum temperatures have increased by 0.75°C, while average maximum temperatures recorded at the lighthouse station have increased by 1.2°C. As a result of this uneven change, the daily temperature range has also increased by 0.45°C. Further increases of between 1.1°C (best case), 1.5°C and 2°C (worst case) are predicted by 2050. If summer temperatures increase by 2°C under the worst case scenario, more than half (65%) of summer days would be 25°C or hotter, compared to less than one quarter (~21%) in the past (conditions averaged between 1971 and 2005). Judging from the shift already seen (see figure below), where there are currently about 38 days that reach 25°C or more, up to 60 such days could be expected in summer by 2050. While Agulhas will not get uncomfortably hot any time soon, these increases have significant implications for the management of fires and the spread of some diseases.



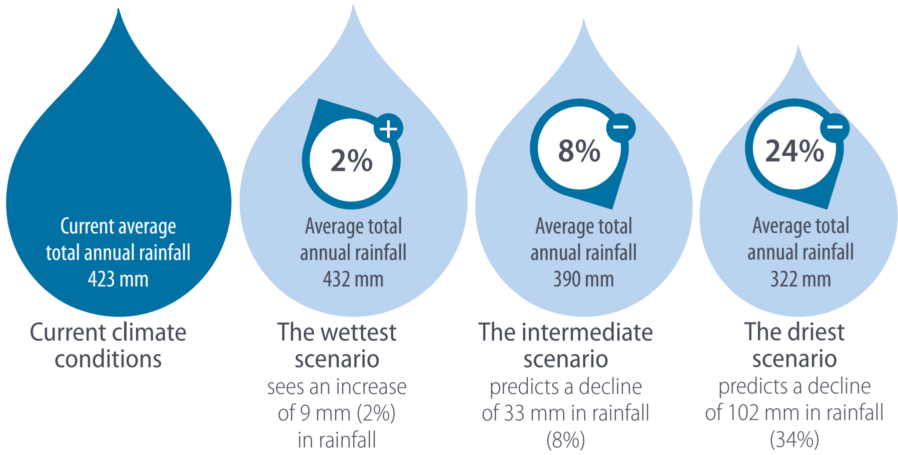
The average number of summer days reaching between 14°C and 30°C at Cape Agulhas, compared to the 2000s, showing how an average shift of just 1°C impacts on warm extremes. In the 1960s, an average of only 15 days would have reached 25°C or more, whereas in the 2000s, an average of 38 days are 25°C and higher.

Possible biome changes

Although no major changes are predicted in the extent of the Fynbos biome as a whole in this region as a result of climate change by 2050, we expect that species will begin to change their distributions. Ericas have been shown to be susceptible to drought, while plant diseases might also become more prevalent (see diagram on p. 34). More high-fire-risk days are already being experienced, and should fire frequency increase, alien species might be favoured over natural vegetation. Sea-level rise will have implications for the park's wetlands and coastal areas, including their attractiveness and usefulness for tourism, as well as reducing habitat for migratory and resident waders and waterfowl. Models of sea-level rise are available.

Rainfall

No major rainfall changes were detected in the historical rainfall record for the past 100 years, although there was a slight decrease in the percentage of dry days in a year.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8 × 1.8 km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely for the southern coast of South Africa, taken collectively, it appears that no change to a moderate rainfall decline is likely. Also note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events).

Although there are many uncertainties, it is good to understand the range of future conditions and to have plans in place to deal with different scenarios.

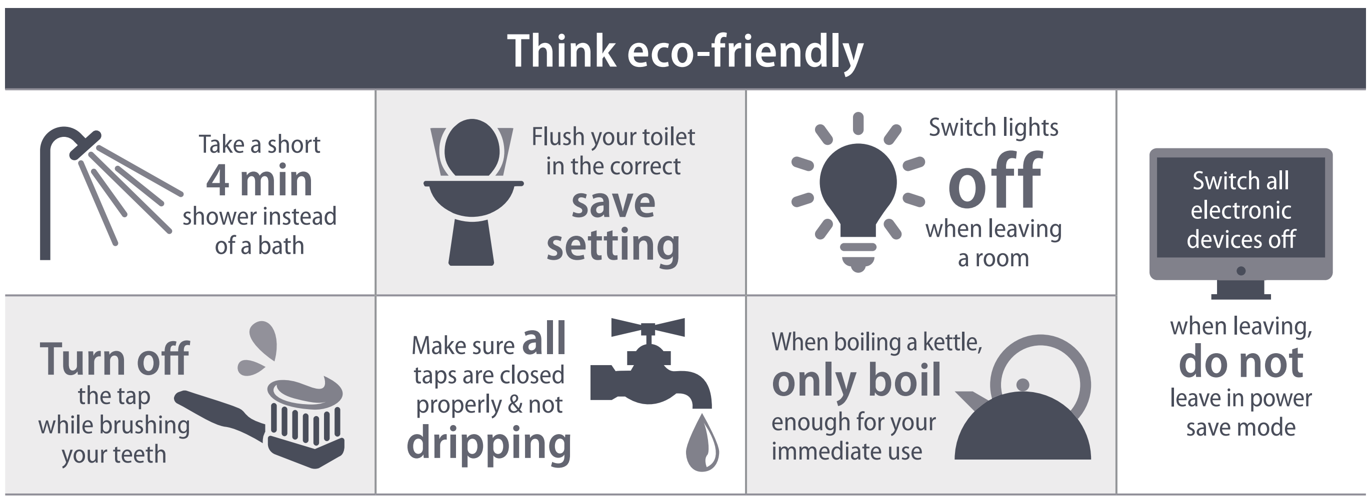
SANParks has an important role in educating the public about the importance of greener lifestyles.

Reducing waste and increasing opportunities for recycling are also critical.

Adaptation strategies that save water and energy are recommended including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference



One of the outcomes of the ABI (Agulhas Biodiversity Initiative) German project (2008–2009) was for land managers to be more 'fire-ready'. A fire truck was purchased for the district municipality to assist in prescribed burns. Aerial images show clearly that these burns have been taking place. This should have a positive impact on biodiversity and reduce wildfire risk.

The Nuwejaars Wetland SMA should be declared a Protected Environment. If not declared there is a risk that the SMA area could be developed and 22 000 ha of natural vegetation could be lost.

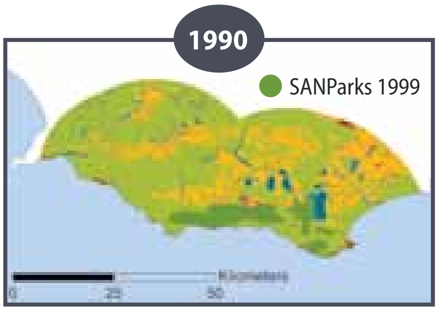
Land-use, resource use and disease

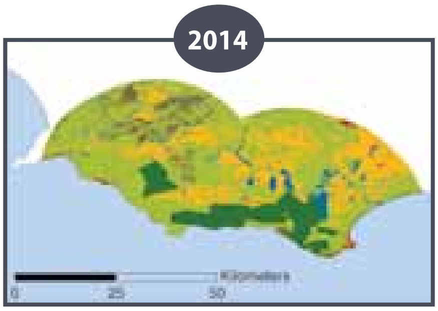
M H L

Historical land-use on the Agulhas Plain included farming of merino sheep for wool, cut-flower harvesting and agriculture. The value of the area for conserving the highly diverse lowland Fynbos was recognised and the first 91ha of the park was declared in 1999. Since then, the park has expanded to over 21 000 ha, conserving 11 unique habitat types (up from only 2 at declaration). Following the proclamation of the park, the Agulhas Biodiversity Initiative was formed in 2003, with the aim of conserving the remaining pieces of natural vegetation in the wider area. Through this initiative the idea of forming a conservancy adjacent to the park was born and the Nuwejaars Wetland Special Management Area (SMA) was created including all the landowners around the park. The SMA and the park are managed through a co-management committee that deals with issues such as land-use, tourism and biodiversity conservation, and monitors activities in the park buffer zone to promote the core mandate of biodiversity conservation. These changes in management are reflected in national land cover maps, where cultivated land has decreased by 45 km^2 (9%) in a 20 km radius from the current park boundary since 1990. An increase in degraded land (84 km^2) to the north west of the park is also apparent. Investigation of the aerial images show marked fire scars. What therefore appears as degraded land on the land cover map is actually indicative of the positive change that has come about with landowners in the region proactively managing fire and conducting prescribed burns.

Landcover

- Cultivation
- Mining
- Urban
- Plantation
- Water
- Natural
- Degraded
- National Park
- Park at proclamation





Land-use in 1990 versus 2014 in the 20km from the current park boundary. The boundary of the first section of the park to be declared in 1999 is shown on the 1990 map, while the current park boundary is shown on the 2014 land-use map.

The Nuwejaars Wetland Special Management Area (SMA).

Resource use, both within the park and the SMA, plays a vital role in supporting the communities that live on the Agulhas Plain. Park staff identified 37 resources harvested within the park and have encouraged the historic resource use practices of thatch and sour fig harvesting. Benefit sharing programmes also exist for firewood from alien species clearing. Other commodities used in the area include honey, driftwood, food and medicinal plants such as waterblommetjies (*Aponogeton distachyos*), kooigoed (*Helichrysum* sp.), and cancerbush (*Sutherlandia frutescens*). Estimates of harvest quantities are however currently uncertain, although they are thought to be relatively stable as it is mainly the older generation who are involved in harvest activities.

Harvesters include mainly members of the older generation. Beneficiaries are pictured here with a harvest of sour figs from the park, and preparing sour figs for sale.

Harvesters collect sour figs during the summer holiday period and use the income from selling the jam, chutney or dried figs to cover the costs associated with the new school year for their children. A recommendation to park management is to extend the areas where harvesting is allowed to enable communities to continue to support their children's rising education costs. Research into the use of existing old cut-flower fields and wild areas for cut-flower harvesting found that market demands for straight stemmed and unblemished flowers is unrealistic for the national park. To meet quality expectations the park would have to undertake pest control such as spraying with insecticides and regular pruning of the plants, which is counter to management practices in a protected area. A future benefit sharing programme to be investigated is the establishment of hives within the park for honey production. Care needs to be taken however to ensure that no alien bees are introduced. Declines in bee populations have been observed elsewhere in the world as a result of disease from alien bees as well as pesticide use with potentially dire consequences for native species as well as crops that require pollination.

Harvesters use funds generated from sour fig sales to cover costs associated with the new school year for their children.

Extend the areas where sourfig harvesting is permitted.

- 37 biological and/or abiotic resources are harvested from Agulhas
- Key benefit sharing programmes include: thatch harvest, sour fig harvest, firewood collection
- Mainly the older generation are involved in harvesting

Booklet on the useful food and medicinal plants from the region – *Emmerentia de Kock*

Sour figs are a rare example of a resource which is not threatened and relatively abundantly available and sought after by the local community, providing a win-win scenario for benefit sharing.

Wildflower harvesting for the cutflower market is not compatible with protected area management and should not be pursued (see text).

Previous land-use, the natural distribution of species, resource use market drivers and climate change can all interact to determine the susceptibility of Proteas to disease.

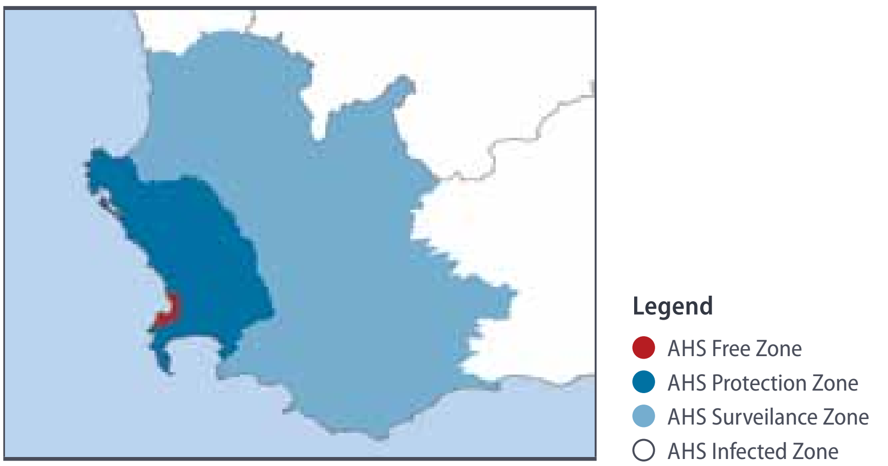
Photos: Carly Cowell

There is no need to treat inappropriately planted proteas that are becoming diseased, the dieback is a natural restoration.

Joseph Hubert (University of Pretoria) has been assisting management to conduct a survey of *Phytophthora* species (a plant disease) in the Fynbos biome. Samples of diseased plants have been taken for testing and results will be made available to park management.

Bontebok on the Agulhas Plain are dying of lung-worm disease. An investigation into the cause still needs to be carried out.

Historically the Agulhas Plain hosted a number of large mammal species that were exterminated, largely by early settlers. Because Agulhas no longer has a high density of large mammals and the climate is not that suitable for tropical diseases, notifiable diseases (those which require reporting under the Animal Diseases Control Act) have not been a problem in this park to date. However, Agulhas and Bontebok National Parks are situated just inside the Controlled Area for African Horse Sickness (AHS), a state controlled disease known to be potentially damaging to the livestock economy.



African Horse Sickness Control area.

AHS is a highly infectious viral disease affecting all species of Equidae, including zebra. It occurs naturally on the African continent and in horses. It usually has a high mortality rate of 70–90%. Wild species such as zebras have evolved resistance to the disease but can act as hosts of the virus. AHS does not spread directly from one horse to another, but is transmitted by the Culicoides midge which becomes infected when feeding on other infected animals. AHS outbreaks occur mostly in the warm, rainy season when midges are plentiful and disappears after frost when the midges die. At present the disease does not occur in the Agulhas National Park area but with the change in climatic conditions and distribution of the *Culicoides* midge this status could change in the future. AHS control has management implications when translocating zebras, that can only be moved into the AHS Controlled Area (comprising the AHS free, surveillance and protection zones, see map) during the months of July and August, provided they have gone through a vector protected quarantine period and they have undergone two negative Complement Fixation Tests.

Other disease threats include plant diseases (see schematic), a change in the distribution of tick vectors (currently spreading from the Eastern Cape due to climate change) and botulism, which could be present in soil and can be responsible for waterbird deaths. Dying vegetation as well as a change in the distribution of birds contribute to this phenomenon as spores are carried between systems and multiply in areas where water and decaying vegetation are present (see Garden Route).

Fungal plant diseases such as *Phytophthora* are spread mainly via spores in water. Roads through wetlands can act as pathways of introduction when 'contaminated' vehicles drive through the water and disperse the spores. Closing of current roads through wetlands and preventing creation of new roads by management would make a significant difference.

Zebras (*Equus zebra*) have evolved a resistance against African horse sickness disease but can act as hosts of the AHS virus which has management implications when translocating zebras.

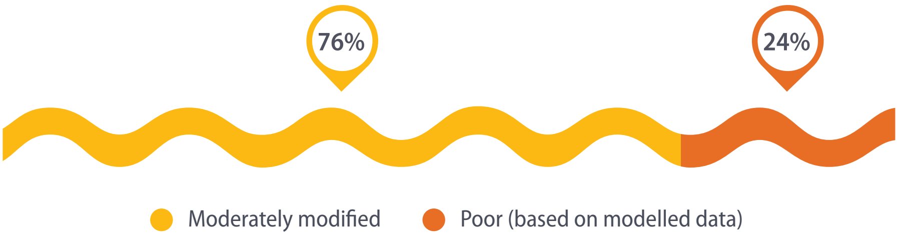
Freshwater

H

Agulhas has a high diversity of wetlands: 23 ecosystem types, which can broadly be grouped into four groups on a scale of increasing salinity – 0.2 g/kg in the freshest systems to 198 g/kg in the most saline. These diverse wetland types contribute to sustaining the high floral diversity of the region. Substantial work has been done on wetlands in the park.

QUICK STATS

- Total river length in park: **~26 km**
- River Ecosystem types (of 223 in SA): **6**
- None of the river area is in good ecological condition (Category A or B), with the majority being modified (Category C), however the region is an important fish support area
- Total wetland area: **~40 km^2**
- **23** wetland ecosystem types (of 791 in SA) are found in the park



Condition of all rivers in Agulhas National Park (as per the National Freshwater Ecosystem Priority Assessment of 2010).

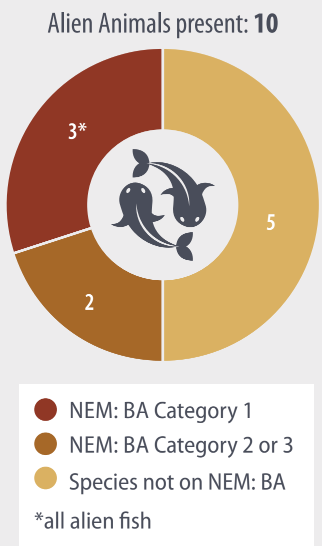
The Ratel River supports populations of the indigenous redlisted Cape Kurper (*Sandelia capensis*) and Cape Galaxias (*Galaxias zebratus*). Cape Galaxias don't have scales.

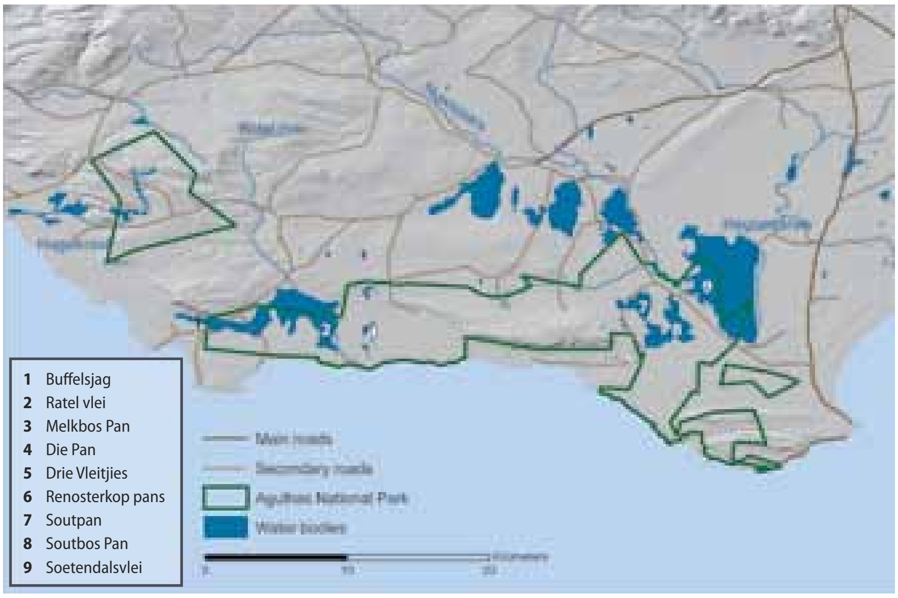
- No freshwater monitoring is being done: there are no River Health sites in the park
- Agricultural water impoundments prevent proper water flow and wetlands in Nuwejaars catchment
- There is eutrophication from agricultural lands especially in the Nuwejaars catchment
- Alien plants as well as native species with an invasive tendency, e.g. *Phragmites,* and fish (e.g. bass and bluegill sunfish) are a problem in the freshwater systems and threaten two indigenous redlisted fish

- The feasibility of river rehabilitation should be explored as the present ecological status of rivers is moderately and not heavily modified
- Work with private land owners to clear Ratel River of aliens outside of park

- An inventory of wetlands needs to be finalised for Agulhas National Park to contribute to the revision of the FEPA maps. This work is currently being carried out via a collaborative project between SANParks, CapeNature, DEA, CSIR, SANBI and private consultants
- River Health sites need to be established in the park

- 86% of wetland area in the park comprises Freshwater Ecosystem Priority Areas
- Waterford conserves the upper reaches of three different river systems
- Working on Wetlands has restored hydrology in several wetlands





Distribution of major wetlands and freshwater systems in the park.

Melkpan

Working for Wetlands works extensively and continuously to restore and improve hydrology in wetland and river systems, plugging old furrows, rehabilitating drainage lines and restoring water flow. Scientific Services has also been involved in work with partners to ground-truth the National Freshwater Ecosystem Priority Areas (NFEPA) GIS layers that represent the distribution and characterization of wetlands. Mapping in the Ratel River and Hagelkraal River catchments have been completed, and work is ongoing in the Nuwejaars catchment. The NFEPA maps appear to be relatively accurate, but a number of seeps that were not previously mapped were added. Information on soils and vegetation have been added and a number of classifications have been revised.

Alien species H

Ninety-two alien species have been documented in the park.

Animals

The alien animals in the park include mainly domestic species that are present in the old farm area as well as several alien fish species, but following the reports resulting from this work, cows and horses have been removed from the park and, along with other domestic species, are being managed on an opportunistic basis.

Fallow deer (*Dama dama*) an alien antelope present on properties outside of Agulhas.

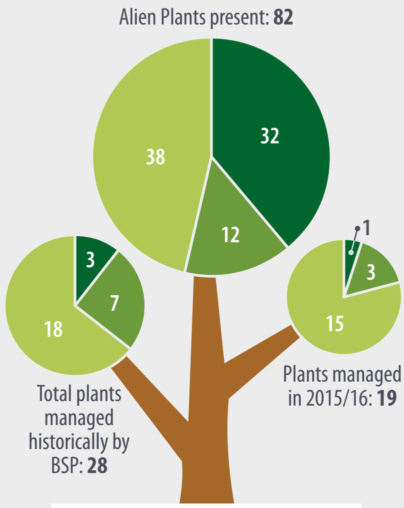
Domestic animals (including cows and horses) brought to park attention through the GEC project have been successfully removed.

Plants

Clearing operations:

Rietfontein and the new Jeffrey's area require initial clearing for over 1000 ha, but all areas are expected to be reached in the next year, should no fires occur.

The midge (*Dasineura dielsi*) was introduced as a biocontrol agent in South Africa. The plant produces galls instead of seed pods and the midge larvae and pupae develop inside the galls



3 biocontrol agents have been used in the management of alien plants

- Since 2002 BSP has worked on 28 species
- On average 13 species are worked on per year
- All areas affected by 2009 fire have been cleared, but 2–3 year maintenance and immediate action following new fires is required.

Biocontrol species for the Port Jackson willow *(Acacia saligna)* and rooikrans *(Acacia cyclops)* are well established in the wider Agulhas region.

Threats and challenges:

Fifty of the plants present in the park are listed on NEM: BA legislation and will require some form of management action. Currently ~25 NEM: BA species have been worked on, but while many species are treated on an ad hoc basis, only four species are worked on routinely (every year): rooikrans (*Acacia cyclops*), Long-leaved wattle (*Acacia longifolia*), Port Jackson willow (*Acacia saligna*) and Spider gum *(Eucalyptus lehmannii*). This leaves a major shortfall between capacity and legislative requirements.

A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

Several areas require burning in the near future and follow-up clearing within the first few years thereafter is essential. Use of volunteer blitz days that involve the community in clearing young plants can be rewarding. The redeployment of biocontrol to assist in reducing re-infestation of certain plants from buffer areas is being considered.

Clearing in dense areas can be a challenge.

Alien seedlings can sprout in high numbers following fires and BSP should continue hand-pulling of saplings in their operational plans and budgets to be effective.

High rainfall in 2015 resulted in many seedlings which BSP are not able to clear as herbicide application is not possible and spraying is not biodiversity friendly.

Clearing in areas where Fynbos has regenerated to shoulder height is challenging. Better integration of fire and alien species management is urgently required to enable teams to clear in the right places at convenient and strategic times.

Major problem species include Port Jackson, Rooikrans, Spider gum and Australian myrtle. *Banksia* species (previously cultivated for the cut-flower market) are also an emerging problem following the 2009 fire.

Port Jackson flank the road.

- The use of volunteers in blitz days has proved successful at removing large numbers of alien saplings and seedlings and in involving the community in park management
- Planning for fire and alien species management needs to be integrated e.g. Waterford burned in February 2016 and needs to be prioritized for post-fire clearing

There are many stacks of alien vegetation from clearing years ago that are now a fire hazard. These need to be burnt to reduce the risk and the fuel load. Chipping is not an option as there is too much material and it would smother the ground and seedlings trying to germinate, as well as continuing to be a fire hazard.

There is a shortfall between current clearing and legislative requirements effective from September 2016.

Biocontrol is set to be released to assist in control of re-infestation of the park from buffer areas and will require monitoring.

AUGRABIES FALLS
NATIONAL PARK

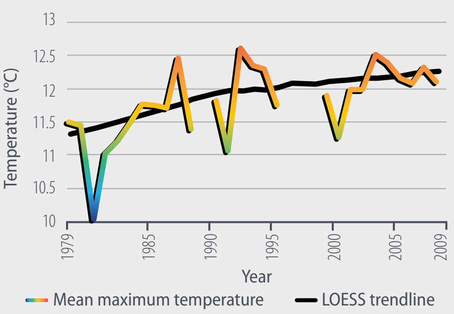
The Augrabies Falls National Park (~53 000 ha) conserves an area of geological interest around the Augrabies Falls, the largest waterfall on the Orange River. Its downstream gorge, which stretches over 20 km, offers breath-taking views. Increased temperatures and a decreased rainfall pattern might lead to a biome shift with the area becoming more desert-like with uncomfortable living conditions. The Orange River plays an important role in viticulture and the irrigation of farms close to the river. There is still livestock farming in large areas around the park. A proposed hydropower plant could have had a negative impact on the water flow of the Orange River, especially the main falls which are a large tourism attraction. Water will always be a restriction in an arid environment and careful planning is needed to conserve water and limit consumption.

Climate change

L

Temperature

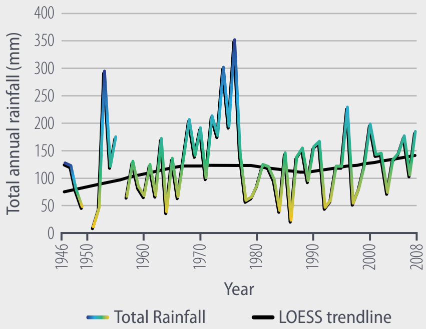
Temperature data were not available for the park for a sufficiently long duration to analyse, but an increase of 1.15°C was detected in average minimum temperature at the Pofadder station between 1978 and 2009. The number of nights that stay warm (where the temperature does not drop below 20°C) also increased at Pofadder. By 2050, mean annual temperatures in the region of the park are predicted to increase by between 1.6°C (best case), 2.3°C and 2.8°C (worst case). We have used data from Pofadder to demonstrate what effect a 2.8°C might have on summer maximum temperatures in the figure on p. 40. These changes would have a dramatic effect on the number of extremely hot days experienced in the park.



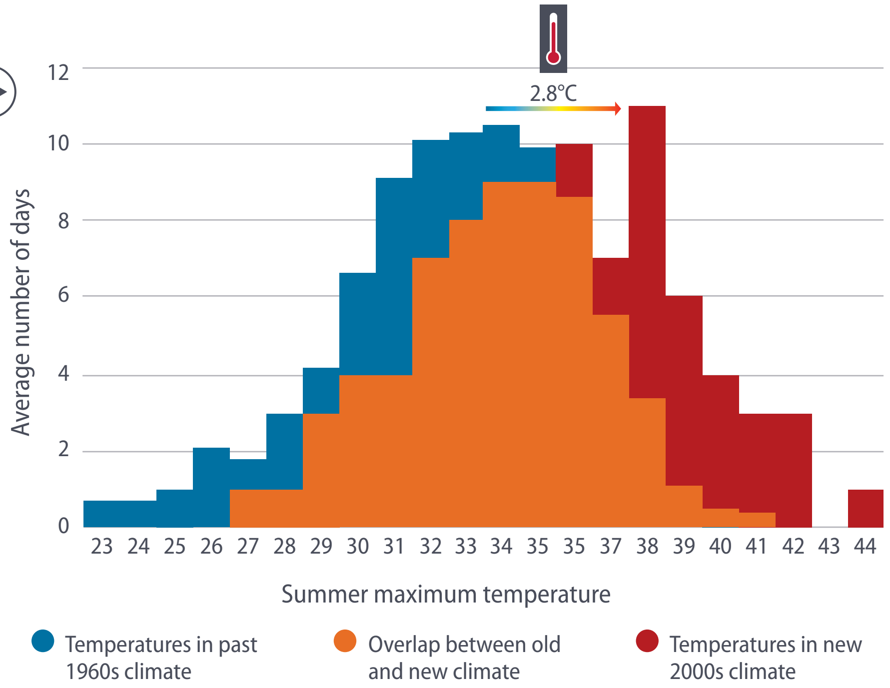
Annual average minimum temperatures at Pofadder since 1978 have increased significantly.

By 2050, mean annual temperatures in the region of the park are predicted to increase by between 1.6°C (best case), 2.3°C and 2.8°C (worst case).

Temperature and rainfall changes are predicted that will have a dramatic effect on the biodiversity composition of the region. The park will need to plan for changing futures.



Total annual rainfall at Augrabies since 1945, showing no overall trend.



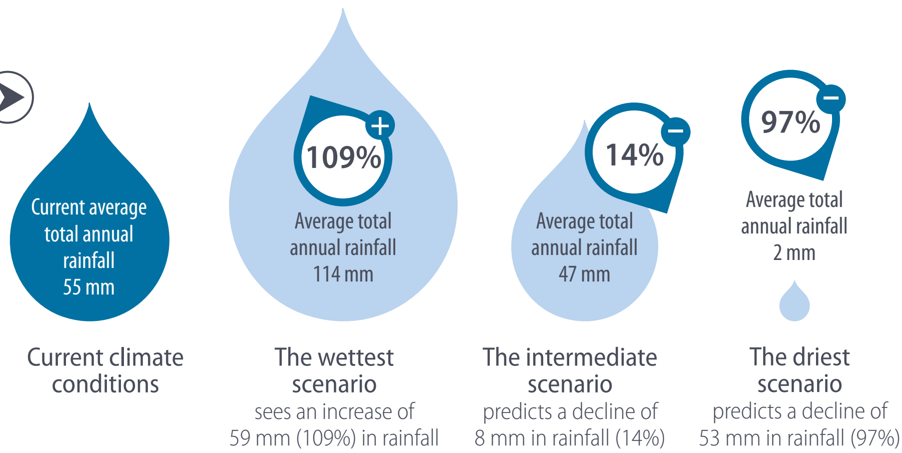
The average number of summer days reaching between 23°C and 44°C in Pofadder in the past (1978–2005) compared to a hypothetical summer where temperatures have increased on average by 2.8°C, showing how this shift impacts on warm extremes. In the past, an average of 29 summer days would have reached 35°C or hotter (that is about a third of summertime). If summer temperatures increase by 2.8°C, 54 or more days could get this hot – that is almost two thirds of summer days. Temperatures below 30°C will also become much less frequent than in the past (only about 5% of summer days).

Under the hottest and driest scenario, the entire park area would be outside of its current biome envelope, i.e. there would no longer be Nama-Karoo in the area, but rather desert.

An impact of climate change that is seldom considered is the impact of increasing temperatures on people who work outdoors: Under hotter conditions, people's work rate will be reduced and in some instances people may not be able to do much outdoor work at all. This has dramatic implications for several of the northern parks where summer temperatures are predicted to become unbearably hot.

Rainfall

No changes in annual rainfall totals were detected in the historical rainfall record for the past 65 years. Rainfall patterns however appeared to be changing with more rain days, but less rainfall on days when it did rain and a decrease in the length of the longest spell without rain. Smaller rainfall events are biologically significant as they may evaporate faster. Future projections are however for less rain.



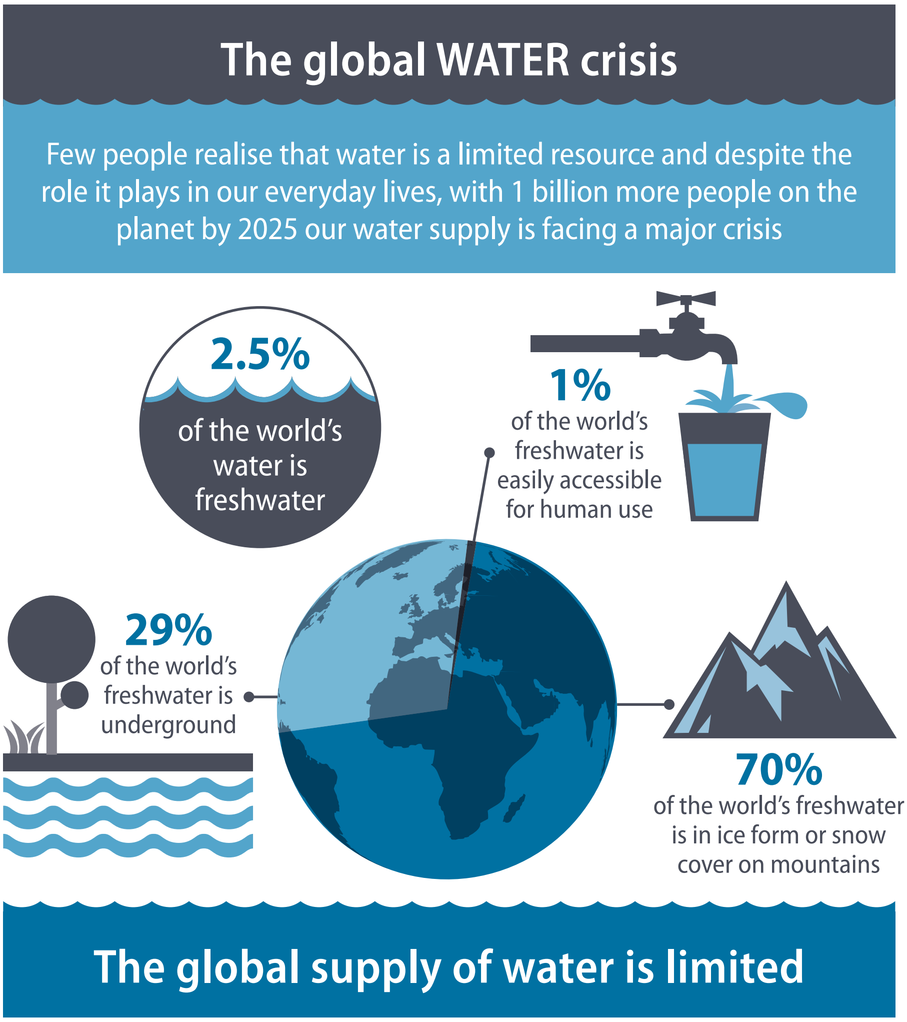
This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8 × 1.8 km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely, drying is more commonly predicted for this part of the country, favouring the drier scenarios. Also note that the range of predictions provided here does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events).

Possible biome changes

The biome changes predicted are severe given the dramatic decrease in rainfall under the most extreme scenario. The likelihood of the different rainfall scenarios is uncertain. Scenario planning is a useful tool to plan for different futures and think ahead about the type of management changes that would need to be implemented given different levels of rainfall and temperature changes. Then when it becomes clear in which direction things are changing, a plan is already in place.

- SANParks has an important role in educating public about the importance of greener lifestyles.
- Reducing waste and increasing opportunities for recycling are also critical.
- Augrabies can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.
- Appropriate signage for tourists can increase awareness and support for water and energy management changes.

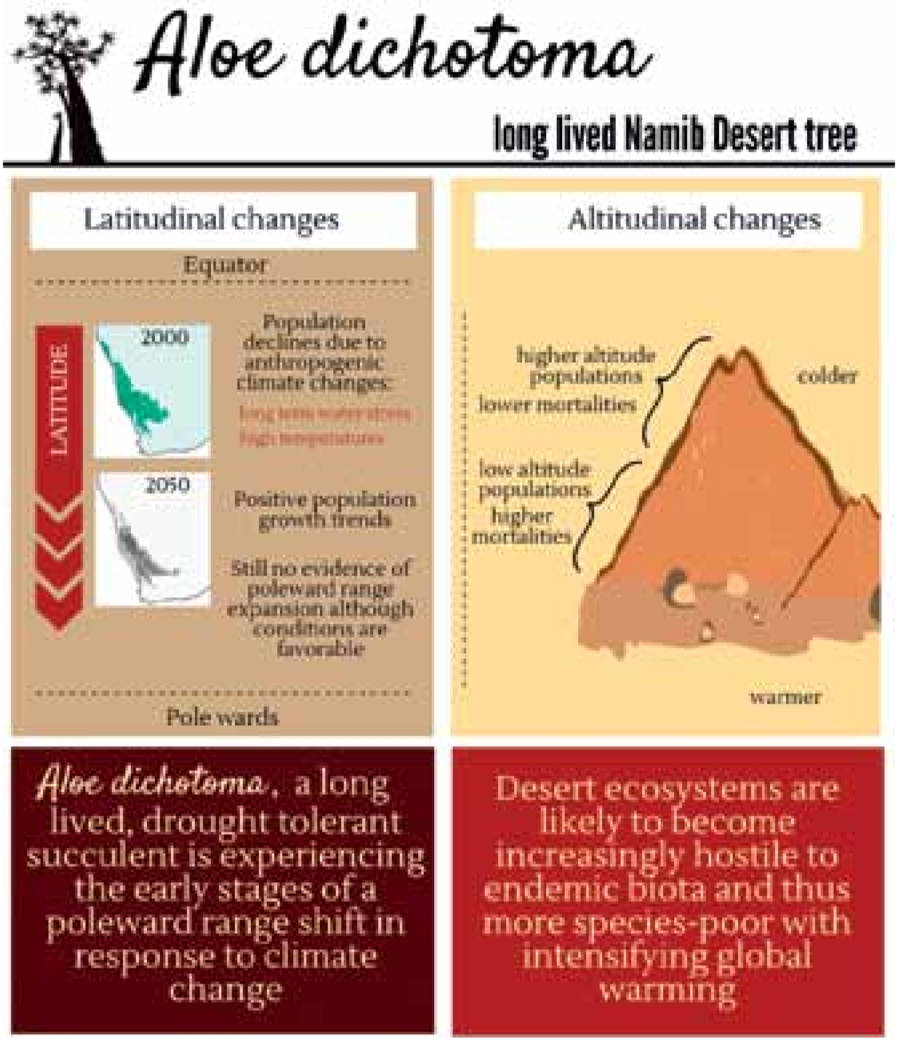
Actions to make a difference



Case scenario of the Quiver trees in the face of global environmental changes

Quiver trees (*Aloe dichotoma*) are endemic to the Northern Cape and an iconic species to see in Augrabies Falls National Park. The trees start to bloom only after about fifty years and recruitment occurs only after favourable weather conditions. Optimal conditions occur at an average interval of about 17 years in the Northern Cape. Quiver tree populations are declining due to changes in climatic conditions with range contraction from the north (equatorward zone) and a lagging of range expansion to the south (poleward zone). This increases the conservation status of these trees. Future predictions of biome changes could have a dramatic effect on these iconic species in the park.

Quiver tree (*Aloe dichotoma*) monitoring in Augrabies Falla National Park.



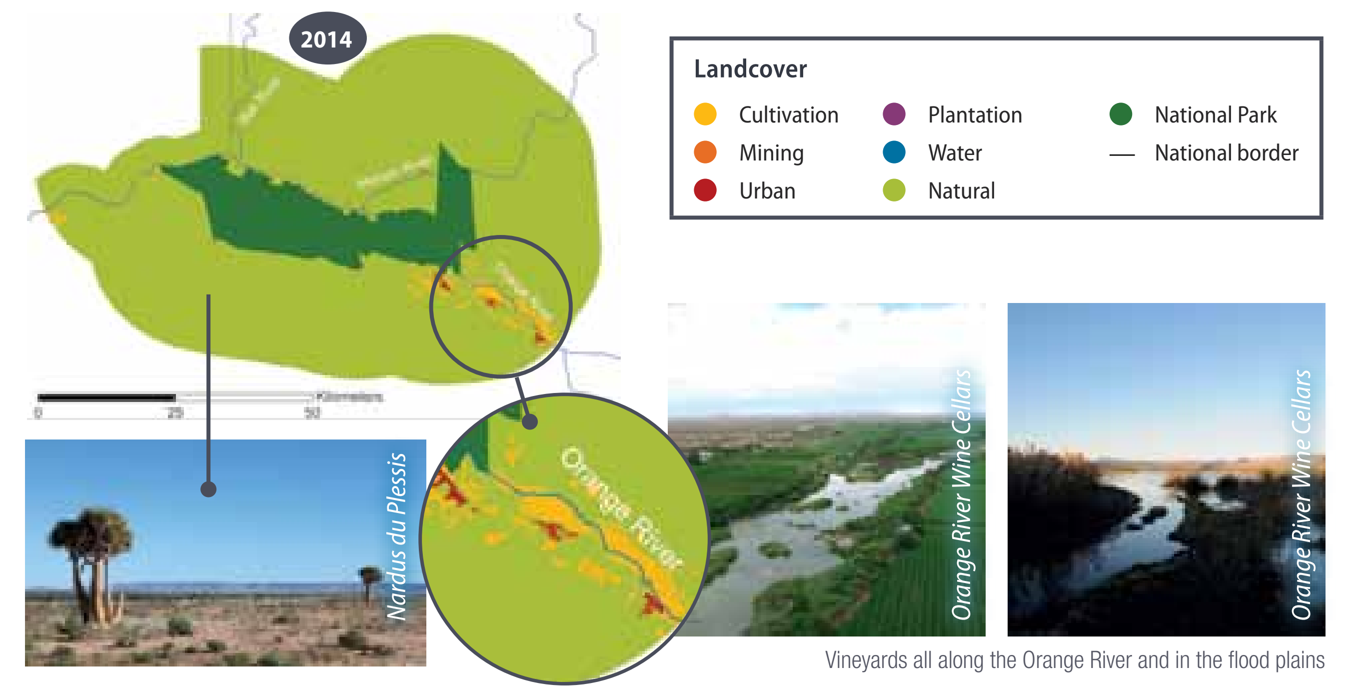
Foden et al 2007 A changing climate is eroding the geographical range of the Namib Desert tree Aloe through population declines and dispersal lags DOI: 10.1111/j.1472-4642.2007.00391.

See: BBC Earth Report – All of a Quiver by Wendy Foden https://www.youtube.com/watch?v=GK4fwe4XMIg.

Land-use change

L

Since declaration in 1966 Augrabies has expanded by 51 000 ha and now conserves 5 habitats, compared to the 3 at proclamation. The overriding observable land cover change in the Augrabies Falls buffer zone has been a massive (100s to 1000s of km^2) conversion of natural to degraded land. It is unclear whether this change reflects true degradation of the habitat at a large scale; it seems more likely a result of difference in classification of land-use outside the park. The land-use practices around Augrabies Falls are mainly viticulture and livestock farming that contribute significantly to the economic security of the region. However these practices along with increased clearing of riparian vegetation, increases in pollution products and increased sedimentation have led to erosion and habitat degradation. This links strongly with the regulation of water up-stream and the quantity of water entering the park. Another observable change is an increase of 21 km^2 of cultivated land (across the 20 km radius from the park boundary), with most change between 5 and 10 km from the park. The increase in cultivation consists mostly of vineyards along the river. This is prime property with very expensive market prices and makes expansion of the park to include the floodplains unlikely.



Vineyards all along the Orange River and in the flood plains

Cultivation is prominent along the Orange River

Buffer area land-use in the 20 km radius around the park as at 2014. The largely natural areas are used for livestock farming, while all along the Orange River viticulture is an important economic land-use for the local communities, from Upington, Kakamas and Keimoes.

The riparian vegetation type was especially identified as a threatened habitat that needs to be monitored. Natural disturbances like floods as well as unnatural disturbances, especially uncontrolled fires originating from outside the park, were listed as key threats to the riparian vegetation. Only small pockets of natural riparian vegetation are left along the Orange River below the main waterfall. Disturbed areas are prone to alien and invasive species that leads to further habitat degradation.

Disease

M

Disease is not currently a major threat in most of the arid parks, although the incidence of particularly vector borne diseases may increase in the future, especially along rivers such as the Orange which may have implications for Augrabies Falls National Park and the Richtersveld. A good example of how anthropogenic landscape change is impacting disease outcomes is that of the black fly (*Simulium chutteri*) in the middle and Lower Orange River. Black fly problems have been linked to the largely regulated flow by large impoundments demanded by irrigated agriculture in the catchment. Blackflies have been implicated in the spread of leucocytozoonosis, bovine and human onchocercosis, the cytoplasmic polyhedrosis virus, the iridescent virus, vesicular stomatitis virus, avian trypanosomes, myxomatosis and Dirofilaria species. It has also been shown that allergic reactions to black fly bites, similar to that described in humans, can lead to death in cattle. In South Africa, simuliids have been implicated in the spread of two pathogens to animals namely a Chlamydophila that causes blindness in sheep and abortion in cattle and Rift Valley Fever virus. Mechanical transmission of this virus by blackflies may have contributed to the major Rift Valley Fever outbreak between Prieska and Groblershoop. Blackflies readily attack exposed parts of the bodies of livestock, such as the eyes, ears and teats, and the resulting wounds are prone to secondary infections which sometimes lead to the death of animals. Blackflies also cause considerable irritation (annoyance) to livestock, animals do not feed or mate, and this results in loss of mass and a reduction in lambing percentage. Due to the large economic losses from black fly worry, attempts to control blackflies in South Africa started with the use of DDT in 1965. This was followed by water manipulation in the 1970s and 1980s, and in the late 1980s the use of larvicides was tested and developed into planned control programmes. Though extensive environmental testing in the mid-90s showed that aerial application of organophosphate larvicides are not damaging to the environment, the chronic low dose impacts of their use is not known and they can cause significant mortality in a number of aquatic invertebrates, not just the targeted blackfly.


LNW | KORTLIKS
MODEL SAL MUGGIEPLAE KAN VOORSPEL

Landbouweekblad November 2016

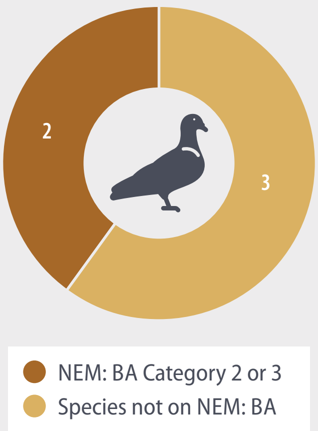
The photos show larvae and pupae of both black fly species (*Simulium chutteri* and *S. damnosum*). The Water Research Commission is currently doing research on at the black fly problem on the Orange River, between Douglas and Blouputs. The study is collecting water temperature data for modelling current and future impacts of water temperatures on blackfly outbreaks.

Alien species

L

Animals

Alien Animals present: **5**



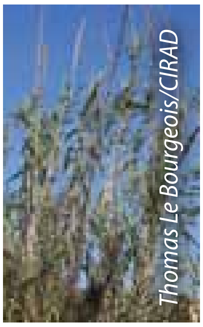
Rock Dove (*Columba livia*) and house sparrow (*Passer domesticus*).

Donkeys and other livestock are present at irregular intervals in the section of the park north of the Riemvasmaak road, which is unfenced, but the animals have little impact. Five alien animals have been documented in Augrabies Falls.

Plants

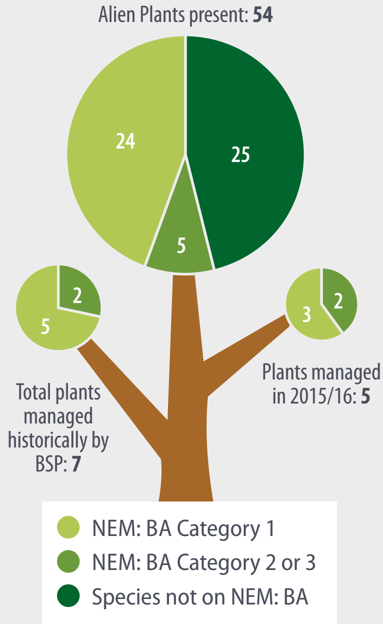
Fifty-four plant species (including 24 Category 1b-listed NEM: BA species) have been documented in Augrabies Falls. Alien species are not a major problem in this park, but as with the other arid parks, mesquite (*Prosopis* sp.) is the main problem. *Prosopis* and Fountain grass (*Pennisetum setaceum*) are relatively widespread, but there has been no appearance of new species. Red water fern (*Azolla filiculoides*) and giant reed (*Arundo donax*) are present in wetter parts of the park.

Mesquite (*Prosopis* sp.)



Giant reed (*Arundo donax*)

Fountain grass (*Pennisetum setaceum*)



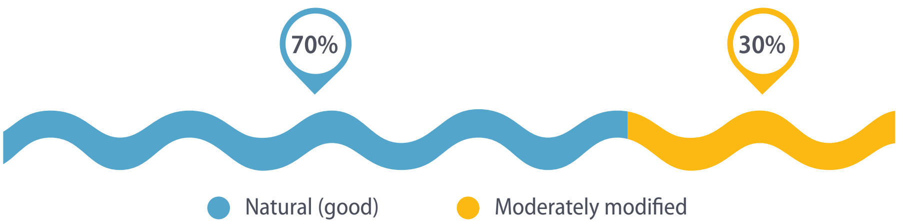
A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

Freshwater

H

QUICK STATS

- Total river length in park: **65 km**
- River Ecosystem types (of 223 in SA): **11**
- River length in good condition: **70%** (remainder moderately modified ecological condition)
- Freshwater Ecosystem Priority Area (FEPA): **18%** of river length
- The development of a wetland inventory is a high priority



Condition of all rivers in Augrabies Falls National Park (as per the National Freshwater Ecosystem Priority Assessment).

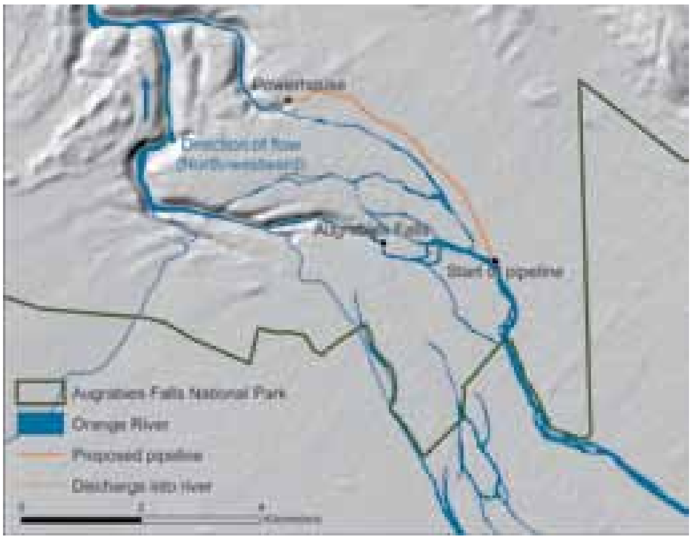
The Orange River downstream of the main falls.

Good relationships between stakeholders, government agencies, farmers and surrounding communities are important for the good governance of the Lower Orange River.

A proposal to develop a hydro power plant in Augrabies Falls National Park has successfully been opposed. The development proposed to divert the river, which could have implications for the flow of the waterfall as well as surrounding aquatic resources and fauna and flora. The developer has been granted time to object.

Since the waterfall plays such an important role in terms of tourism in the park, the decrease in water quality and quantity and inappropriate flows from upstream were listed as concerns.

Aerial photograph of the main falls during flood.



An illustration of where a pipeline was proposed to be built. Water would be diverted to a powerhouse for hydro-electricity generation, after which it would be pumped back downstream of the main Augrabies waterfall.

Resource use

L

Resources used from the park include the harvesting of common reed, the management of *Prosopis* and the use of gravel and water for management and tourism. Donkeys, goats and other livestock belonging to local communities are present at irregular intervals in the section of park north of the Riemvasmaak road (6 342 ha), which is unfenced. While there is no agreement for this action there is little impact at this stage. A separate game fenced area north of the Orange River (7 685 ha), and managed by SANParks, belongs to the community who access the area to visit grave sites. No livestock is allowed.

The off-take of live game from Augrabies Falls supplements game numbers in other parks and has also provided eland (*Tragelaphus oryx*), ostrich (*Struthio camelus*) and giraffe (*Giraffa camelopardalis*) to the ‡Khomani San for introduction onto their farm Erin, in fulfilment of a land claim agreement. Harvesting quotas are informed by ongoing research, monitoring and adaptive management principles to ensure ecosystem integrity.

BONTEBOK
NATIONAL PARK

> Increases in mean annual temperature of between 1.1°C (best case), 1.5°C and 2°C (worst case) are predicted for Bontebok by 2050.

This figure shows the number of summer days reaching between 24°C and 39°C for a hypothetical situation where the historical average maximum summer temperature was 31°C, compared to the range of summer temperatures if average conditions increased by 2°C. Under the previous climate there would be an average of 4 days per summer that get to 35°C or hotter and it would never get hotter than 38°C, whereas there are about 17 days over 35°C under the new climate that has warmed on average by 2°C and 3 days reach 38°C or more. These are conditions not experienced under the previous climate.

Bontebok National Park (~35 000 ha) was initially declared to protect the population of bontebok, but is now also an important reserve providing protection to endangered fynbos and Renosterveld and within this, several endemic and threatened plant species. Bontebok is particularly susceptible to a number of global change factors due to its small size, limited topographical variation and lack of a natural buffer area. The park is entirely surrounded by cultivated land and the town of Swellendam means there is little option for expanding the park to mitigate some of the threats.

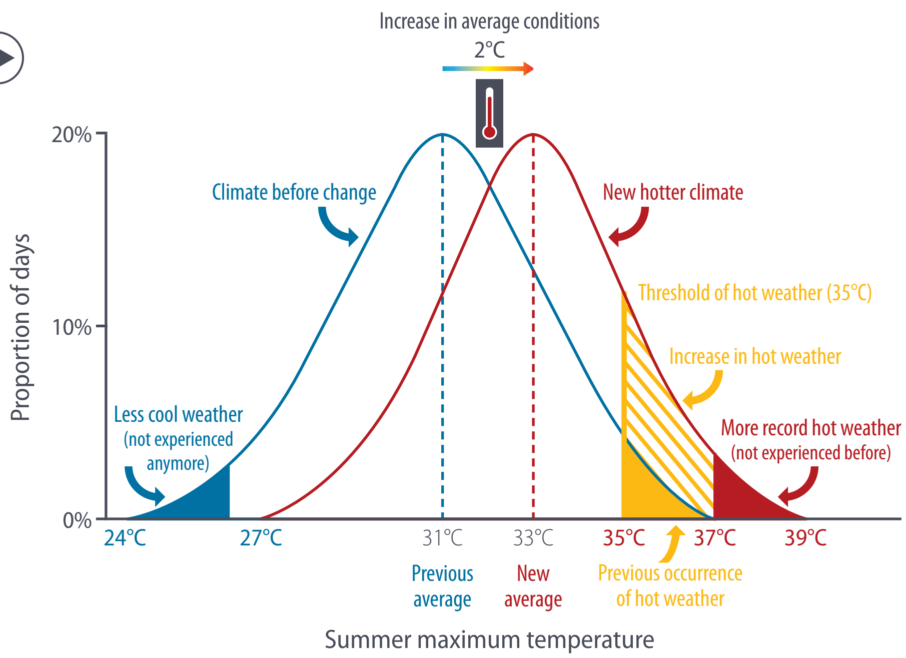
Climate change and land-use change

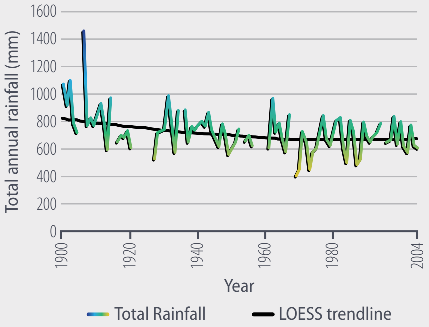
M

Temperature

Temperature data were only available from 1991, and no daily data were available. Therefore no trend analyses were conducted. Average temperatures at Agulhas have however shown an increase of roughly 1°C since 1960. Increases of between 1.1°C (best case), 1.5°C and 2°C (worst case) are predicted for Bontebok by 2050. While the predicted changes seem small, we have demonstrated the effect that a 2°C increase would have on the relative proportion of days above 35 degrees for a hypothetical park where, similar to Bontebok, average summer maximum temperatures are about 31 degrees (see schematic below).

For Bontebok, the biggest climate change impacts in the near future will be the effect that increased temperatures will have on the fire danger index, as well as the ability of fire fighters to control wild fires.





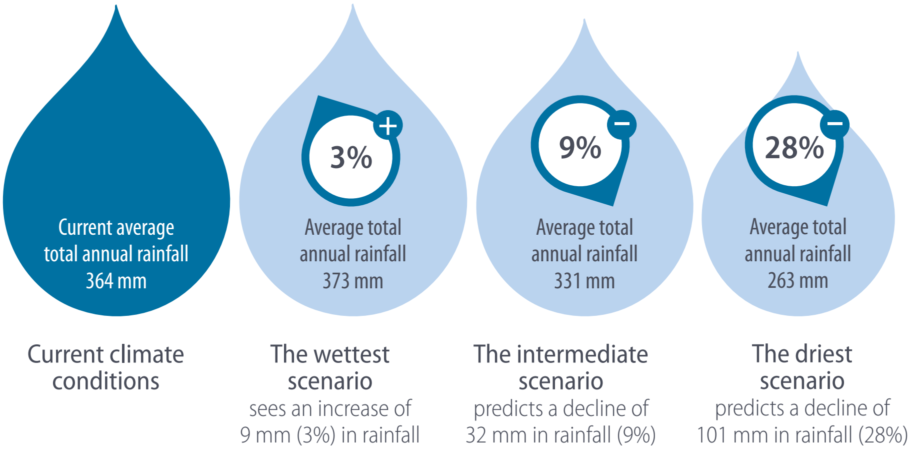
Total annual rainfall at Swellendam since 1900, show a significant decline. Further investigation is required to determine the accuracy of the data in the early part of the century, similar decreases were seen at Bloukrans in Garden Route as well as at Alexanderbos in Addo, and the park should begin investigating the possible impacts of a drier future.

Research is required to determine the impacts that less rainfall and warmer temperatures will have on the plants and animals in this very small park, which provides no options for species to disperse.


the size of Swellendam has **DOUBLED** in the last **24** years!

Rainfall

A decrease in annual rainfall of over 200 mm was detected at the Swellendam station since 1900, but both the park's station as well as the Swellendam station show no change in the last 50 years (since 1960). Other stations in the southern Cape have also showed a decrease in rainfall since 1900. The decrease in total rainfall at the Swellendam station was accompanied by an increase in the percentage of dry days in a year. Predictions for the future largely suggest that the area will receive less rainfall over time.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8 × 1.8 km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios are the most likely for the area, taken collectively in combination with the trends observed at Swellendam, it appears that a decline in rainfall is likely. Also note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of smaller steadier rain events).

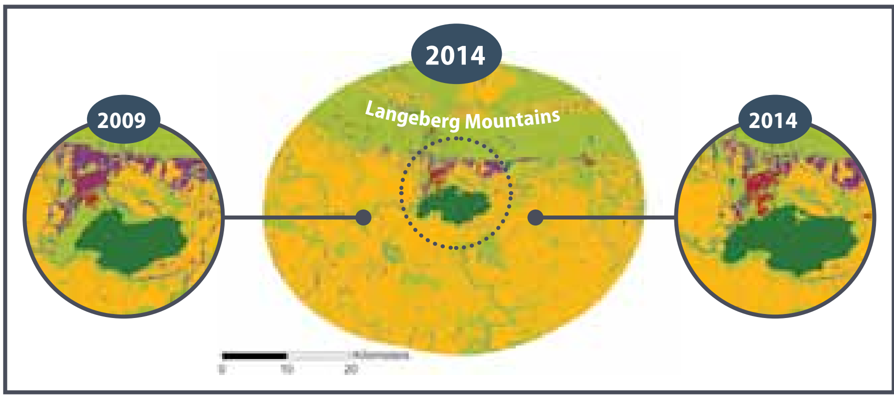
SANParks has an important role in educating the public about the importance of greener lifestyles.	Reducing waste and increasing opportunities for recycling are also critical.
Bontebok can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.	Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

Land-use change

H

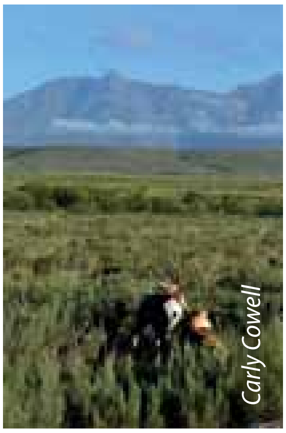
While Bontebok has expanded in size by almost 2000 ha since declaration in 1961, and 700 ha since 1990, the park is now entirely surrounded by cultivated land and the town of Swellendam. The only natural land in proximity to the park consists of drainage lines. The park is separated from the more extensive surrounding natural areas in the Langeberg Mountains and Marloth Nature Reserve by the N2 and Swellendam. Cultivated land in the 20 km surrounding the park has expanded by 33 km^2 (4%) since 1990 into most of the area suitable for cultivation (largely at the expense of plantations and natural land), while Swellendam itself has expanded by 2.4 km^2 (107%), that is, the size of the town has doubled in the last 24 years!



Landcover

- Cultivation
- Mining
- Urban
- Plantation
- Water
- Natural
- Degraded
- National Park

Comparative land-use in the 20 km area around Bontebok in 1990 and 2014. Areas of change include the area directly around Swellendam and scattered increases in areas of cultivation.



The small size and isolated nature of the park, mean that species and populations often do not have a natural ability to respond to chance events and there is always a likelihood that populations may go extinct as a result. More intensive and active management (i.e. sourcing plants and animals of species that occur in the park from elsewhere to supplement the park's populations) is therefore required in Bontebok to ensure that populations remain genetically diverse and retain sustainable sizes.

Disease

M

Disease is not currently a major threat in the park, although the small population sizes of the ungulate species pose a risk should a new disease break out. While the bontebok (*Damaliscus pygargus*) population is currently reasonably large, they have very low genetic diversity, which reduces their ability to adapt to new diseases and climatic conditions. In the 1960s the lungworm *Dictyocaulus magna* was introduced along with the extralimital introduction of springbuck to the park and bontebok subsequently started dying of lungworm. Introducing antelope beyond their original range is not good ecological practice and in this instance also proved detrimental to the bontebok. Springbuck have since been removed from the park, but this case highlights the risk of relocating species from vastly different habitats and outside their natural distribution ranges. The special bontebok population in the park remains a priority for continued disease monitoring.

Equine sarcoids affect the zebras in the park. The incidence of this disease is increasing globally, and although the cause is uncertain, it could be linked to climate change. The virus reached epidemic proportions in Bontebok National Park where 53% of the population were affected. Since then active management has reduced the prevalence of visibly affected animals to close to zero. Though the disease seems complex in its etiology, one study found that the worst affected populations were highly inbred. Isolation of small populations may therefore lead to increased susceptibility to disease by inbreeding. Monitoring is essential for early detection, so that management can be applied to prevent progression of lesions and spread to other animals.

Continued monitoring of disease in ungulates is important. Identifying and monitoring plant diseases is an important future priority.

In terms of notifiable diseases (those which require reporting under the Animal Diseases Control Act), only botulism is thought to be present in the park. African Horse Sickness is however a concern as there are implications for translocating zebras into and out of the control zone for the disease which impacts on SANParks ability to move Cape Mountain Zebras (*Equus zebra*), complicating attempts to manage their genetics across populations.

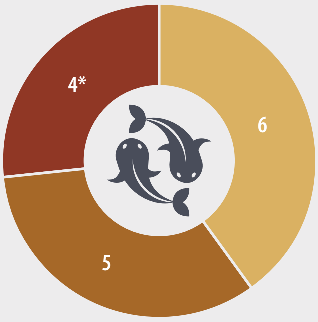
The impacts of plant disease were not considered by the current assessment but could be important under changing climatic conditions.

Mountain zebra (*Equus zebra*) with sarcoid lesions.

Alien species

H

Alien Animals present: **15**



- NEM: BA Category 1
- NEM: BA Category 2 or 3
- Species not on NEM: BA

* All fish species

It would be useful to erect a board at the fishing spots depicting the native and alien fish in the Breede River and explaining some of the negative impacts that alien fish can have.

Animals

Alien animals include several problem fish, such as sharptooth catfish (*Clarias gariepinus*), common carp (*Cyprinus carpio*) and bass (*Micropterus* sp.) that are found in the Breede River and several alien birds, such as mallards (*Anas platyrhynchos*) and hadedas (*Bostrychia hagedash*): although hadedas are an indigenous species that naturally expanded its range, likely largely due to modern agricultural practices. There is currently no management of alien animals in the park, although alien fish species are caught by anglers in the park.

Sharptooth catfish

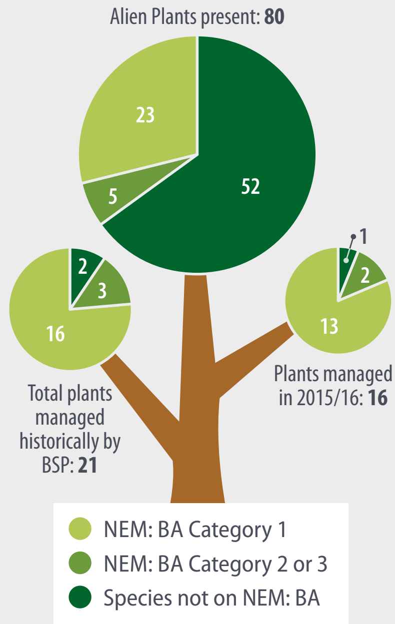
Common carp

Bass

Plants

A total of 80 alien and extralimital plant species have been recorded in the park. This is a high number given the small size of the park and represents the combination of results from a detailed desktop assessment that included BSP data, cybertracker data and numerous published sources (pre-2010) and the results of a fine scale mapping project led by Chad Cheney and collaborators, completed in 2013. The mapping exercise, which documented species presence in 1482 plots across the park, detected 53 alien species. For several reasons only 27 of these species were in common with the desktop assessment. Firstly, unlike the desktop study, the mapping project did not include all extralimital species (such as the protea species that are native to other parts of the Fynbos but were planted in Bontebok). Secondly many of the ornamental species documented in the desktop study have since been removed from the park. Exactly which ones remain could not be confirmed and therefore all have been retained on the list for now. More importantly, the mapping recorded 26 alien species that were not previously known from the park.

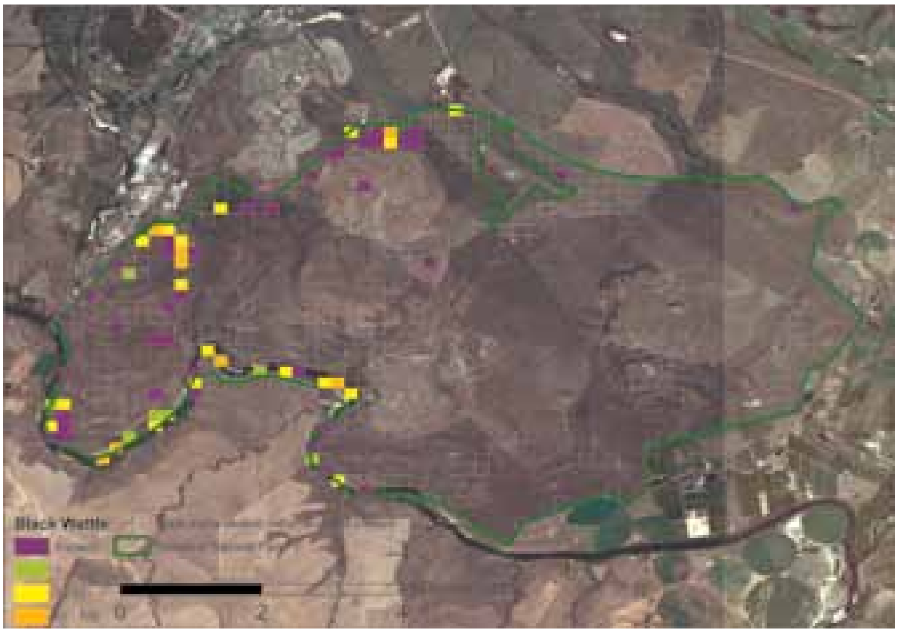
The park is largely in a maintenance phase, with little need for initial clearing, though fires may change this. Currently the mapping shows the highest species richness on the borders of the park, especially along the Breede River, while the inner area of the park is relatively uninvaded. There is also relatively widespread invasion by herbaceous and agricultural weeds.



Fine-scale mapping has provided significant insights into the nature and extent of invasions and will enable:

- Through repeat monitoring, accurate determination of the impacts of control interventions and the impacts of ecological events such as fires and floods or management actions such as the creation of new paths or trails
- More accurate budgets to be determined for work required to control and eradicate species, thereby increasing the likelihood of successful control and eradication of damaging species

A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.



Example of fine-scale mapping results for Black wattle (*Acacia mearnsii*), showing distribution mainly along the park border and the river.

The impact of NEM: BA control requirements will need to be considered before the park takes over management of alien species as there is currently quite a large difference between the average of 10 species that BSP manage annually (13 in 2015/16) and the 23 that will require control plans.

Bontebok is the least invaded of all Cape parks (in terms of density), but significant funds are still committed to the park from Working for Water. The low density invasion, and the presence of fine-scale species distribution data provide an ideal scenario for testing what is required for SANParks to take over the alien species clearing and maintenance function.

Water hyacinth (*Eichhornia crassipes*) is a problem in the Breede River and constantly reinvades the park from upstream after floods. Biocontrol as well as the use of physical barriers placed out of sight under the N2 highway bridge that runs across the river have been suggested as potential management interventions.

Fishing and use of alien plants are beneficial to park management due to their assistance in reducing alien numbers. Fishing clubs are being encouraged to fish in the park to remove the alien fish.

Freshwater

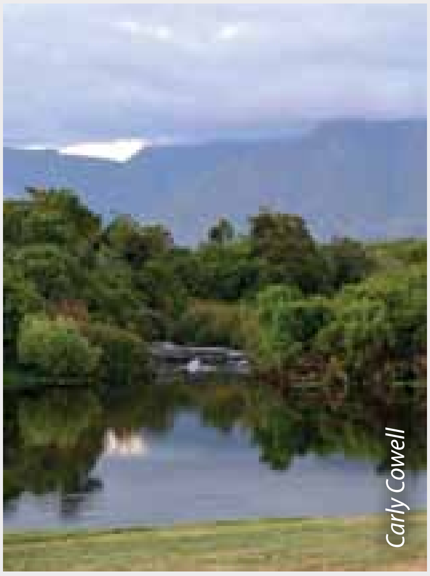
H

QUICK STATS

- Total river length in park: **9.6 km**
- River Ecosystem types (of 223 in SA): **3**
- River length in good condition: 5%; remainder moderately modified condition
- Freshwater Ecosystem Priority Areas: None for rivers
- There is one River Health monitoring site in the park with site code H7Bree-Bonte. The 2011 State of Rivers Report indicate a present ecological state of Good and a Desired State of Good. Flow data is also available for the Breede River just upstream of the N2 bridge at station H7H006Q01

Condition of all rivers in Bontebok National Park (as per the National Freshwater Ecosystem Priority Assessment).

Working for Wetlands is working extensively to restore and improve hydrology in wetland and river systems, rehabilitating drainage lines and restoring water flow. Scientific Services and park management ground-truthed the National Freshwater Ecosystem Priority Areas (NFEPA) GIS layers that represent the distribution and characterization of wetlands. Bontebok covers sections of three different catchments. Mapping of the sections only within the park boundary was completed during 2016. The ground-truthing showed that the NFEPA maps were relatively accurate, but a number of seeps that were not previously mapped were added, boundaries of certain wetlands had to be changed, a number of classifications have been revised as well as information on soils and vegetation added.



Breede River

Resource use

H

Twelve resources are known to be used within the park. This includes game capture off-takes and species used after alien clearing. In some years surplus bontebok are captured and sold, generating income for SANParks and serving a dual management aim of population control and distribution of genetic material in the larger bontebok population. Only isolated incidents of unauthorized resource use such as the picking of aloes and proteas and the occasional snaring of porcupine have been recorded. Illegal resource use is not currently thought to be a major threat. The main resource use activities are angling (of mainly alien fish) and the use of alien plant wood.

CAMDEBOO NATIONAL PARK

Camdeboo National Park (19 000 ha) comprises an arid sub-desert landscape where vegetation cover and composition is primarily influenced by the variation in rainfall. The park virtually surrounds the historic town of Graaff-Reinet and while the Karoo is generally highly resilient, the veld in the park is still recovering from the prolonged effects of mismanagement before proclamation. Non-compatible land-use patterns around the park create challenges; for example stock invasions from neighbouring farms as well as town animals such as goats and marauding dogs. Poor waste management practices within the town result in the pollution of the Sundays River (albeit not within the park boundary), while littering constitutes a serious problem. With the park enclosing a community of some 35 000 people, threats include poaching with the use of dogs, snares or traps; illegal wood collecting by individuals as well as commercial concerns where both dead wood and live trees are removed, and theft, including the removal of material from fences. Breaking, entering, theft, as well as vandalism of a diverse nature throughout the park are all real threats to the biodiversity.

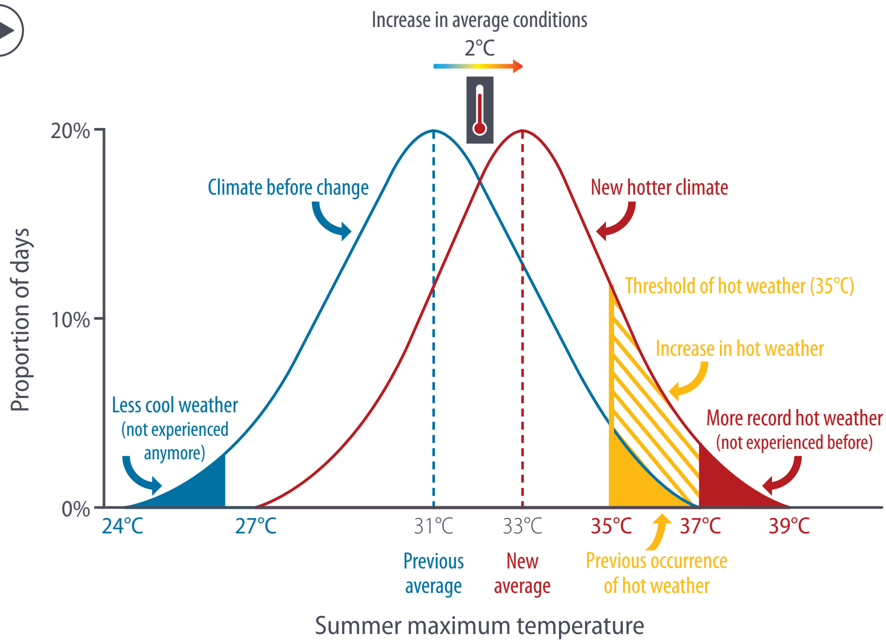
Climate change

L

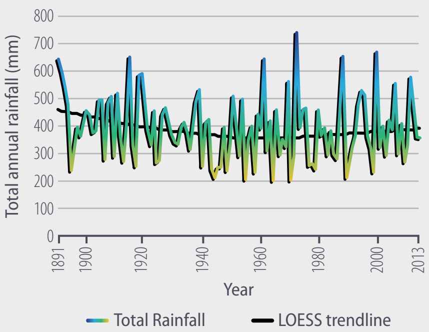
Temperature

At the time of the study, temperature data of a sufficiently long period were not available to analyse. Future projections of climate change are however not encouraging. Increases of between 1.4°C (best case), 2°C and 2.5°C (worst case) are predicted by 2050. While the predicted changes seem small, we have demonstrated the effect that a 2°C increase would have on the relative proportion of days above 35°C for a hypothetical park where average summer maximum temperatures are about 31 degrees (which is very similar to the current averages for Camdeboo; see figure below). The effect of a 2.5°C would be even more dramatic, and under this scenario, nearly half of summer days in Camdeboo would be likely to reach 35°C.

Increases in mean annual temperature of between 1.4°C (best case), 2°C and 2.5°C (worst case) are predicted by 2050.



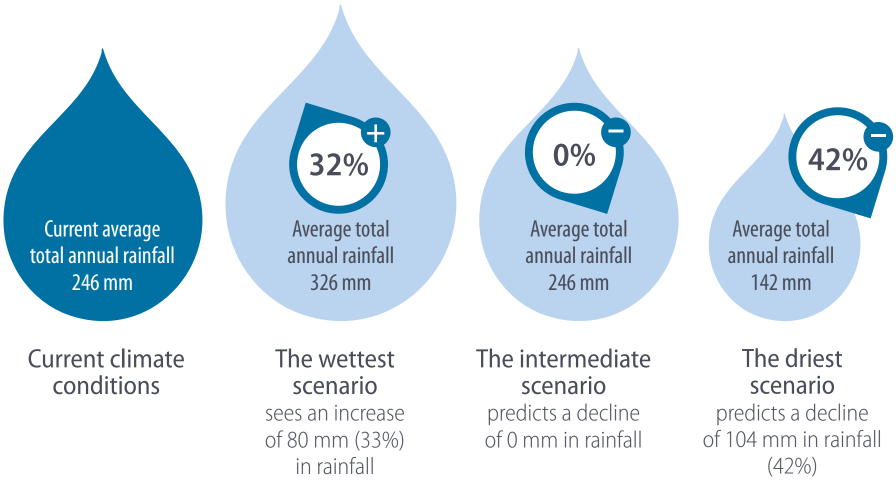
This figure shows the number of summer days reaching between 24°C and 39°C for a hypothetical situation where the historical average maximum summer temperature was 31°C, compared to the range of summer temperatures if average conditions increased by 2°C. Under the previous climate there would be an average of 4 days per summer that get to 35°C or hotter and it would never get hotter than 38°C, whereas there are about 17 days over 35°C under the new climate that has warmed on average by 2°C and 3 days reach 38°C or more – conditions not experienced under the previous climate.



Total annual rainfall at Winterhoek since 1900, showing no significant overall trend.

Rainfall

Analysis of monthly data (dating from 1890) at Winterhoek did not reveal a significant increase or decrease, but detailed analyses were not possible as daily data were not available. Camdeboo is one of few parks where rainfall totals are not predicted to change under the intermediate scenario.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8 × 1.8 km) of which all or part occur in the park, thus representing current averages at a landscape level. The future scenarios are quite variable and it is not yet clear which of these is most likely. Planning for a variety of different possible futures (scenario planning) is therefore recommended. Also note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but could mean heavier rainfall downpours in place of smaller steadier rain events).

Possible biome changes

Future conditions for parts of the park are likely to resemble those currently associated with Savanna whereas under the hottest and driest scenario almost the entire park will resemble Savanna. However higher levels of CO_2, currently being experienced globally, have not been taken into account in these predictions and will favour the growth of woody plants (shrubs and trees), over grassy plants.

While changes in rainfall are not yet apparent, increases in temperature could reduce water availability.

SANParks has an important role in educating public about the importance of greener lifestyles and wise water and energy use.

Reducing waste and increasing opportunities for recycling are also critical.

Camdeboo can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

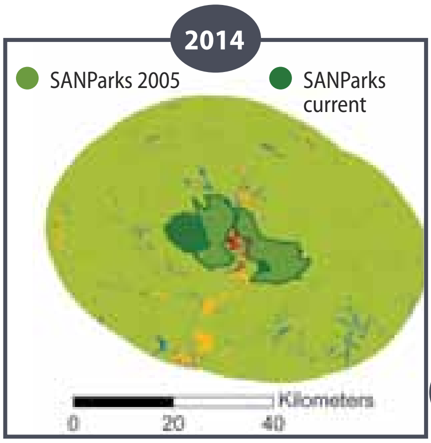
Actions to make a difference

Land-use change

L

Since Camdeboo National Park was declared in 2005, it has expanded by 4500 ha and conserves 5 habitat types. There are long-term plans to connect Camdeboo and Mountain Zebra National Parks, largely through agreements with private land-owners as well as the purchase of some key farms. This corridor project would create a mega-reserve that would seek to conserve 12 habitat types in the transition zones between the Thicket, Grassland and Karoo biomes. Currently the main land-uses around the park are game and sheep farming with little change detectable between 1990 and 2014. Proximity to the town of Graaff-Reinet poses many management challenges, although the size of the town has remained relatively stable since 1990. The major current threat from land-use change is the potential of fracking as well as other mining applications, although many of the land-owners are opposed to fracking.

BSP rehabilitation work has made significant and successful contributions towards combatting soil erosion that was inherited when farms were procured and the park expanded. This is an example of good science-management partnerships for developing, planning and implementing conservation interventions.



Landcover
- Cultivation
- Mining
- Urban
- Plantation
- Water

SANparks
- Natural
- National Park
- Park at proclamation

Land-use in the 20 km buffer area from the park as at 2014. The largely natural areas are used for sheep and game farming, while there is some cultivation south of the park along the Sundays River. The park surrounds the town of Graaff-Reinet.

Disease

L

Disease is not currently a major threat in the park, although the introduction of disease is. This park currently has disease free buffalo, and intends to keep it this way. African horse sickness, malignant catarrhal fever and Botulism are the only notifiable diseases currently thought to be present in the park. Environmental pollutants and pollutant bacteria could also become a problem, especially at the dam.

The Nqweba dam

Alien species

H

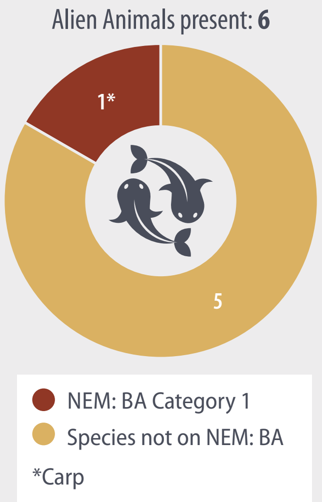
Animals

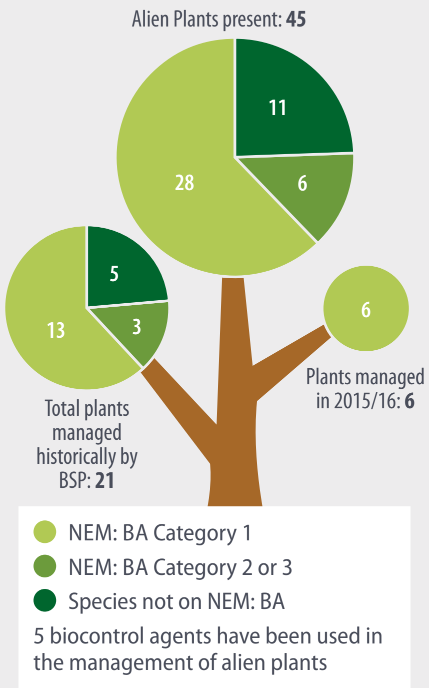
Cats, dogs, domestic ungulates and extralimital mammals regularly enter the park from Graaff-Reinet and surrounding game farms and are controlled opportunistically by park management. Carp (*Cypinus carpio*) (NEM: BA category 1b) are present in the dam and are removed opportunistically through recreational and subsistence fishing.

Plants

Mesquite (*Prosopis* sp.), multiple Cactaceae species, grasses and poplars are present in the park with moderate to high impacts, while the Tamarisk (*Tamarix* sp.) around the dam is a concern. It is currently spreading and thought to be the source of the Tamarisk population downstream in Addo Elephant National Park. Tamarisk is influenced by the dam fluctuation which makes it hard to manage effectively. The cactuses appear to be kept under control through a combination of biocontrol and bi-annual application of foliar herbicide spray.

- Integrated alien species management needs to consider how aliens move within the broader landscape and the implications of clearing in different areas. For example, clearing of Tamarisk in Addo will have little effect if the species is not dealt with upstream in Camdeboo and surrounds
- There is a strong link between degraded sites and the presence and spread of alien species. Rehabilitation of these sites therefore plays a key role in the ability to retain control over alien species





A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

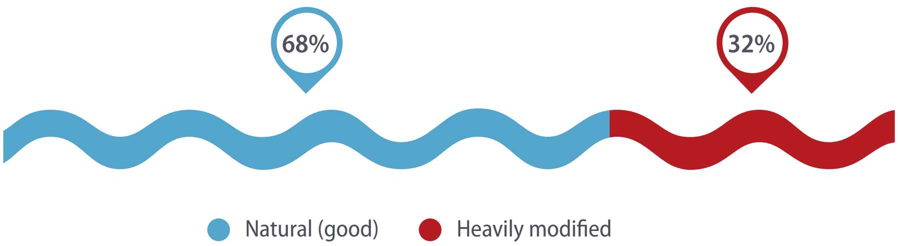
BSP work on an average of 5 species annually, whereas NEM: BA legislation effective from September 2016 requires all 28 category 1b species to be included in plans, and may also require action for the 6 category 2 and 3 species.

Freshwater

M

QUICK STATS

- Total river length in park: **21 km**
- River Ecosystem types (of 223 in SA): **6**
- River length in good condition: **68%** (remainder heavily modified)
- Freshwater Ecosystem Priority Area (FEPA): **58%** of river length
- The wetlands in the park still need to be mapped



Condition of all rivers in Camdeboo National Park (as per the National Freshwater Ecosystem Priority Assessment).

The Pienaars River after a rainfall event.

The park management plan is clear on the state of freshwater in the park: Camdeboo is situated on the edge of the Great escarpment and is part of the Sneeuberg mountain complex which is drained, in the park, by the Sundays, Gats, Melk, Camdeboo, Pienaars and Erasmuskloof Rivers. These are seasonal rivers, although surface water persists year-round in riverbed pools fed by fountains. Strong thunderstorms during spring and late summer cause runoff via these rivers and streams that drain towards the Nqweba Dam in the central area. As a result of poor grazing and hydrology management during the decades preceding 1990 the dam is almost completely silted up and has only about 60% of its original storage capacity.

Resource use

H

Sixteen resources were reported to be used from the park in an initial survey, but this is likely an underestimate. There is a large amount of illegal harvesting happening in Camdeboo due to the proximity of the town and the impoverished state of the local community who see the park as a source for traditional hunting or harvesting. Species and resources targeted include medicinal plants such as elephant's foot (*Dioscorea* sp.) and gifbol (*Boophone* sp.), wood, including sweet thorn (*Vachellia* [*Acacia*] *karroo*), particularly around the dam, and biltong hunting. Resource use has therefore emerged as one of the top priority issues to monitor for the park. Obtaining estimates of the quantities of resources harvested will be important for weighing up the pros and cons of the various suggested management interventions.

Income is generated annually from fishing permits for carp species (*Cyprinus carpio*) and the African Sharptooth Catfish (*Clarias gariepinus*). Neither of these species is indigenous to the park. A small amount of money is also generated through the sale of venison from animals such as black wildebeest (*Connochaetes gnou*) and ostriches (*Struthio camelus*) which are culled according to the management plan. In some years live game sales also take place.

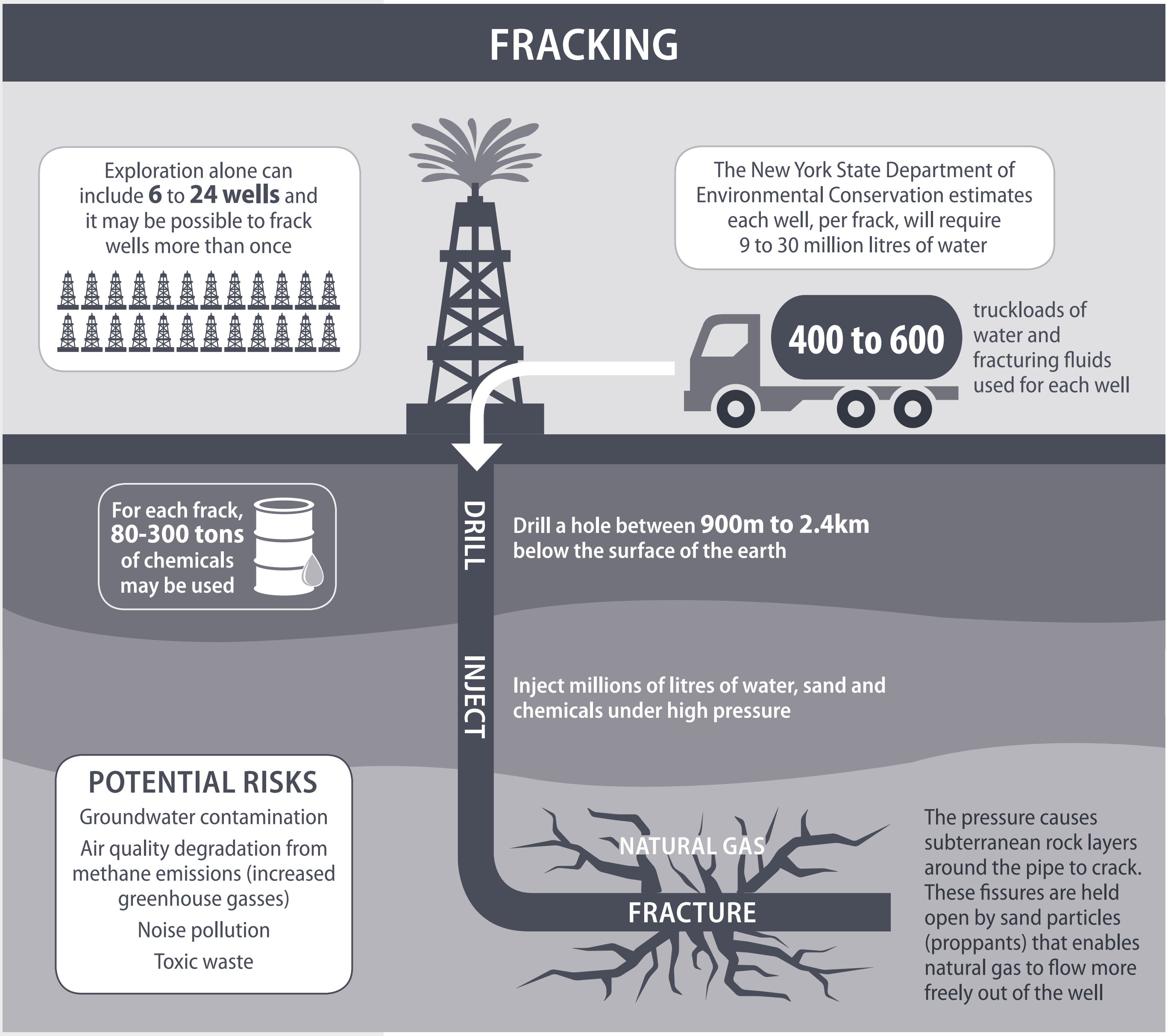
Carp (*Cyprinus carpio*) and Sharptooth catfish (*Clarias gariepinus*).

It will be increasingly important for rangers to document illegal harvesting in order to inform estimates of total harvested quantities of different resources. This information is needed to assess the feasibility of various potential management interventions.

Further research into the impact of sustainable resource harvesting on human well-being needs to be undertaken.

Despite intense poverty, Camdeboo has a highly involved stakeholder community that supports the park in various ways (similar to honorary rangers). The largely open (unfenced) system provides valuable opportunities for comparisons and joint learnings with other karoo parks.

Abiotic resources including gravel and water are used in management. Monitoring the use of these resources is also increasingly important as water security is threatened by climate change and there is ever increasing mining pressure on rocks and minerals outside of protected areas.



Fracking is a process of injecting liquid (in most cases water) at high pressure into underground rocks to force open existing cracks to extract oil or gas. These statistics have been taken from the United States and demonstrate the large volumes of water involved in this process as well as some of the other associated risks.

Fracking and other mining constitutes a threat throughout the Karoo and there is an increase in mining applications for a variety of resources (including sand). Research has already commenced to provide baselines of current conditions.

GARDEN ROUTE
NATIONAL PARK

Over the past decade the district has experienced climate related extreme events, resulting in floods, coastal inundation, fires, and drought. It is anticipated that the greatest impacts will however be on water supply. The expected increase in temperatures may result in increased fire frequencies and more intense fires which could have a major impact on the biodiversity of the region. Other impacts include sea level rise and increased flooding.

A buffer zone was established around the park as a climate change adaptation strategy and to protect the ecological integrity of the Garden Route National Park. The buffer zone footprint consists of a fire management area (north of the park) and an ecological infrastructure restoration area (see the section on land-use change). The aim is to enable biodiversity persistence by allowing for the migration of plants, animals and birds in response to changing climatic conditions. It is thus important to protect important areas of high value for biodiversity beyond the boundary of protected areas.

The Garden Route National Park, hereafter GRNP, (115 000 ha, plus 27 000 ha of Marine Protected Area) lies between the Outeniqua and Tsitsikamma mountains and the Indian ocean, extending from Mossel Bay in the west to 30 kilometres east of Storm River. The area includes major towns and scenic biodiversity, forests, fynbos and rugged coastline. The Garden Route is a matrix of landscapes including protected areas, agriculture, plantations and development nodes with an increasing human population. The diverse land-uses increase the spread of alien species throughout the protected areas where the fire regime has already been altered. Aliens also contribute to an increased fire load that could have devastating effects on all land-users in the area. There is already increased pressure on the limited water resources that have been altered by the construction of various dams. Agriculture, households and plantations are the major water users in the Garden Route. Weather records support a drying trend from west to east, with weakening winter rainfall and possibly slight increase in summer rainfall (more variable) and rising temperatures in an already transformed landscape. Sea levels are predicted to rise with extreme wave run-up events. Protected areas in the Garden Route are important climate change refuges, protecting natural water sources and acting as buffers for adaptation in changing times. Stakeholder engagement is important in this park to ensure all communities work together to understand how climate change will affect their daily lives.

Climate change

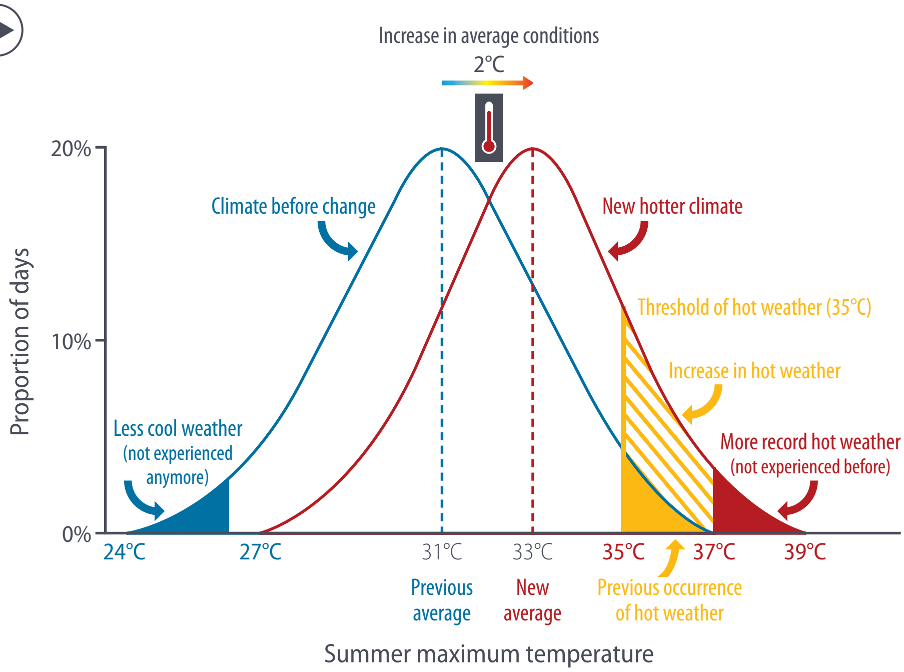
M

Climate change is one of the most significant emerging challenges facing the park. Regional predictions suggest a drying trend with a weakening of winter rainfall, a shift to more irregular rainfall of possibly greater intensity, and rising temperatures.

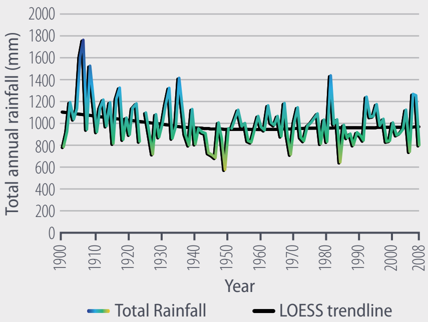
Temperature

Although no temperature data of a sufficiently long period were available for analysis, future predictions indicate that the temperature in the region will increase by between 1.1°C (best case), 1.5°C (intermediate) and 2°C (worst case) by 2050. While the predicted changes seem small, we have demonstrated the effect that a 2°C increase would have on the relative proportion of days above 35°C for a hypothetical park where average summer maximum temperatures are about 31°C (see figure below). Temperatures in the Garden Route are not generally this high, but the principle remains the same and an increase in hot days will in turn affect the number of days with a high fire danger index, as well as the ability of fire fighters to control wild fires.

Increases in mean annual temperature of between 1.1°C (best case), 1.5°C and 2°C (worst case) are predicted for the Garden Route region by 2050.



This figure shows the number of summer days reaching between 24°C and 39°C for a hypothetical situation where the historical average maximum summer temperature was 31°C, compared to the range of summer temperatures if average conditions increased by 2°C. Under the previous climate there would be an average of 4 days per summer that get to 35°C or hotter and it would never get hotter than 38°C, whereas there are about 17 days over 35°C under the new climate that has warmed on average by 2°C and 3 days reach 38°C or more – conditions not experienced under the previous climate.

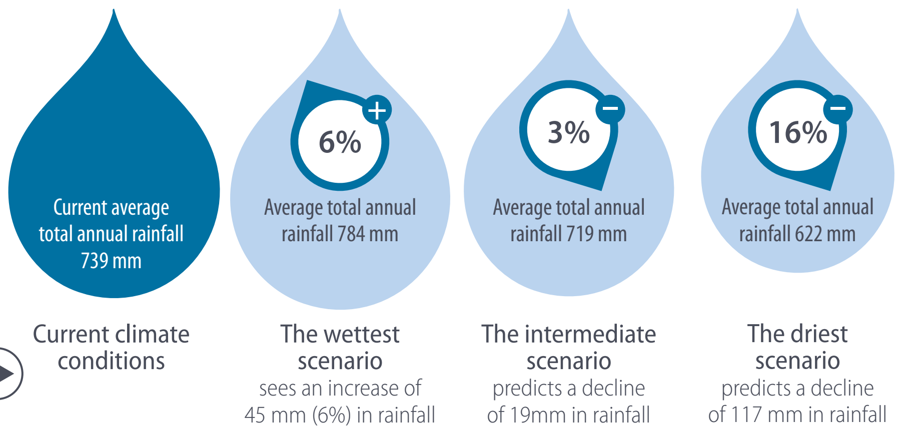


Total annual rainfall at the Bloukrans station since 1900, showing a significant decline.

Rainfall

A significant decrease in annual rainfall was detected over 110 years at the Bloukrans station in the Tsitsikamma section. The decrease in rainfall was also associated with an increase in dry days and rainfall variability (i.e. larger differences in rainfall totals between years). While the trend in rainfall at the Bloukrans station showed a very similar pattern to other stations in the area, it was the only station where a significant decrease was detected (although other stations did however have a higher proportion of missing data). Similar decreases in rainfall were also seen at Alexandriabos in Addo as well as Swellendam, near Bontebok. Although further investigation is required to determine the accuracy of the data in the early part of the 1900s in these parks, Garden Route should begin investigating the possible impacts of a drier future.

This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8 × 1.8 km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely, the historical record (since 1900) suggests that declines have already taken place. Note however, that the range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events).



Possible biome changes

Because the Forest biome is comparatively small in South Africa, it is hard to model what will happen to the forest as climate changes. However, under the hottest and driest scenario it is likely that large portions of the park would have climatic conditions that are more characteristic of areas supporting Thicket than Fynbos or Forest. In general, the eastern portion of the Fynbos biome, in which the GRNP resides, is predicted to be less stable under a changing climate than the western part of the biome.

It will be important for SANParks to continue to: engage with municipalities to encourage them to include critical biodiversity areas in the Spatial Development Frameworks and private landowners to clear alien vegetation, join the Southern Cape Fire Protection Association, maintain connectivity in the landscape, take note of coastal management lines, implement best practice storm water management principles, prevent erosion and to protect indigenous vegetation and rehabilitate degraded areas.

SANParks has an important role in educating public about the importance of greener lifestyles.

Reducing waste and increasing opportunities for recycling are also critical.

The park can save water and electricity in a number of ways including use of low flow toilets, rainwater harvesting and tourist and staff awareness programmes.

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

Coastal erosion at Wilderness.

Sedgefield during the 2007 floods.

Tsitsikamma infrastructure destruction by high seas in 2008.

High sea swell in 2008.

Land-use change

H

The Garden Route National Park (GRNP) is a complex of protected areas managed as a single entity. It includes the previously proclaimed Tsitsikamma and Wilderness National Parks, state forests and mountain catchment areas, contracted areas, as well as the Knysna National Lake Area. SANParks currently manages ~156 000 ha of land in the Garden Route, consisting of 43 500 ha indigenous forests, 80 000 ha fynbos and mountain catchment areas, 2 400 ha of lakes and estuaries, 27 500 ha of marine areas and 2 600 ha of infrastructure e.g. roads, staff houses and tourist facilities. Land-use change within the GRNP is mainly driven by the removal of plantations and conversion of these areas back to fynbos and sometimes forest and in the buffer zone, by development. The GRNP conserves 14 terrestrial and 6 marine habitat types.

The impacts of drying on plant and animal communities and climate change-sensitive species need to be investigated.

The drying detected in the southern Cape is likely to result in a decrease in the proportion of forest in relation to other biomes, which could have implications for tourism in the region. The drying could also have implications for the fynbos. Ericas are particularly vulnerable to drought, while Proteaceae seeds are vulnerable to drought once they have started to germinate. This means that the timing of fire (which stimulates fynbos seed release and germination) in relation to droughts will be a particularly important determinant of biodiversity maintenance in the region.

There is a need for managed retreat and redesign of infrastructure in flood prone areas. Management may have to reconsider the placement of the current rest camp infrastructure at Storm's River and Wilderness' Ebb and Flow as damaging storms are predicted to become more frequent with sea-level rise. Rebuilding and maintenance may become cost inefficient. Climate change adaptation measures should include no new development below the 1:100 year flood line or in coastal hazard zones.

An integrated approach to climate change adaptation is required where landowners across cadastral boundaries actively plan and work together to deal with extreme weather events and related damage to property.

Land use inside GRNP

THE PLANTATION EXIT STRATEGY

1993

SAFCOL requested to remove low yielding plantations from commercial forestry

2000

Cabinet approved ~25 000 ha for other land uses

- Increased biodiversity through the addition of natural corridors for:
  - seed and animal movement
  - a new vegetation type, not previously represented in the park (Kleinplaat Grassy Fynbos)
  - removal of the seed source of pines, the greatest alien species threat in the park
- More tolerance of natural fires that were suppressed in plantations, and better management of fire spread into non-fynbos areas
- Increased tranquillity of hiking trails and mountain bike routes (free of noise created by chainsaws and heavy machinery used during harvesting)

Burning, which is not implemented in plantations, is vital for biodiversity in fynbos which is often dominated by kystervaring (*Gleichenia polypodioides*) during recovery after pine removal. This fern forms hectares of impenetrable 2 m+ monocultures if not burned. Burning plans should be implemented for biodiversity and alien control.

Buffer zone

To protect the ecological integrity and resilience of the system, a buffer zone was established to enable climate change adaptation where possible, consisting of two areas:

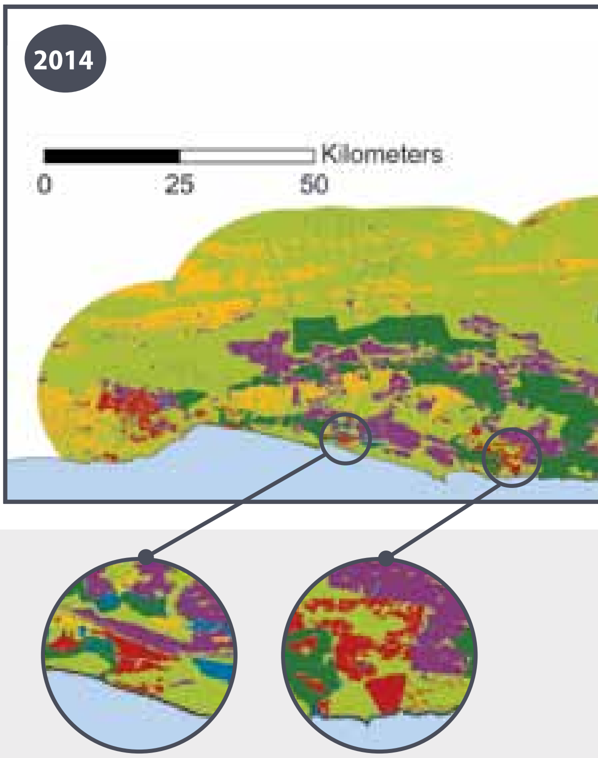
i. the Fire Management Area (151 245 ha) and

ii. the Ecological Infrastructure Restoration Area (231 475 ha)

- priority alien clearing areas
- properties adjacent to the GRNP
- conservation corridors along river systems
- east-west linkage corridors

requires the maintenance and restoration of terrestrial and aquatic ecosystems on private land and to a lesser degree in commercial forestry plantations

Land-use change in the GRNP buffer zone is mainly driven by habitat loss as a result of infrastructure development, and an increase in alien infestation and an expanding agricultural practices



Landscape connectivity varies from functional to dysfunctional, with the most pressure for transformation occurring in the Knysna and Wilderness areas

Land use outside GRNP

(i) Development on floodplain at Lake Brenton.

(ii) Alien vegetation along the Knysna River.

- There are 14 active conservancies in the GRNP buffer Zone (Kaaimans, Touw River, Sedgefield Island, Constantia Kloof, Cola Beach, Phantom-Homtini, Gouna, Western Heads – Goukamma, Noetzie, Indalo, Middle Keurbooms, Redford, Crags and Paradise Ridge)
- The majority of landowners with high-value biodiversity properties are supportive of conservation on their land and want to participate **in alien clearing projects and biodiversity conservation**
- The Robberg Coastal Corridor Protected Environment was declared on 4 September 2015. It is located within a highly ecologically sensitive coastal area that links the Robberg Nature Reserve and the Harkerville Section of the GRNP

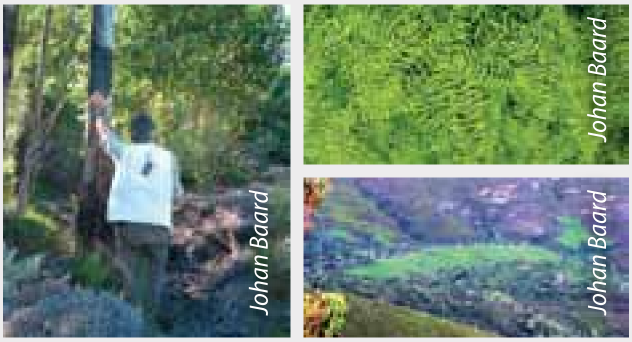
Landscape connectivity is important as it determines dispersal opportunities between patches which influence:

- gene flow,
- local adaptation,
- extinction risk,
- colonisation probability,
- potential for organisms to move as they adapt to climate change

– Garden Route National Park

2012

First geo units were transferred to SANParks



Kystervaring (*Gleichenia polypodioides*). The burn mark on the tree in the left-hand photo indicates the height at which the Gleichenia had been growing.

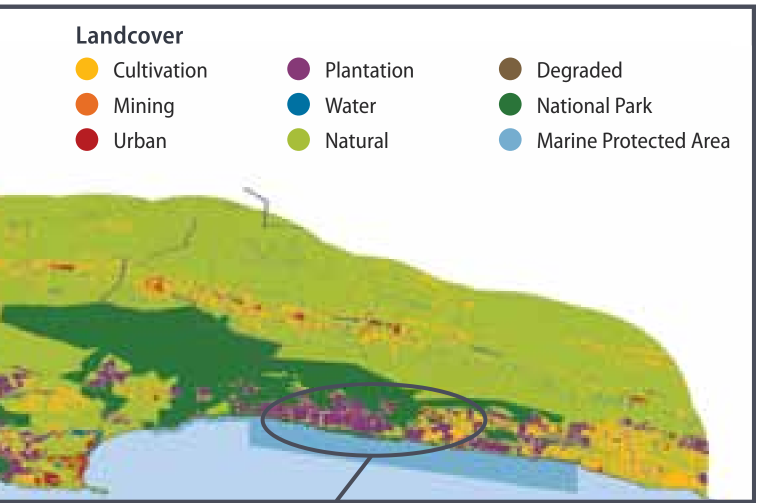
2016

Process currently halfway with ~12 008 ha transferred to SANParks

Additional land brings added responsibilities and expenditure

- 750 km of new roads to maintain, erosion control, quarries rehab
- fire management (previously absent)
- law enforcement
- servitudes and land register needs to be updated
- budget and implementation capacity for new work

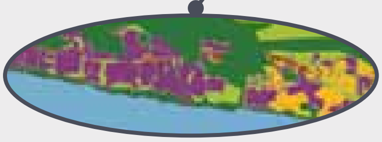
Controlled burns should be undertaken in plantation exit areas. Emphasis needs to be placed on maintaining the skill of conducting prescribed burning.



Floods, coastal inundation, fires and drought, invasive alien vegetation, poorly located infrastructure and an increased demand to transform threatened ecosystems and remaining natural vegetation for new development are the key challenges in the GRNP buffer zone.

As a proactive measure to promote conservation outcomes in the GRNP buffer zone, SANParks has commented on in excess of 300 development and land-use change applications over the past 7 years.

Private landowners are supportive of alien clearing projects and belong to the Southern Cape FPA (316 landowners).



The Tsitsikamma area is heavily transformed by dairy farming and plantations

Dairy farming and plantations contribute to landscape transformation.

Red flags include:

- Inappropriate approval of housing developments in areas with high biodiversity value or in flood prone areas and a general lack of maintenance of municipal infrastructure
- Inadequate and ill-functional waste water treatment systems polluting rivers and estuaries in the GRNP and its buffer zone
- Demand for potable water is exceeding available supply in times of drought in Knysna and Sedgefield
- Infilling of wetlands for new housing developments, sports fields and agricultural activities
- Historic infrastructure was developed on floodplains and flooding takes place during extreme rain events
- Coastal Management lines (setback lines) are not in place in the Eden District
- The CAPE Nature protected area expansion plan (priority areas for stewardship) falls largely outside of the GRNP buffer zone thus limited capacity to support in ecological functionality of buffer zone
- Increased baboons and other damage causing wildlife interactions on private property over the past 5 years

With good stakeholder engagement and relationships, challenges such as wild animals entering urban areas can be mitigated.

- Good stakeholder relationships in an urban park and associated buffer zone are important to maintain joint collaboration and conservation benefits
- Continue to provide comments on any new developments or land-use change applications
- A more integrated approach between conservation authorities, municipalities and landowners is required to deal with wildlife in an anthropogenic landscape
- SANParks should consider adopting a formal biodiversity stewardship approach for possible conservation areas in collaboration with other PA agencies and NGOs in the buffer zone

There is often a conflict of interest when baboons live in close proximity to people.

Land-use and alien species:

- Analyse and quantify the contribution of SANParks commenting role over the past 8 years on ecosystem functionality, biodiversity conservation and climate change adaptation in the GRNP buffer zone
- Identify and prioritise private properties that contribute to achieving national biodiversity targets in the park's buffer zone
- Quantify the current status and value of wetlands in the GRNP buffer zone
- Investigate the effect of landscape fragmentation on forest and fynbos mammal species assemblages
- Determine whether natural regeneration of forestry areas (including assessment of compacted former commercial forestry depot areas) leads to acceptable levels of diversity and document restoration of natural processes
- Fire management and implementation strategies including monitoring of alien species before and after burning

Why fire is important

- Fire in fynbos is an important driver for seed germination and fynbos rejuvenation
- Lack of periodic fires in the fynbos resulted in the Thicket-Fynbos biome interface being largely eliminated and replaced with Thicket vegetation and thus the Lowland fynbos in Garden Route is under severe pressure
- The following ecosystems are poorly protected and without fire in the system extinction is probable:
  - Knysna Sand Fynbos (critically endangered)
  - Garden Route Granite Fynbos (endangered)
  - Garden Route Shale Fynbos (vulnerable)
- Fire management is also very important in an open access park as risk of wild fires to property developments and commercial plantations can have considerable financial implications

Fires in the Garden Route.

Disease

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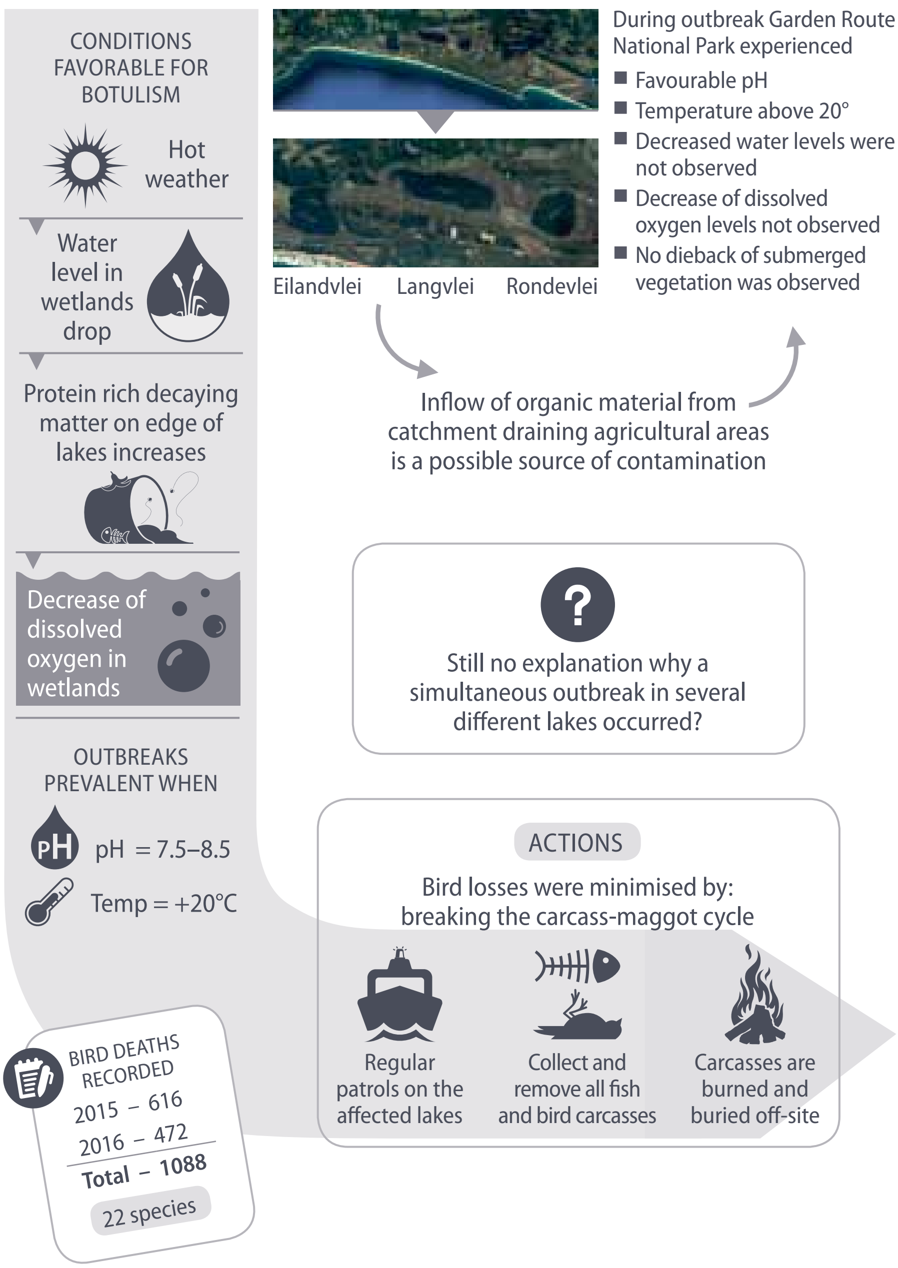
Disease is not currently a major threat in the park, although this may change in the future, especially considering the recent outbreak of avian botulism in waterbirds in the lake system. The coastal component of the park may be at risk for future disease, especially shore birds, while plant diseases have not currently been considered, but could have significant impacts under changing climates.

Avian Botulism Outbreak 2015/16

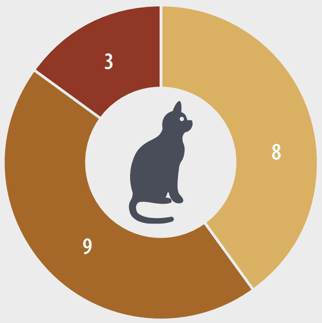


Changes in the abundance of most waterbirds are likely being driven by factors other than local disease outbreaks, though short-term declines in the local abundances of Cape shoveller (*Anas smithii*) and Yellow-billed duck (*Anas undulata*) due to disease may be possible.

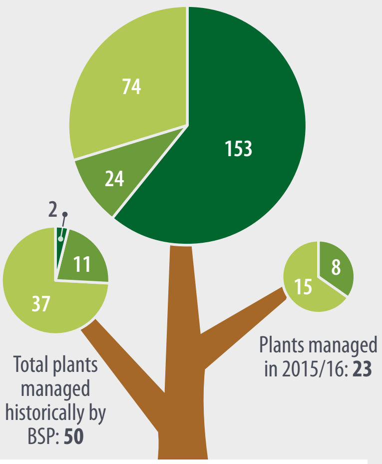
- Declining waterbird numbers with Thresholds of Potential Concern exceeded for commonly affected species
- Long duration of botulism outbreak suggests possible continuing organic inputs into the lakes

- Assessment of tissue samples from affected birds and fish for toxins, undertaking histological investigations and monitoring of environmental conditions to confirm the diagnosis and provide advice on the management of outbreaks
- Linkage of botulism outbreaks to the recent proliferation of alien carp (which are susceptible to Botulism type E), and their habit of mobilising sediments during feeding, is unknown though warrants attention

Alien Animals present: **20**



Alien Plants present: **251**



12 biocontrol agents have been used in the management of alien plants

- Proactive measures to promote conservation outcomes in the GRNP buffer zone, resulted in alien vegetation clearing on private land over the past 3 years via the BSP buffer zone project
- Approximately 2 500 initial hectares and 950 follow-up hectares have been cleared with in excess of R12 million having been invested
- A prioritisation methodology for alien clearing on private land was developed to focus available resources on the most important areas for climate change adaptation and biodiversity conservation
- Currently 361 landowners are members of the Southern Cape FPA in the GRNP buffer zone

Alien species

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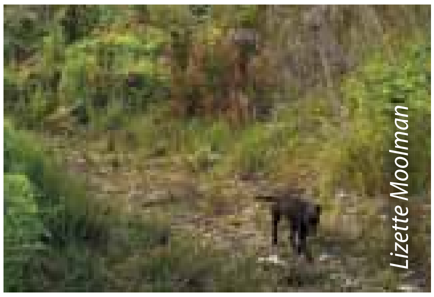
Animals

There are no formal eradication programmes and animals are managed on an ad hoc basis.

Cats and dogs can enter the park and become a problem. Dogs have been seen on camera traps and are cause for concern.



Camera trap photo of domestic dog in GRNP.

Plants

The GRNP is highly fragmented, consisting of approximately 30 detached portions, and has a high edge-to-area ratio, with farmland, plantations and towns dispersed along its boundaries. This makes the park particularly susceptible to the immigration of species. There are also many public roads in the park, including the N2 that runs through the length of the park. Numerous access points and trails for vehicles, cyclists and hikers also act as conduits for alien plant introduction and dispersal. Commercial forestry has contributed greatly to the high number of alien species in the park. Approximately 8% of the terrestrial park area was previously covered by plantations.

The areas most impacted by aliens are disturbed and transformed habitat, although undisturbed fynbos is also being invaded. Fynbos appears to be more vulnerable to alien species than other vegetation types. Although fewer species are found in riparian habitat, all species in these areas are either invasive or transformers. The GRNP has a comprehensive invasive alien clearing plan that covers all habitat and land-use types. The plan prescribes clearing of fynbos areas on a four year cycle, forest on an eight year cycle, and the rivers on a two year cycle.

- Alien vegetation increases the fuel load and can be a fire risk close to developments or burn too intensely in natural areas destroying seed and changing soil structure.
- There are no guarantees that landowners will keep their properties clear after one initial clearing and two follow-ups by SANParks / BSP teams. Land is sometimes converted to crop land after clearing.
- The important rivers draining into the various lakes and estuaries are highly infested with alien plants.
- The rivers traverse a number of land managers and owners (e.g. SANParks, Cape Pine, private, etc.).
- Optimally, fynbos clearing should start 1–2 years after a fire, with the four year follow-up cycle aiming to clear young pines before seedset takes place. This clearing plan is possible under the current budget, but does not allow for clearing other habitat types such as forest.
- 98 species are listed on NEM: BA (74 category 1) and will require management. Only 48 NEM: BA listed species have been prioritised for work in at least 10 of the last 13 years (available collated data).

Pines (*Pinus* sp.) growing in the fynbos.

Alien clearing on private land in Homtini conservancy.

Private land earmarked for an ecological burn to restore critically endangered Knysna Sand Fynbos.

Rivers draining into the lake and estuary systems are heavily infested with alien plants.

Good planning and skilful project management, including follow-up, is essential for alien clearing to be successful in the long-term.

A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

- Maintain the Invasive Alien Plant Clearing Plan unless lessons indicate a change in activities are required
- The alien plant species, their locations, densities and the best control practices should be known by all involved
- Very little high altitude and river clearing has been done. This needs to be aligned with normal BSP work
- Encourage ecological burns of lowland fynbos where it is still possible
- Liaise with other government agencies to put mechanisms in place for fiscal incentives and rate rebates for landowners that manage their properties for conservation
- Co-ordinate river clearing incentives and actions amongst all relevant stakeholders
- Alien clearing teams need skilful management, good planning and capacity building with effective supervision and continued monitoring where clearing and hacking have been done

Freshwater

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Alien vegetation along the Gouna River.

Effective freshwater management and conservation can be best achieved through cooperation with other resource users, including the catchment management agency, in relevant catchments. Good stakeholder relationships and engagements are important.

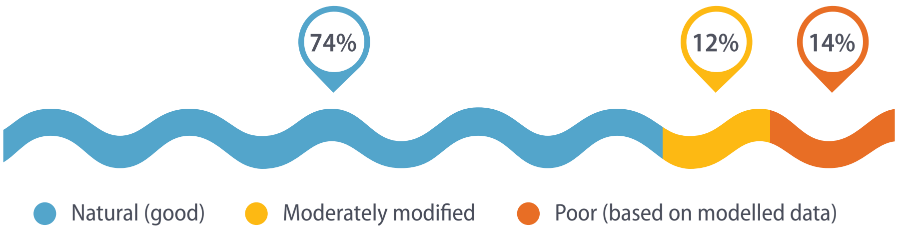
- Because of the fragmented nature, most of the estuaries and lakes within the park are not buffered from actions that take place outside the park. Multiple impacts accumulate along longitudinal (the length of a river) and lateral (from terrestrial to aquatic) gradients, degrading the overall condition of aquatic ecosystems
- Although the River Health monitoring programme monitors rivers in the Garden Route the coverage of rivers inside the park is very limited
- Alien vegetation especially black wattle and blackwood is a serious problem along all rivers

- Two percent of GRNP overlaps with South Africa's Strategic Water Source Areas, making it the biggest contributor among NPs to the conservation of these important water source areas
- Eight free-flowing rivers occur in GRNP – more than in any other park. These rivers and the percentage inclusion by river length within the park are: Groot (West) (100), Bloukrans (90), Palmiet (67), Karatara (51), Hoëkraal (51), Knysna (43), Homtini (34) and Touw (32) Rivers

A socio-ecological systems model for rivers, lakes and estuaries needs to be developed to aid future management.

QUICK STATS

- Total river length in park: **352 km**
- River Ecosystem types (of 223 in SA): **7**
- River length in good condition: **74%**, all of which has also been designated a Freshwater Ecosystem Priority Area (FEPA). The remainder is split between moderately modified (**12%**) and 'not intact' (**14%**)
- The development of a wetland inventory is a high priority and the process for inventorying wetlands has already commenced in some of the other parks



Condition of all rivers in Garden Route National Park (as per the National Freshwater Ecosystem Priority Assessment).

Strategic Water Source Areas (SWSAs) are those areas that supply a disproportionately high amount of the country's water in relation to their surface area. South Africa's SWSAs make up 8% of the land area but provide 50% of the mean annual runoff. Only 16% of these SWSAs enjoy formal protection in South Africa as a whole, with national parks contributing approximately 1%. Five national parks overlap with strategic water source areas: Bontebok, Garden Route (by far the largest contributor) Golden Gate Highlands, Kruger and Table Mountain National Parks (see infographic on p. 193). Only three free-flowing rivers in the country have their entire length fully protected, the Groot River in Garden Route and Mbyamiti and Nwanedzi-Sweni Rivers in Kruger.

Resource use

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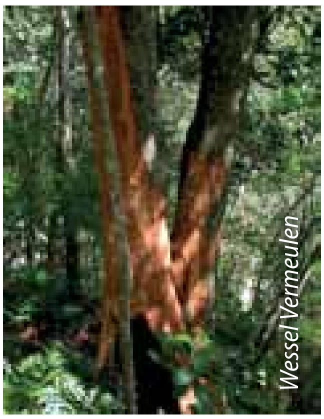
A total of 134 resources were reported to have been harvested from terrestrial and aquatic systems in the park. These include marine species such as bait organisms and various fish species and indigenous and alien plants, plant parts and animals as well as abiotic resources (e.g. soil and water). Some resource harvesting, for example timber and ferns for commercial purposes, is authorised under tender or licence agreements. Unauthorised and uncontrolled harvesting, especially of marine and medicinal plant resources also takes place. The open-access and fragmented nature of the park make access control difficult.

Terrestrial resource use

Resource use in GRNP includes plants for medicinal and ritual purposes, timber harvesting, selling of indigenous plants in the nurseries and cuttings and seeds for propagation. Estimates of quantities harvested are available for ferns and timber species and for some medicinal plants. In addition to indigenous timber, large volumes of alien timber species are harvested for furniture items and quantities are aligned with the invader plant control and rehabilitation programme in the park. The demand and user needs for resource use in the GRNP could increase due to urban population growth and influx of people with different cultural and traditional practises.

Medicinal plant harvesting and harvesting of kystervaring (*Gleichenia polypodioides*) used as greenery in flower arrangements.

Research on rooiwortel (*Bulbine latifolia*) harvested for medicinal purposes and the monitoring of seven weeks fern (*Rumohra adiantiformis*) used in flower arrangements.



An example of illegal bark harvesting and the monitoring of experimental harvesting of bark.

The costs and input required to develop sustainable harvest systems through appropriate research and long-term monitoring should not be underestimated

- A better understanding of user needs and stakeholder dynamics is required
- The viability of nurseries to supply medicinal plants instead of harvesting in the wild, should be explored. For example, rooiwortel (*Bulbine latifolia*) shows a slow rate of renewal in the wild, but could be grown successfully in nurseries
- The harvesting of medicinal bark as by-product of timber harvesting should be explored as an alternative to bark stripping. For most species (e.g. *Curtisia dentata* and *Rapanea melanophloeos*) strip harvesting is not a sustainable harvest option
- Continue with long-term monitoring of target species to support sustainable use (e.g. *Rumohra adiantiformis* used in flower arrangements and timber species)

- Alternatives to harvesting from the wild, such as the use of alien species and the establishment of medicinal plant gardens, could reduce the pressure on natural resources. The supply of fynbos species in particular is limited within the defined resource use zone in the park
- Keeping accurate records of resource use, including incidences of unauthorised harvesting, is of critical importance in managing resource use and identifying long-term trends
- Harvest systems should be developed and implemented in collaboration with the relevant user groups

- Poor awareness of fishing regulations by recreational and subsistence anglers
- High retention rates (most fish caught are kept and not released)

- Increase our understanding around the drivers of non-compliance and angler behaviour
- Understanding connections and site selection choices amongst anglers (sense of place)

- An angler education and awareness program needs to be implemented to inform anglers of fishery regulations and their importance
- Catch and release angling should be promoted
- Law enforcement is an integral component of fishery management and should be taken more seriously and actively undertaken
- Avenues should be explored to increase communication and improve relationships between anglers and SANParks

- Well established monitoring of the recreational and subsistence line fishing occurs within the park
- Innovative means of monitoring coastal fish communities through the use of baited remote underwater cameras are being evaluated

Marine resource use

Coastal and estuarine fishing occurs within the GRNP by both recreational and subsistence fishermen, whilst some commercial and charter boat fishing occurs within the De Vasselot section of Tsitsikamma. Fishing effort is generally seasonal with an increase in fishing effort occurring over the summer holiday period. On average:

- Swartvlei and Knysna = 29 092 fishing trips occur annually
- De Vasselot and Sedgefield/Wilderness coastal sections = 12 978 coastal fishing trips
- In 2005 total offshore ski-boat fishing effort in Plettenberg Bay (including De Vasselot) was estimated at 890 boat days/year or 3 560 fisher days/year

In 2008, 29% of Knysna anglers indicated they were fishing for subsistence purposes whilst in 2014 subsistence anglers made up 51% of all fishermen. Although total effort fluctuates between years and no directional trend is obvious, the proportion of anglers fishing for subsistence purposes has increased within the estuarine systems. Bait collection also takes place in the park.

Catch rates for 2014	
Swartvlei	220 fish per 100 hours
Knysna	360 fish per 100 hours
De Vasselot	210 fish per 100 hours
Sedgefield to Wilderness	100 fish per 100 hours

The Island at Swartvlei Estuary, a mix of recreational and subsistence fisher men and women.

Spotted grunter (*Pomadasys commersonnii*) (minimum size restriction = 40 cm) and Dusky Cob (*Argyrosomus japonicus*) (minimum size restriction = 60 cm).

Marine Resource Harvesting

On average **29 092** fishing trips made per year on Swartvlei and Knysna

Whilst **12 978** coastal fishing trips occur within the De Vasselot and Sedgefield/ Wilderness sections

(= 1000 fishing trips)

LESS THAN ½ of all anglers know the current size and bag limits

4 OUT OF EVERY 10 FISH kept are undersized

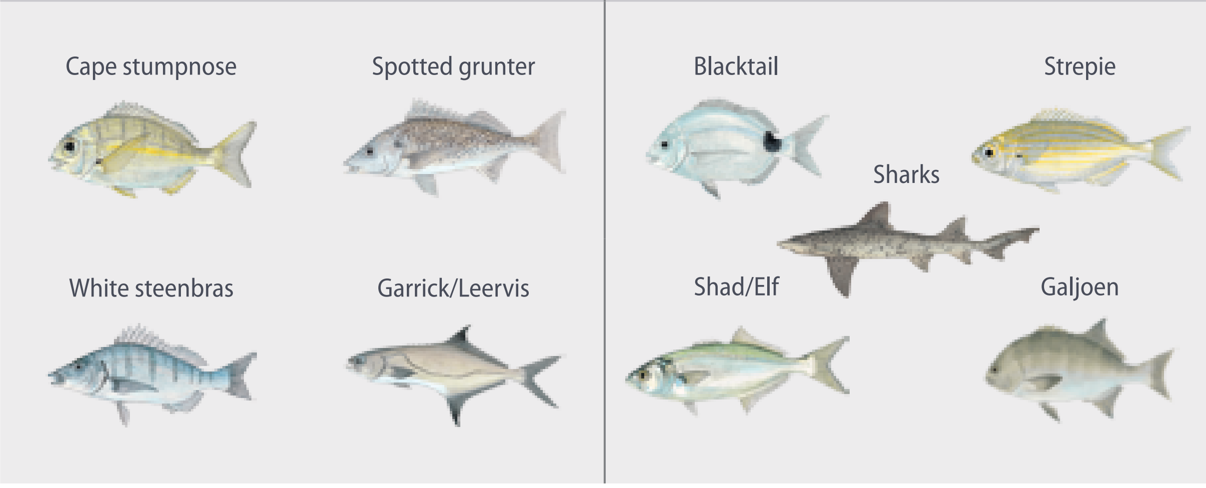
ONLY **3** OUT OF EVERY 10 FISH are released

× 6 000 = 60 000

Up to **60 000** FISH caught per year

COMMONLY CAUGHT FISH

Estuary	Coastal



Knysna's Bait Fishery

BAITING PRACTICES

81% anglers collect their own bait

Popular methods include

Prawn pump   Prawn pusher   Wire

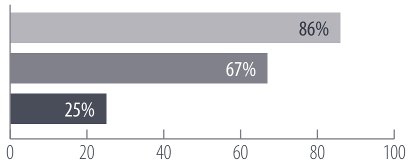
CONCERNS

23% of anglers said illegal bait collection methods were a concern

Bait collectors under-estimated the number of prawns they had collected by 32

KNOWLEDGE OF BAIT REGULATIONS

Angler knowledge of bait regulations for different species

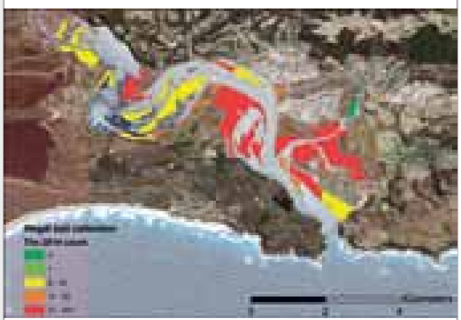


- **Primary species:** the bait species they most commonly use (the 1st choice in bait species)
- **Secondary species:** the second most commonly used bait species by each angler (the 2nd choice in bait species)
- **Tertiary species:** The third most commonly used bait species by each angler (the 3rd choice in bait species)

Average time spent collecting bait

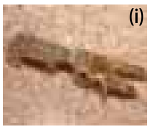
40 MINUTES

Bait collecting occurs throughout the estuary but certain mudbanks are used more often



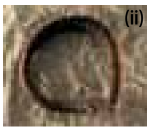
Illegal bait collecting occurs within the bait reserve

POPULAR TARGETED BAIT SPECIES



Most **popular** with around **50%** of all anglers using **MUDPRAWN**

POLYCHAETE WORMS have **doubled** in popularity between 2008 and 2014



Popular with around **6%** of all anglers using **BLOOD WORM**

ESTIMATED ANNUAL HARVESTS

Mudprawn **770 307**

Blood worm **7 259**

Pencil bait **1 899**

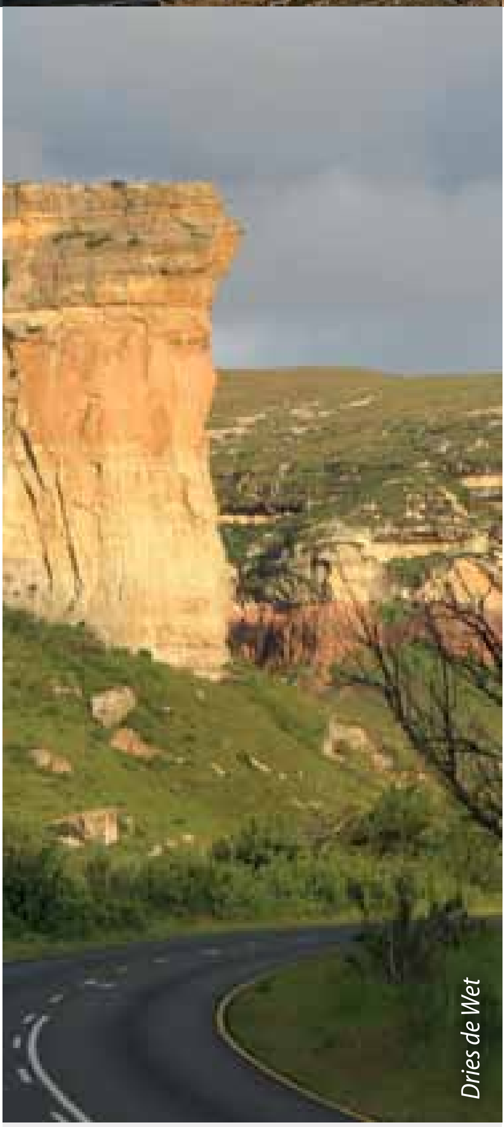
Sandprawn **26 287**

Polychaete worms **15 500**

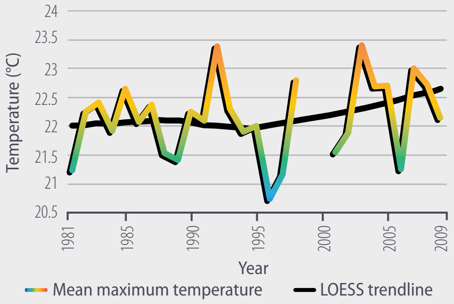
Cracker shrimp **6 038**

Photographers:
(i) George Branch
(ii) George Branch
(iii) Kyle Smith
(iv) Carol Simon
(v) Charles Griffiths
(vi) George Branch
(vii) George Branch

GOLDEN GATE HIGHLANDS
NATIONAL PARK



The Golden Gate Highlands National Park (32 700 ha) falls in the Grassland Biome of South Africa and includes an endangered vegetation type (Eastern Free Sate Grassland), vulnerable vegetation type (Basotho Montane Shrubland) and the Lesotho Highlands Basalt Grassland that are all considered to be poorly protected and to have a high conservation rating. Although the Grassland is predicted to be severely influenced by climate changes and become more savanna-like, the area of Golden Gate is predicted to be in the most stable area in terms of climatic changes. The park also forms the watershed between the Vaal and the Orange River systems, contributing to quantity and quality water, via the Lesotho-Highlands Water Project and the Tugela-Vaal transfer scheme, to the Gauteng region and into the Orange River system. As such, the park is part of the most important water catchment in Southern Africa, namely the Maluti Drakensberg Catchment Complex. Approximately 30% of the total water supply of Southern Africa is produced by this catchment complex. Therefore any climatic changes could have an impact on water in the landscape outside the park.



Annual average maximum temperature at Bethlehem, near Golden Gate, since 1981 does not show any trend.

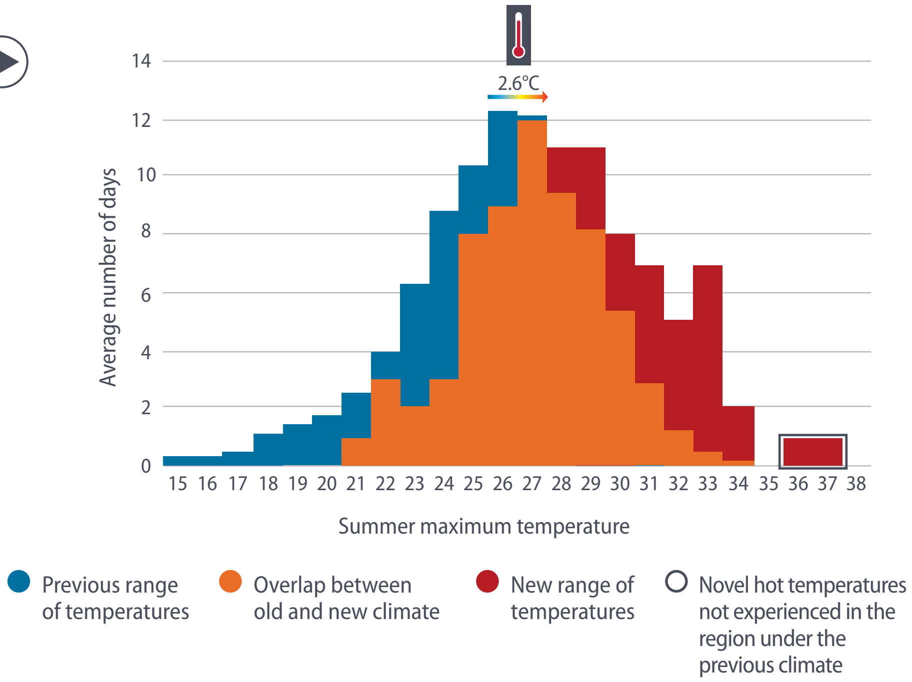
Climate change

L

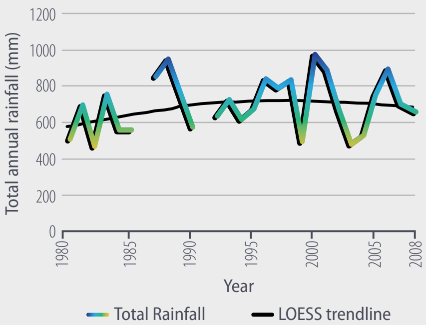
Temperature

Only a very short period of data were available from the park. Data from Bethlehem (1980–2009) did not show any trends. However, future increases in mean annual temperature of between 1.5°C (best case), 2.2 and 2.6°C (worst case) are predicted by 2050. While predicted increases may seem small, we have used data from Bethlehem to demonstrate the effect of a 2.6°C increase in summer temperatures in the figure on p. 74. Such a change would have a dramatic effect on the number of extremely hot days experienced in the park.

Increases in mean annual temperature of between 1.5°C (best case), 2.2°C and 2.6°C (worst case) are predicted by 2050 for the area.



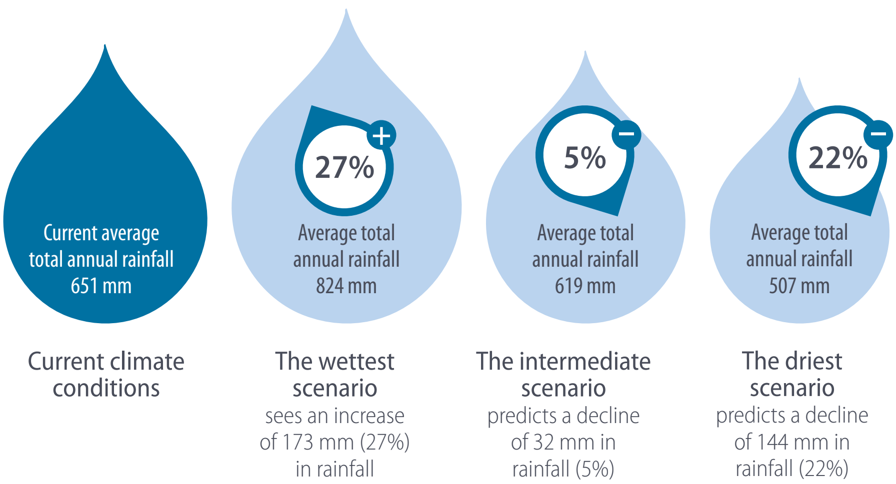
The average number of summer days reaching between 15°C and 38°C in Bethlehem in the past (1981–2005) compared to a hypothetical summer where temperatures have increased on average by 2.6°C, showing how this shift impacts on warm extremes. In the past, only one summer day would reach 35°C or hotter. With a 2.6°C increase, 11 or more days could get this hot. Temperatures above 30°C will also become much more frequent (over a third of summertime will get this hot), while cooler temperatures will become less frequent.



Total annual rainfall at Bethlehem, near Golden Gate, do not show any trend.

Rainfall

As with temperature, the data series available from the park was too short to analyse, while the 33 years of data from Bethlehem was also insufficient to allow for any meaningful analysis of trends. Future projections are variable, ranging from a 27% increase in rainfall to a 22% decrease.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8 × 1.8 km) of which all or part occur in the park, thus representing current averages at a landscape level. It is not yet clear which of the future scenarios are the most likely, but the park should note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events).

Scenario planning is a useful tool to plan for very different futures and think ahead about the type of management changes that would need to be implemented given different levels of rainfall and temperature changes. Then when it becomes clear in which direction things are changing, a plan is already in place.

Possible biome changes

The Grassland biome as a whole is expected to suffer the greatest contraction under the forecast climatic changes, largely giving way to savanna. Golden Gate however is in the area of the biome predicted to be most stable under this changing climate – a rare occurrence of fortuitous placement of a national park that will be increasingly important in the context of grassland conservation. Higher levels of CO_2, currently being experienced globally, favour the growth of woody plants (shrubs and trees), and give them a competitive advantage over grassy plants. The impact of this carbon 'fertilization' has not been considered for Golden Gate, but could be costly if many of the indigenous C4 grass species are outcompeted.

SANParks has an important role in educating public about the importance of greener lifestyles.	Reducing waste and increasing opportunities for recycling are also critical.
Golden Gate can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.	Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

Golden Gate Highlands National Park is situated in the portion of the Grassland biome that is predicted to be most stable in the future, providing an important opportunity for conservation of grassland species.

Land-use change

H

Since declaration in 1963, Golden Gate has expanded by 30 000 ha (26 000 ha since 1990) and in 2008 the QwaQwa National Park was included so that the park now conserves 5 habitat types. Expansion of Golden Gate to its 113 000 ha desired state would see the addition of a further 4 vegetation types that are representative of the mid-to-upper altitude northern grasslands landscape. This is particularly important in the light of expected climate change and its increasing threat towards the grasslands and also the park's increasing role in national water conservation.

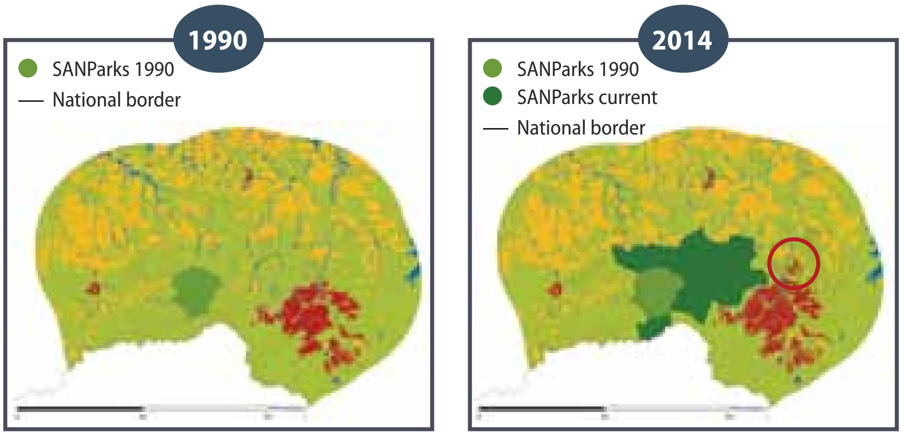
Golden Gate has exceptionally steep slopes and dispersive soils which are susceptible to erosion. Erosion disturbs flow patterns, and negatively affects wetland functioning. Erosion could be accelerated by human activities such as exposed soil after alien clearing, inappropriate fire regime (especially accidental fires originating outside the park), and overgrazing. Fire is one of the major ecosystem drivers and is vital for ecological processes that influence the landscape. It is considered one of the tools that managers possess to actively influence the dynamics of grassland ecosystems. Fire is a natural phenomenon in the region, and the flora and fauna of the region are adapted to a natural fire regime. The main land-use in the area surrounding the park is livestock farming as well as increasing urbanisation and a 4.8 km^2 increase in urbanized land in the 10 km buffer were detected. However this could be old university settlements that have subsequently been removed.

Golden Gate park management should continue to engage with the two municipalities in the development of IDPs as well as with the Maluti Drakensberg TFCA strategic plans.

The park is situated in between the impoverished QwaQwa (a Presidential Nodal Point with high levels of poverty, unemployment and population growth) and the affluent Clarens and environs. There is a strong need for socio-ecological studies in this area.

Landcover

- Cultivation
- Mining
- Urban
- Plantation
- Water
- Natural
- Degraded
- National Park
- National border



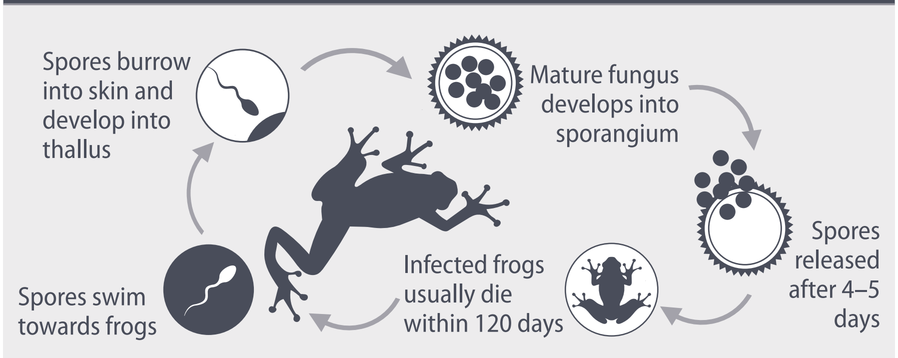
Land-use change between 1990 (only 6 000 ha was proclaimed at this time) and 2014 in the 20 km radius around the current park boundary. The second map shows an increase in urbanisation of Phuthaditjhaba, a town on the QwaQwa side of the park. Golden Gate plays an important role as a strategic water source (one of only 5 parks) and catchment area for water for a large part of the Gauteng province.

Disease

L

Disease is not currently a major threat in the park, although there are concerns that disease vectors will start moving to higher elevations as the climate changes. Diseases such as Chytrid fungus could become a concern, although South African frogs have yet to demonstrate the same susceptibility to the disease as those of their overseas counterparts.

Amphibian chytrid life cycle



CHANGING GLOBAL TEMPERATURES may be responsible for the increase spread of chytridiomycosis.

It seems that the combination of **LOWER DAY TIME** temperatures and **HIGHER NIGHT TIME** temperatures could be the reason.

The potential that changes in global temperatures could have on the spread of diseases. Temperature changes have not been recorded to cause mass amphibian deaths in South Africa, but outbreaks have been recorded in western North America, Central America, South America, eastern Australia, and Dominica and Montserrat in the Caribbean.

Chytrid fungus *(B. dendrobatidis)* is a waterborne pathogen and disperses zoospores into the environment. The zoospores use flagella for locomotion through water systems until they reach a new host (amphibians) and enter cutaneously. The fungus lifecycle continues until new zoospores are produced from the zoosporangium and exit to the environment or re-infect the same host. Once the host is infected with *B. dendrobatidis*, it can potentially develop chytridiomycosis, but not all infected hosts develop it. Other forms of transmission are currently unknown; however, chytridiomycosis is postulated to be transmitted through direct contact of hosts or through an intermediate host.

The clearing of alien plants in catchment areas is of critical importance. It is estimated that about 7% of the annual flow of South Africa's rivers is lost due to the excessive use of water by invasive alien woody plants, over and above the water used by natural vegetation.

Currently a contractor and a team of 12 people from local communities work in buffer zones as part of the BSP programme for economic upliftment and empowerment of communities.

Alien species

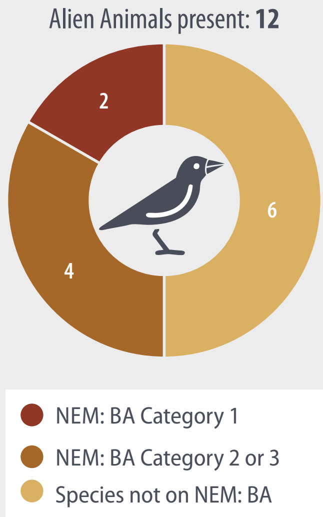
L

Eighty-nine alien species (77 plants and 12 animals) have been documented in Golden Gate Highlands National Park.

Animals

Cats, dogs and domestic ungulates regularly enter the park, but the extent of such occurrences and their impacts have not been evaluated. Alien fish, including the Category 1 NEM: BA-listed Common Carp (*Cyprinus carpio*) are found in the rivers. Wild pigs (*Sus scrofa*) as well as Indian mynas (*Acridotheres tristis*) are also present.

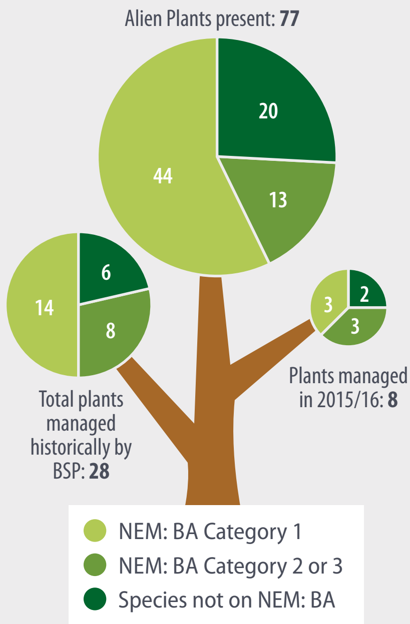
Indian myna (*Acridotheres tristis*)



Plants

Management programmes are currently in place for most of the alien plant species, but many potential transformer species, including 57 plants listed on NEM: BA as category 1b (and 44 across NEB: MA categories), are present in the park. These include wattles (Acacia species), water fern (*Azolla filiculoides*), giant reed (*Arundo donax*), gum trees (*Eucalyptus* sp.), Lantana (*Lantana camara*), Congress weed (*Parthenium hysterophorus*), poplars (*Populus* sp.) and willows (*Salix* sp.) (although the latter two are not 1b listed). Without continued clearing operations, these species would have significant negative impacts.

Giant reed (*Arundo donax*)



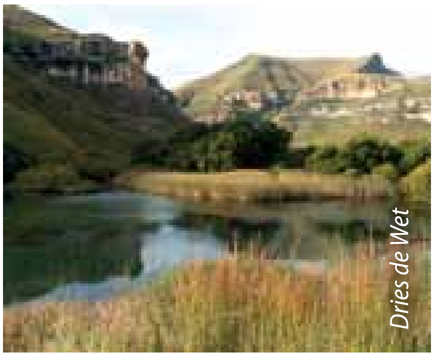
A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

- Not much has been done recently regarding riverine ecosystem monitoring. The last (and only) sampling done on macro-invertebrates was in 2011 in both the Klerkspruit and Klein Caledon streams
- The presence of a sewage system along the catchment could negatively impact the riverine ecosystem

A study on macro-invertebrates done by Scientific Services found that the demographic groups in Golden Gate do not differ much from what should be found in ideal riverine ecosystem. This was what was expected considering that the Golden Gate catchments mostly start within the park and therefore should not be anthropologically impacted.

- A study to investigate, verify and/or provide empirical data of the role that the Golden Gate catchments and wetlands play in providing ecosystem services to the downstream areas of the country
- There is a need for more monitoring of the freshwater ecosystems of the Golden Gate and extend methods beyond the normal SASS surveys to pick up water quality and sediment depositing
- The socio-ecological dynamics of communities bordering the park

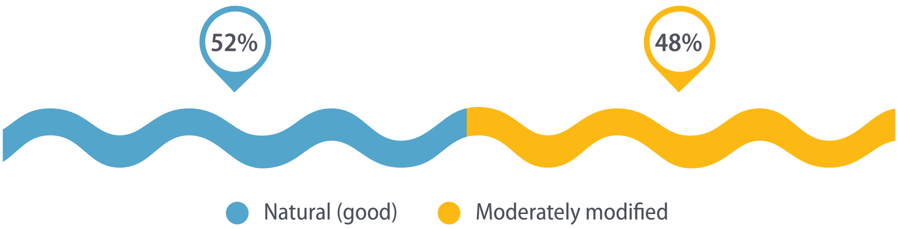
Freshwater



The Little Caledon River

QUICK STATS

- Total river length in park: **62 km**
- River Ecosystem types (of 223 in SA): **5**
- River length in good condition: **52%** (remainder moderately modified)
- Freshwater Ecosystem Priority Area (FEPA): **48%** of river length
- The development of a wetland inventory is a high priority



Condition of all rivers in Golden Gate Highlands National Park (as per the National Freshwater Ecosystem Priority Assessment).

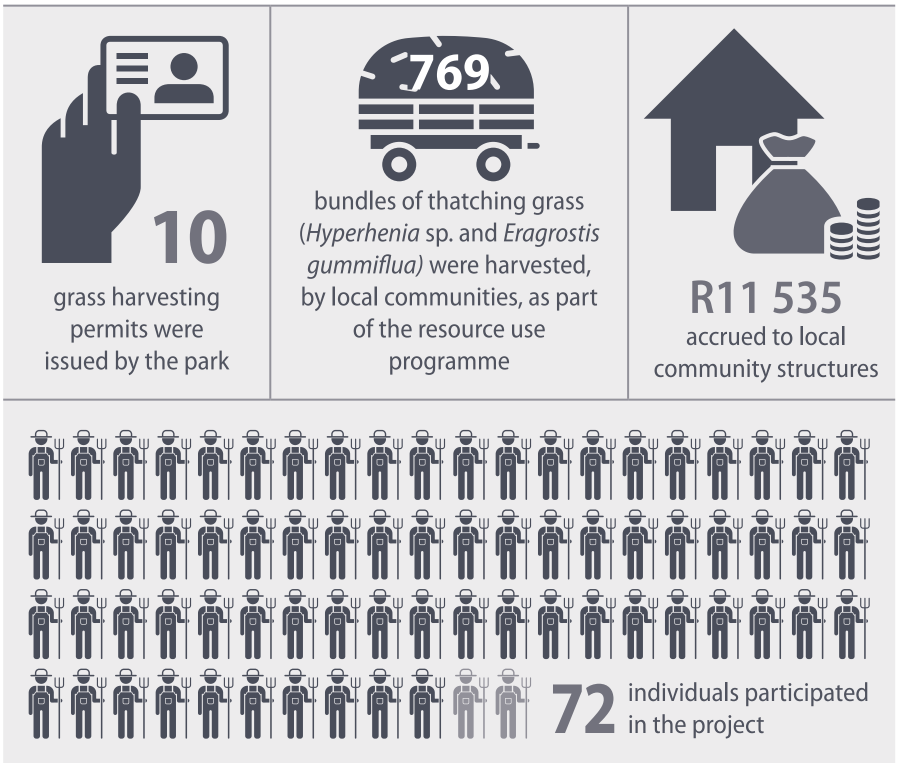
SANParks scientist surveying the Ribbokspruit entering the Klein Caledon.

Resource use

H

The main resource use in Golden Gate is grass harvesting. Various grasses from the area have been harvested for generations by people living in the area for practical and cultural use alike. Prior to the amalgamation of QwaQwa National Park into Golden Gate in 2009, these grasses were harvested from QwaQwa. In 2012, Scientific Services launched a monitoring programme to inform the sustainable use and continued benefit sharing from these grasses in the park. Although this is a long-term project and no informed conclusions can yet be drawn, preliminary observations suggest that the grassland ecosystem, as well as its patterns and processes, have not been negatively affected by the harvesting.

Currently harvesting takes place mainly in degraded former agricultural lands that have previously been ploughed and grazed. The two main grasses collected, the common thatching grass (*Hyparrhenia* cf. *hirta*), the most popular thatching grass species in South Africa, and the thatching grass (*Hyparrhenia* cf. *dregeana*), are commonly found in disturbed places. *Hyparrhenia* is not generally palatable. Historically livestock graze the grass early in the growing season because it becomes less palatable as it matures. Harvesting of this species opens areas for other more palatable plant species which then become available for the grazers. Due to the sustainable manner in which these grasses are harvested, they continue to contribute to the stability of the degraded land they occupy.



Grass harvesting April 2015 – March 2016.

Excess game such as eland (*Taurotragus oryx*), red hartebeest (*Alcelaphus buselaphus*), black wildebeest (*Connochaetes gnou*) and blesbok (*Damaliscus pygargus*) are culled for the vulture restaurant and sold as venison.

The grass harvesting improves the palatability of the grasses grazed, making them available for the other grazing wildlife, thereby supporting a natural succession process in these degraded areas. The harvesting also allows other plant species to establish in areas that are typically dominated by only 1–2 grass species.

Grass harvesting for thatching at Golden Gate.

Other resource use includes the use of the black wattle (*Acacia mearnsii*) for firewood as part of alien clearing programme. The collection of medicinal plants by medicinal healers has been observed during aerial surveys in the park. This use is currently not regulated and should be monitored in the future. The logistics of a permitting system for this harvest would also need to be considered. Aside from biological resource use, borehole water is also used for the park's tourism facilities.

Traffic of various items (including items other than local resources) through the park, to and from Lesotho has also been observed, but this activity has not been studied in any detail.

Evidence of trafficking: illegal goods stashed in the mountains were found and retrieved during an aerial game census

During an aerial census survey in 2010 SANParks staff came across a suspicious looking bag, concealed high in the mountains under a rocky outcrop against a very steep mountain slope. It was filled with dried dagga leaves.

Illegal grazing in the park is a concern, especially the overgrazing and developing of livestock grazing paths which could lead to erosion in steep mountainous regions. This could have a negative impact on wetlands in the park.

The photos show signs of illegal grazing where livestock pass through the park fence, as well as sheep grazing against the steep mountain slope.

KALAHARI GEMSBOK
NATIONAL PARK

Nicola van Wilgen

Marna Herbst

Nicola van Wilgen

Marna Herbst

The area between the Auob and Nossob Rivers was first declared as the Kalahari Gemsbok National Park in 1931 and land was added over time (now 957 700 ha). The original inhabitants of the area lived in harmony with animals and plants but the settlers, together with the biltong hunters from further afield, denuded the area of game. The park was established to protect the wildlife which it continues to do today. Iconic species include black-maned lion, camel thorn (*Vachellia* [*Acacia*] *erioloba*) and tsama melons (*Citrulllus lanatus*). The latter provide a source of water and are an essential part of surviving in this semi-arid ecosystem. Under very dry conditions, even the tsamas disappear and only animals that are well adapted to the harsh conditions survive.

The Kalahari Gemsbok has experienced an extraordinary increase of 1.95°C in mean maximum temperature since 1960 at Twee Rivieren. As a result of this rising average temperate, the park is already experiencing 36 more days above 35°C than it did in 1960. Such an increase in extreme temperatures will impact on tourists' enjoyment of the park and willingness to vacation in the area as well as their activities while in the park (e.g. use of resources such as air-conditioning and swimming pools). In addition, much of the available groundwater is unfit for human consumption due to naturally high concentrations of certain trace metals. Already limited availability of surface water will be exacerbated by additional evaporation from increased temperatures, potential changes in rainfall and the presence of alien species that use significant quantities of water in the upstream section of the rivers on the Namibian side of the park. These kinds of interactions are likely to impact on biodiversity and ecosystem function, potentially further jeopardizing the tourism potential of the area. An additional concern is the change in land-use in the Kalahari area, with an increase in commercial livestock farming that increases the potential for human-wildlife conflict. Retaliation killings, management responses and disease transmission between domestic animals and wildlife could threaten the persistence of mega-charismatic fauna like lions. Cases like this highlight the increasing importance for SANParks to consider the interactions between global change drivers and the implications of these interactions across divisions.

- Climate change has already happened. The change that has already taken place equates to the extent of the change that is predicted to take place by 2050
- Increasing minimum temperatures may open the way for diseases and pests that were previously kept out by colder winters

Between 1960 and 2000 only 5 years had more than 100 hot days where maximum temperatures were 35°C or more. Since 2001, not a single year has had less than 115 such hot days and 2003 had 149 hot days.

- Observe trends in water use over the last years and correlate water use with daily maximum temperature
- Make predictions for water use under conditions of increased temperature
- Monitor changes in water quality and the relationship between water quality and volume extracted

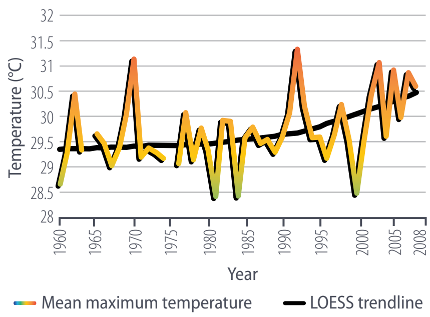
Further increases in mean annual temperature of between 1.7°C (best case), 2.5°Cand 2.9°C (worst case) are predicted by 2050.

Climate change

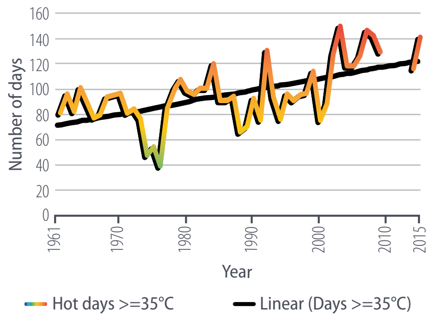
H

Temperature

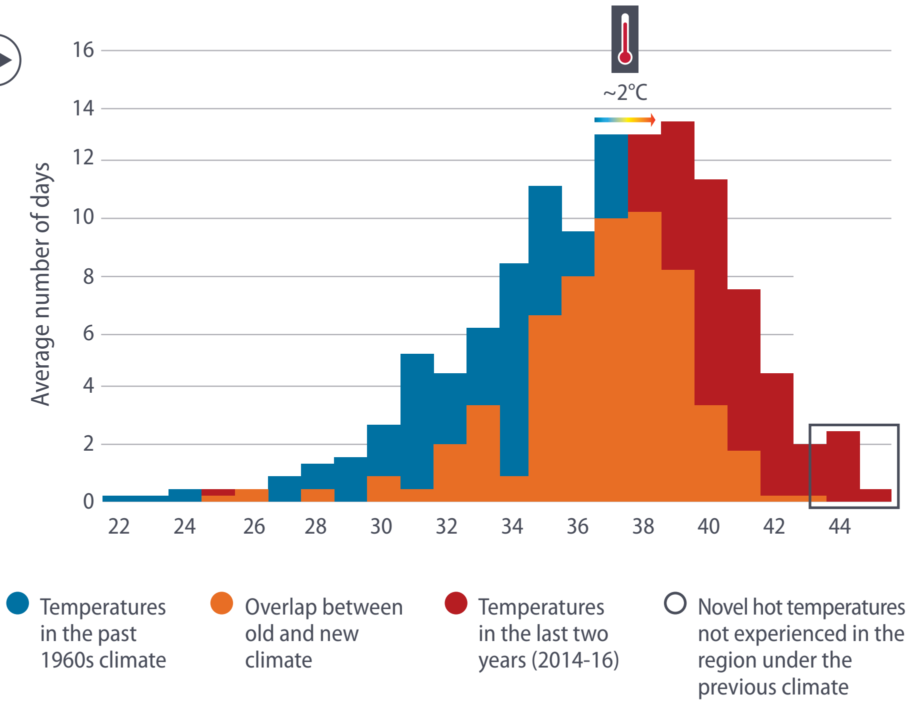
Over the last 50 years (1960 to 2009), absolute minimum, average minimum and average maximum temperatures have increased by 1.2 to 1.95°C at Twee Rivieren. As a result, by 2009 the number of days in a year above 35 degrees had already increased by 36 compared to 1960. Data from the last two years suggest that over 90% of summer maximum temperatures are now over 35°C (graphic below). In addition to an increase in hot extremes, increases in minimum temperatures mean that it doesn't get as cold as it used to, and there are significantly less days where temperatures start below 0 than there used to be. This might have implications for pest organisms and alien species that were previously kept from spreading by cold temperatures in the winter. Further increases of between 1.7°C (best case), 2.5°Cand 2.9°C (worst case) are predicted by 2050. The uncomfortableness of 1.95 degree increase in maximum temperature is already being felt by those without air conditioners. The impact of a 3 degree increase in average temperature will be severe.



Annual average maximum temperature at Twee Rivieren since 1960, showing a significant and quite sudden increase starting around 1990.



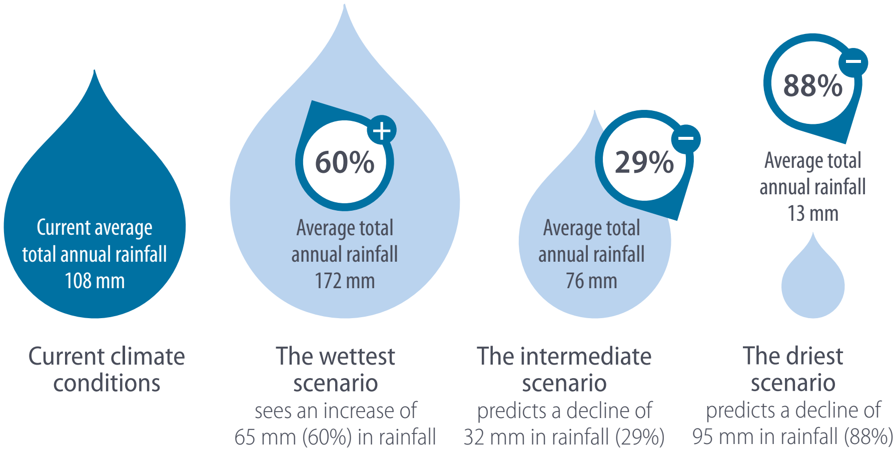
The number of days in the year where the temperature has reached or exceeded 35°C, showing a significant increase.



The average number of summer days reaching between 22°C and 45°C at Twee Rivieren in the 1960s compared to the last two years (2014/15 and 2015/16), showing how an average shift of just ~2°C dramatically impacts on the number of hot days experienced. Far less of the cooler extremes (shown in blue), are currently experienced, while there are now an average of 17 days equal to or hotter than 41°C, something that happened roughly only twice per summer in the 1960s. In addition, in the 1960s, about 64% of days would have been above 35°C and above, whereas over the last two summers, nearly 90% of days have reached or exceed this 35°C threshold.

Rainfall

No changes in total rainfall were detected in the 90 year historical rainfall record for Twee Rivieren.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely, drying is more commonly predicted for this part of the country, favouring the drier scenarios. Also note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events).

Possible biome changes

No major changes in the distribution of the Savanna biome are predicted for the park under the intermediate scenario. However, under the driest scenario, up to 80% of the park would have conditions more similar to Desert or Succulent Karoo than Savanna.

SANParks has an important role in educating public about the importance of greener lifestyles. The changing climate presents SANParks with an opportunity to educate the public and showcase methods for sustainable living.

Additional energy and water saving measures that can be implemented include: Geyser blankets, geyser timers and/or use of solar geysers as well as restrictions on the amount and time of day during which water can be used.

Finding novel and green solutions to improve sustainability through, for example, natural ways of cooling accommodation and solving water quality problems, which will be essential.

Rain water tanks at all accommodation should be a priority and alternate power sources should also be explored including the use of biogas from waste.

The levels of tourism that will be feasible under future conditions should be assessed.

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Working with external companies to create opportunities for recycling waste will also be very beneficial.

Actions to make a difference

Unbearably hot temperatures through most of the year could become a reality. Along with predicted drying trends, this has significant implications for wildlife and tourism. Tourists may request additional water, swimming pools, large amounts of ice, air conditioners and other such amenities which may not be ecologically or financially viable in an increasingly water scarce area. Warmer temperatures also mean faster evaporation of any rain that does fall, which will further exacerbate the current water availability and quality problems. There is a possibility that the area will face a decline in tourism, especially if charismatic fauna and flora are also negatively affected.

An assessment of the impacts of temperature increases combined with the impact that changing rainfall pattern may have in conjunction with this need to be investigated in terms of biodiversity and tourism.

Birds are negatively impacted by sustained high temperatures. At temperatures of 35 degrees and more, babblers (*Turdoides* sp.) struggle to regain any body mass lost overnight and continue to lose weight during sustained heat waves, while in common fiscal (*Lanius collaris*) chicks, body mass at the time they leave the nest is reduced when they are exposed to high temperatures.

The possibility for combining climate change mitigation and benefit sharing should be investigated, for example setting up communities to generate solar energy that can be sold back to a park.

Conserve water in the bathroom

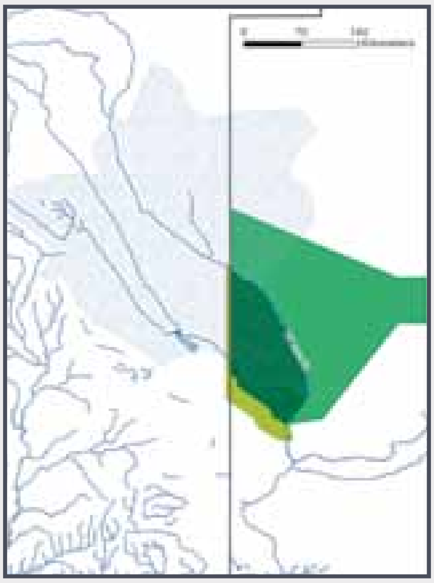
Land-use change

M

Since declaration in 1931, the park has expanded by 197 500 ha to a total of 957 770 ha and conserves 7 habitat types. In 1999 the Presidents of the two countries, South Africa and Botswana signed a transfrontier conservation area agreement, establishing the Kalagadi Transfrontier Park which comprises of 3 725 600 ha natural land. There are no fences between the two conservation areas and each country manages their area separately with bilateral agreements in place.

There has been very little land-use changes around the park with mainly livestock farming. Approval of mining and/or prospecting rights on the Botswana side of the park could however have devastating impacts on water as well as the wildlife that moves between Botswana and South Africa. Although the two rivers in the park are dry fossil rivers, groundwater extraction in the Namibian side of the park can have impact on the groundwater levels in the park.

The Stampriet Transboundary Aquifer System is a large aquifer system situated in the southern part of the Kalahari and it is shared between Botswana, Namibia and South Africa. The aquifer system is well representative of groundwater resources in hot semi-arid regions of Africa, where groundwater is the primary source of water. The Auob and Nossob Rivers originate in Namibia and enter South Africa at the Kalahari Gemsbok National Park. The Nossob forms the park's western border. Groundwater is withdrawn from the Kalahari, Auob and Nossob aquifers, by means of dug wells and boreholes. Water is mainly extracted for irrigation, stock watering and domestic use.



Landcover

- Natural
- Kalahari Gemsbok National Park
- Kalahari Transfrontier
- Stampriet aquifer
- Rivers
- National border

The Stampriet Aquifer is important for groundwater extraction in the park. There has been little change in formal land-use (largely natural) since 1990 and the park has signed a transfrontier agreement with Botswana, establishing the Kgalagadi Transfrontier Park.

It is believed that Central Kalahari lions served as an important genetic source to the Southern Kalahari and current landscape fragmentation and the increase in commercial beef ranches between these two areas has cut-off historical movements, resulting in genetic isolation of the Southern Kalahari lions.

Disease

L

Rabies, anthrax and sarcoptic mange are believed to be endemic diseases circulating in the Kalahari Gemsbok National Park. In terms of rabies, the bat-eared fox (*Otocyon megalotis*) is the dominant maintenance host, with spill-over into various wild species possible. The maintenance of the disease in bat-eared fox is likely bolstered by spill-over from domestic dogs (*Canis lupus familiaris*). Several sarcoptic mange outbreaks have also been reported in jackals (*Canis mesomelas*) in the park. Although, individual mortality can be dramatic, in a self-sustaining population, the mange epizootic does not seem to affect long term population dynamics. The Kalahari Gemsbok also falls within the anthrax endemic region in the Northern Cape; however no dramatic outbreaks have been reported. The only other infectious disease outbreak reported in the park has been canine distemper virus (CDV) disease, a Morbillovirus maintained in domestic dogs and believed to occasionally spill-over into wild carnivores. Dramatic outbreaks have been reported in the Serengeti National Park. The outbreak in the Kalahari Gemsbok in 2009 killed at least 4 lions (*Panthera leo*) and affected several others clinically. Though the CDV outbreak did not have a dramatic impact on lion population abundance, the population sex-skewing seen in the park lion population could be further exacerbated by differential disease effects.

Diseases are a natural occurrence in any natural system and the isolation of the Kalahari prevents large scale outbreaks. However more and closer contact with human and domestic livestock will increase the likelihood of more disease reports between the countries.

Dead Blue wildebeest surrounded by vultures.

Alien species

H

Twenty-one alien species (18 plants and 3 animals) have been documented in this park, the second least across parks (only Richtersveld, with 14 documented alien species has less).

Animals

Domestic cats pose a problem through hybridization with indigenous African wild cats. The Kalahari region is isolated and sparsely populated and one of the last places where pure African wild cats can still be found. European starlings and house sparrows are also present in the park.

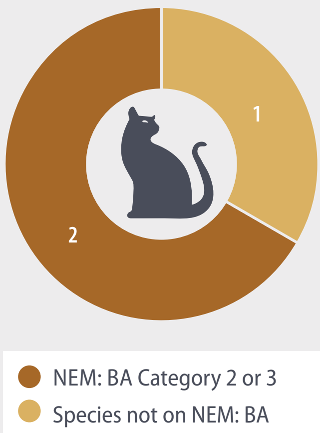
House sparrow (*Passer domesticus*)

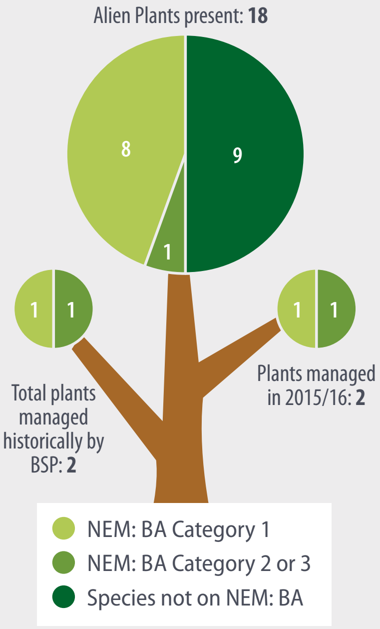
Radio-collared African wild cat (*Felis silvestris*) in the Kalahari during a study testing the genetic status of wild cats that are known to hybridise with domestic cats.

Retaliation killings of damage causing lions, management responses in terms of relocation of these break-out lions and disease transmission between domestic animals and wildlife could threaten the persistence of these charismatic fauna.

- It is important to continue with on-going passive disease surveillance and reporting any outbreaks to the local state veterinarians, SANParks Veterinary Wildlife Services and Scientific Services
- Due to the costs of disease studies all opportunities should be taken to collect and store appropriate biological tissue samples

Alien Animals present: **3**





A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

Work with conservation entities on the Botswana and Namibian sides of the border to eradicate *Prosopis* in the upstream sections of the river bed. Infestation of these species is noted to be particularly dense in Namibia. Clearing of these plants is expected to lead to substantial increases in groundwater flow as well as surface water flow during flood conditions. The availability of this water will be increasingly important given the dire climate change predictions.

Plants

Invaded areas of the park include the two river systems (the Nossob and the Auob), camps and infrastructure areas as well as groundwater extraction points along the river courses. The largest problem however is high densities of Pepper trees (*Schinus molle*) and Mesquite (*Prosopis*) in upstream reaches of the Nossob and the Auob in Namibia (the Nossob forms the boundary between South Africa and Botswana). The latter invasions mean that there is very little surface water in the park at any time of the year, even in flood conditions. Using the Joint Management Board meeting as platform, SANParks has engaged in communications with Botswana management regarding a strategy to clear both sides of the international border between Botswana and South Africa. In 2015 the total area in the park infested with alien species was estimated to be 7 786 ha. Within the Nossob and Auob riverine corridors 1 310 ha has been designated as an asset protection area, while 6 461 ha is designated for containment. Invasions in camps and around infrastructure make up the remaining 15 ha. An additional 940 ha that is invaded by *Prosopis* within the South African side has also been included in clearing plans. According to the GEC assessment, eight category 1b NEM: BA listed plants are found in the park, all of which have some level of toxicity to humans or animals. The thornapple (*Datura ferox*) is deadly toxic, although it is absent from the alien species lower level plan.

Large thorn-apple (*Datura ferox*)

Mexican poppy (*Argemone mexicana)*

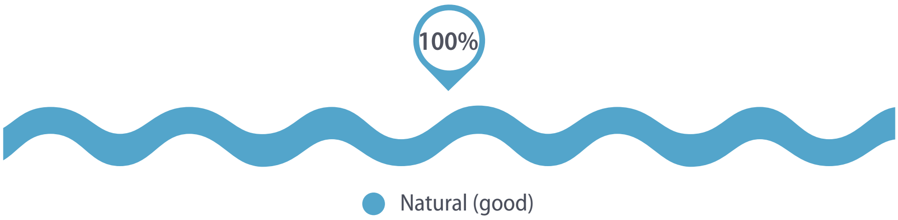
Prosopis in Auob riverbed just outside the park on the border of South Africa and Namibia.

Freshwater

H

QUICK STATS

- Total river length in park: **416 km**, although there is hardly ever surface water in the rivers
- River Ecosystem types (of 223 in SA): **1**
- River length in good condition: **100%**
- Freshwater Ecosystem Priority Area (FEPA): **55%** of river length



Condition of all rivers in Kalahari Gemsbok National Park (as per the National Freshwater Ecosystem Priority Assessment).

Aerial view of the Nossob riverbed.

The Kalahari is a water scarce environment. In addition to increases in extreme hot days, much of the available groundwater is unfit for long-term human consumption due to naturally high concentrations of certain trace metals. Groundwater adopts the chemistry of the surrounding geology. In this instance water has not been replenished sufficiently by fresher surface water in a long time, and therefore groundwater is in contact with the local geology for extended periods, increasing the concentrations of these elements. The two main rivers, the Auob and Nossob, are regarded as fossil rivers as they are relics of rivers which used to have high flows. Today, these rivers are dry for long periods and only flow through the park after exceptional rainfall events. Already limited availability of surface water will be exacerbated by additional evaporation from increased temperatures and potential changes in rainfall (climate change) and the presence of alien species that use significant quantities of water in the upstream section of the rivers on the Namibian side of the park. Clearing of alien species in the Nossob needs to be done in collaboration with Botswana to ensure maximum value from clearing conducted on the South African side of the river. In addition, there is also an extensive agricultural sector based in the Auob catchment in Nambia. These kinds of interactions are likely to impact on biodiversity.

- Water at the three main rest camps is not fit for prolonged human consumption due to high levels of certain natural elements
- There is a possibility of Shale Gas Fracking within the Kalahari Karoo Basin on the Botswana side of the park
- In Namibia there is increased development on the Stampriet Aquifer which underlies the Auob and Nossob rivers, including a large dam where further developments are taking place as more people become reliant on water in towns

- Identify ideal zones for groundwater abstraction in order to minimise the risk of consuming groundwater unfit for human consumption
- Rainwater harvesting at tourist camps and staff accommodation should be able to meet most of the drinking water requirements, while other water saving measures (e.g. low flow toilets) can be implemented to reduce the volume of water required for park operations

SANParks, with team members from South Africa, Namibia and Botswana are involved in a large UNESCO-funded project of transboundary water research and management. The aim is to engage in governance of Transboundary aquifers, i.e. the Stampriet Aquifer System.

Long term monitoring of groundwater quality and quantity are essential and to determine groundwater flow regimes and hydrochemistry for optimal and sustainable groundwater abstraction.

‡Khomani San medicinal plant expert Jan Hendricks.

‡Khomani San medicinal plant experts Oom Gert Swarts, the late Samual Kruiper 'Angok' and the late Pien Kruiper.

Good medicinal plant baseline data has been compiled and should be continued.

A plant harvesting permit system is in place.

MPhil: Gerbrand Nel (MPhil, University Pretoria) mapped the distribution of 42 different plants used by the ‡Khomani San during his study in the park.

Resource use

M

Thirty-nine resources were reported to be used from the park. Small quantities of a variety of plants are harvested for medicinal and ritual purposes by the co-owners of the park, the ‡Khomani San who have cultural and symbolic rights over the entire park. For example, in 2015, 5 roots of Jan Bloed /Rooikabroo (*Jatropha erythropoda*) were harvested and 8 roots of Gifbol/Bushmen's poison (*Boophane disticha*) both listed as species of Least Concern. Although the ‡Khomani San have hunting rights, no hunting was done.

Animals culled for management purposes include gemsbok (*Oryx gazella*) and blue wildebeest (*Connochaetes taurinus*).

Several abiotic resources such as water, gravel and sand are used.

The use of water will become an increasing challenge for management under the predicted and observed changes in climate.

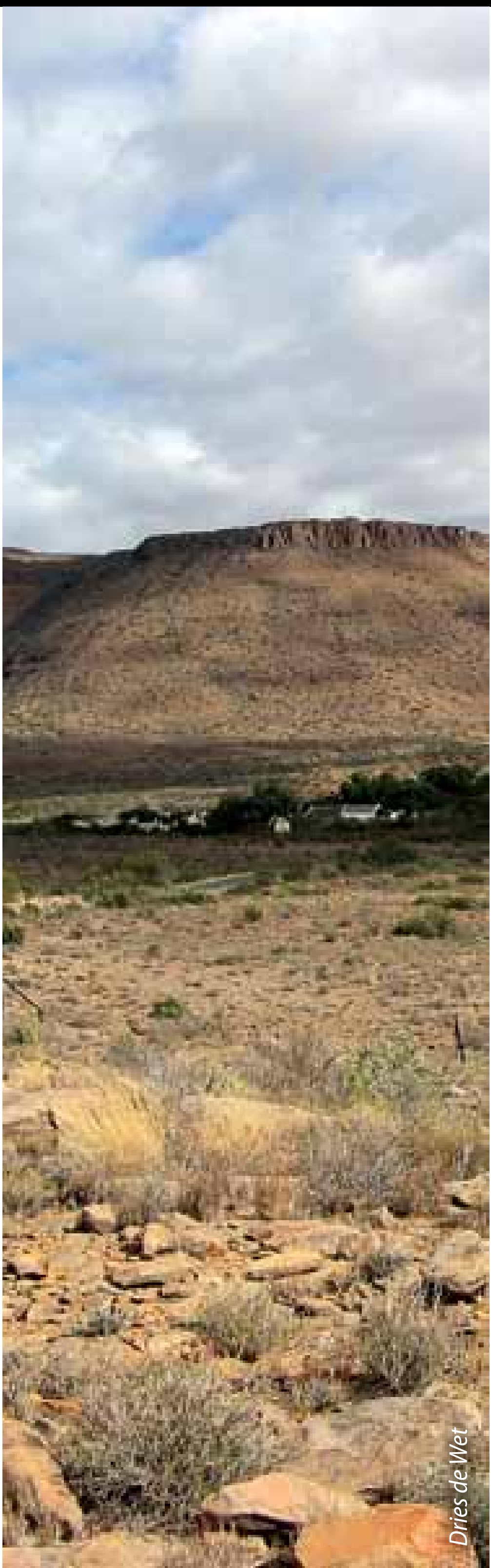
Bulbous species often contain active substances used for medicinal purposes and are the subject of several projects including a long term monitoring project by the National Museum in Bloemfontein and the University of the Free State on *Harpagophytum procumbens* subsp. *procumbens* (Devils claw) as well as *Lindneria clavata* (*Pseudogaltonia clavata*) (Slangkop). The aim of this study is to gather more information on the water relations in the soil where these plant species occur.

Devils claw (*Harpagophytum procumbens* subsp. *procumbens*)

Slangkop (*Lindneria clavata* (*Pseudogaltonia clavata*))

KAROO
NATIONAL PARK

Dries de Wet



Dries de Wet

Karoo National Park (~88 000 ha) is situated against the Nuweveld Mountain range, close to the town of Beaufort West in the Karoo, South Africa's largest ecosystem which covers 35% of its land area. The steep topographical gradients and different altitudes in the Park produce a structurally complex environment which provides many niches for animal and plant species. Vegetation types are closely linked to soil type, soil depth, rockiness, slope and aspect. Climate change and development of conflicting land-uses present the biggest threats to the Karoo National Park. The area was declared a presidential poverty node due to the high unemployment and poverty levels in the region, and Karoo National Park plays a significant role as an economic contributor in the region.

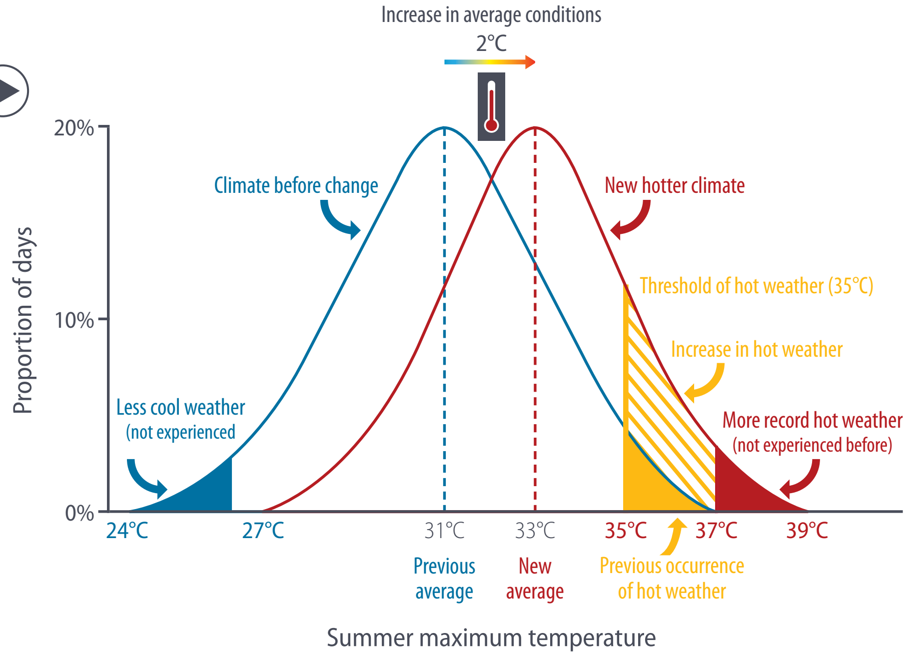
Climate change

L

Temperature

At the time of the study, temperature data from the park were not available and no significant changes were identified in the 17 years of data that were analysed from Beaufort West (although this is a very short time over which to detect change). Future projections of climate change are however not encouraging. Increases of between 1.5°C (best case), 2°C and 2.5°C (worst case) are predicted by 2050. While the predicted changes seem small, we have demonstrated the effect that a 2°C increase would have on the relative proportion of days above 35 degrees for a hypothetical park where average summer maximum temperatures are about 31 degrees (very similar to the current averages for Karoo; see figure on p. 90). The effect of a 2.5°C would be even more dramatic, and under this scenario, nearly half of summer days in Karoo would be likely to reach 35°C.

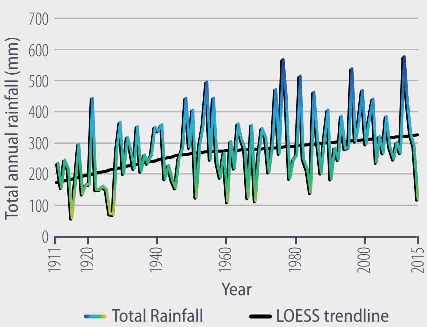
Increases in mean annual temperature of between 1.5°C (best case), 2°C and 2.5°C (worst case) are predicted by 2050 for the area.



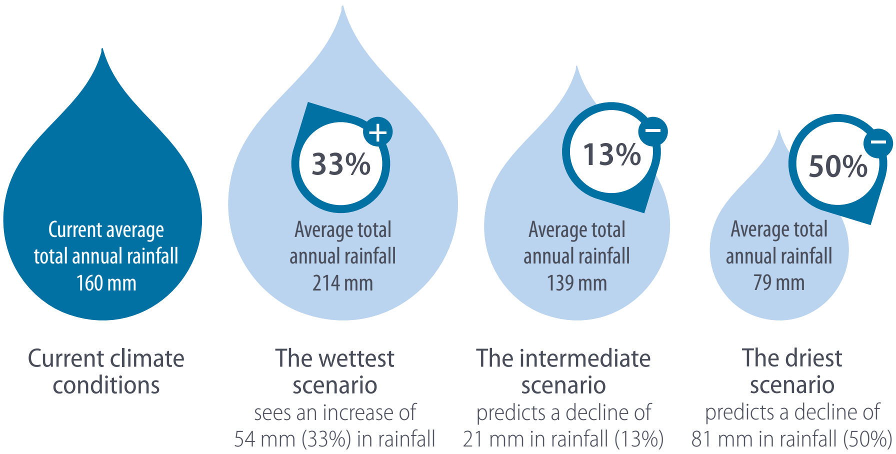
This figure shows the number of summer days reaching between 24°C and 39°C for a hypothetical situation where the historical average maximum summer temperature was 31°C, compared to the range of summer temperatures if average conditions increased by 2°C. Under the previous climate there would be an average of 4 days per summer that get to 35°C or hotter and it would never get hotter than 38°C, whereas there are about 17 days over 35°C under the new climate that has warmed on average by 2°C and 3 days reach 38°C or more – conditions not experienced under the previous climate.

Rainfall

Analysis of monthly data from Stolshoek indicate a substantial and significant increase in total annual rainfall since 1911, although the reliability of the data require further investigation. Monthly data are less reliable than daily data as it is difficult to pick up errors in the data (e.g. missing rainfall data recorded as a 0) and many of the metrics of interest (e.g. changes in the size of flood events) cannot be calculated. Daily data were however not available for any significant length of time.



Total annual rainfall at Stolshoek since 1911, showing a significant increase (slope = 1.39mm/year).



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8 × 1.8 km) of which all or part occur in the park, thus representing current averages at a landscape level. The future scenarios are quite variable and it is not yet clear which of these is most likely, although the trend observed at Stolshoek indicates good rainfall over the last couple of decades. Planning for a variety of different possible futures (scenario planning) is however recommended. Also note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of smaller steadier rain events).

Biome changes and impacts on vegetation types

Despite predicted changes in the climate by 2050, the conditions would still be considered to be within the current range experienced across the Nama-Karoo under all the scenarios. The Karoo National Park is therefore a very important conservation area for this biome.

While the Karoo is expected to get quite a lot hotter, the predicted rainfall changes under the intermediate scenario are not as extreme as in other parts of the country and no signs of a decline in rainfall are currently apparent.

Nonetheless, SANParks has an important role in educating the public about the importance of greener lifestyles.

Reducing waste and increasing opportunities for recycling are also critical.

Karoo can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.

Appropriate signage for tourists can also increase awareness and support for water and energy management changes.

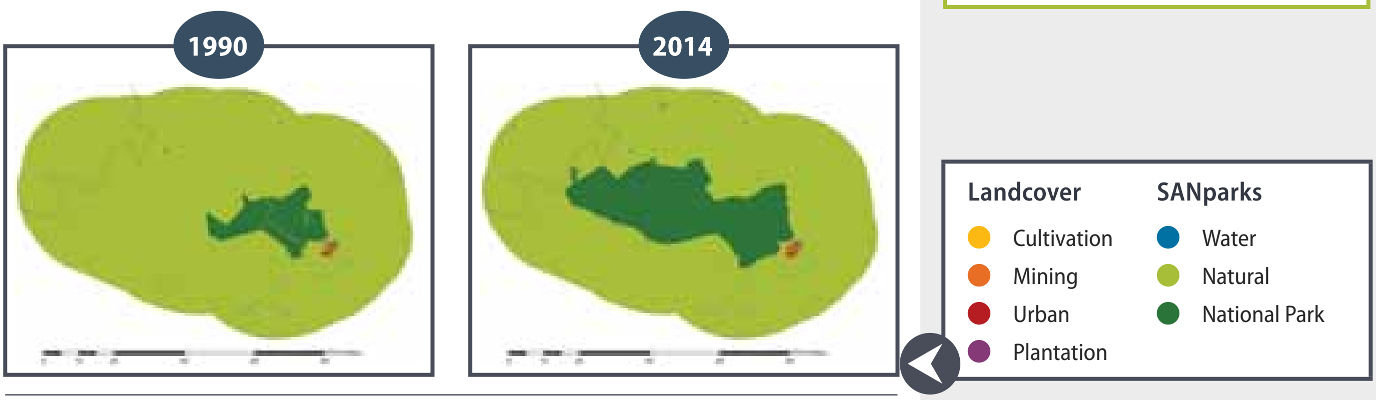
Actions to make a difference

Land-use change and habitat quality

L

Historically the area around the park has been a sheep farming area and there has not been much change in this practice since 1990. There has been a 13% increase in the urban area around Beaufort West. Aerial images from 2014 show large areas of degraded land inside and outside of the park (not shown on the map). While this is quite possibly an artefact of the way that land-use was mapped in 2014, the recent dry conditions may have exacerbated the impact of sheep and game grazing, resulting in higher levels of open soil and seemingly degraded land.

The main land-use change threat to the park is the prospect of fracking in the Karoo, which could significantly impact on water sources and levels of pollution (see Resource Use section), while Uranium mining is also a threat. On the positive side, the park has expanded substantially over the last couple of decades, including an additional 56 000 ha since 1990 and almost 71 000 ha since proclamation in 1979. The park now conserves 5 habitat types (up from 4 in 1990).



While there has been little change in formal land-use around the park since 1990, the park has expanded by over 56 000 ha.

Dry conditions impact quickly on habitat quality, which could be exacerbated by consistently warmer temperatures.

- BSP rehabilitation work has made significant and successful contributions towards combatting soil erosion that was inherited from farms procured for park expansion. This is an example of good science-management partnerships for developing, planning and implementing conservation interventions
- The Karoo National Park has expanded substantially over the past 15 years, providing opportunities to restore ecological processes

Disease

L

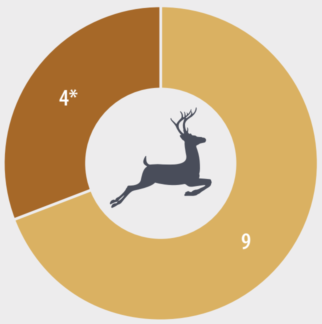
Disease is not currently a major threat in the park, although increasing proximity to Beaufort West increases the threat for transfer of zoonotic diseases. African horse sickness and Botulism are the only notifiable diseases currently thought to be present in the park. African horse sickness has implications for relocations of zebra.

The Western Cape has also experienced several Avian Influenza outbreaks in commercial ostrich flocks, resulting in movement restrictions on wild ostriches as well. This can have an impact on the sale of ostrich meat.

Alien species

M

Alien Animals present: **13**



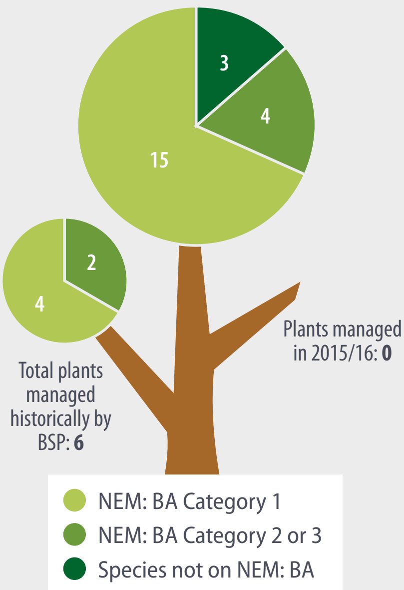
*Fallow deer (*Dama dama*), rock dove (*Columba livia*), house sparrow (*Passer domesticus*) and European starlings (*Sturnus vulgaris*)

Animals

Cats, dogs and other domestic ungulates may enter the park from Beaufort West, but the extent of such occurrences and their impacts has not been evaluated. Alien animals are managed largely on an opportunistic basis.

Rock Dove (*Columba livia*), house sparrow (*Passer domesticus*) and European starling (*Sturnus vulgaris*).

Alien Plants present: **22**



Plants

Alien plants are not a major problem in this park, although climate change may affect their distribution. All aliens in the park have been deemed to be at maintenance level and therefore BSP no longer do alien clearing in the park. Park management spray aliens where possible when they are encountered. NEM: BA regulations which require plans for all listed species, may provide challenges as the park will be mandated to plan for management of the 15 category 1 species that are present (cactuses, *Acacias,* grasses).

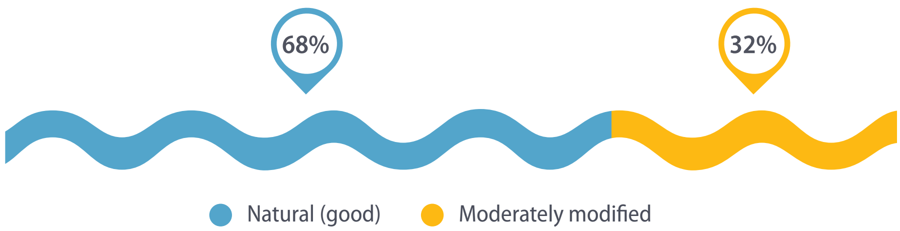
A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

Freshwater

L

QUICK STATS

- Total river length in park: **145 km**
- River Ecosystem types (of 223 in SA): **5**
- River length in good condition: **68%** (remainder moderately modified)
- Freshwater Ecosystem Priority Area (FEPA): **37%** of river length
- Three important rivers, the Sak, Leeu and Gamka, as well as 6 other rivers, have their source in the park.
- The wetlands in the park still need to be mapped.



Condition of all rivers in Karoo National Park (as per the National Freshwater Ecosystem Priority Assessment).

Most of the park is situated to the south of the Nuweveld mountain range where water drains into a large number of drainage lines. The Leeu River flows through the park towards the west, and is joined by the Paalhuis River, Klipplaatsfontein River, Boesmanskop River, Doringhoek River and Sand River, all of which have their sources within the park. In the north east, the Gamka River has part of its source partly in the park and then flows through the park toward the south. The Stolshoek River originates in the park and joins the Gamka River further downstream. The Sak River drains from the Puttersvlei area in the north of the park. All of these streams and rivers are seasonal and dependent on rainfall to flow. Some wetlands occur, mostly small and associated with larger rivers and springs. The condition of the Sak, Leeu and Gamka Rivers are classified as 'Category AB' (largely natural) within the park and 'Category C' (moderately modified) downstream outside the park. Department of Water Affairs' (DWA's) monitoring weirs are situated upstream of the park, but there are no River Health monitoring sites. No free flowing or Flagship Rivers are found in the park.

- Groundwater extraction for Beaufort West from within and adjacent to the park is a concern and needs to be regulated to ensure sustainability. Currently the water table has dropped considerably
- There is a potential threat of uranium mining to rivers flowing into the northwest of the park. Mining will also severely impact the groundwater as significant amounts of groundwater will be extracted and may pollute the groundwater systems. There is a further long-term threat of uranium dust and particles that may wash downstream into the park from proposed mines on the escarpment and just above the park (north- west section). The Chubbyhead Barb (*Enteromius anoplus*) in the Leeu River and on the escarpment in the Sak River would be affected by any pollution from upstream

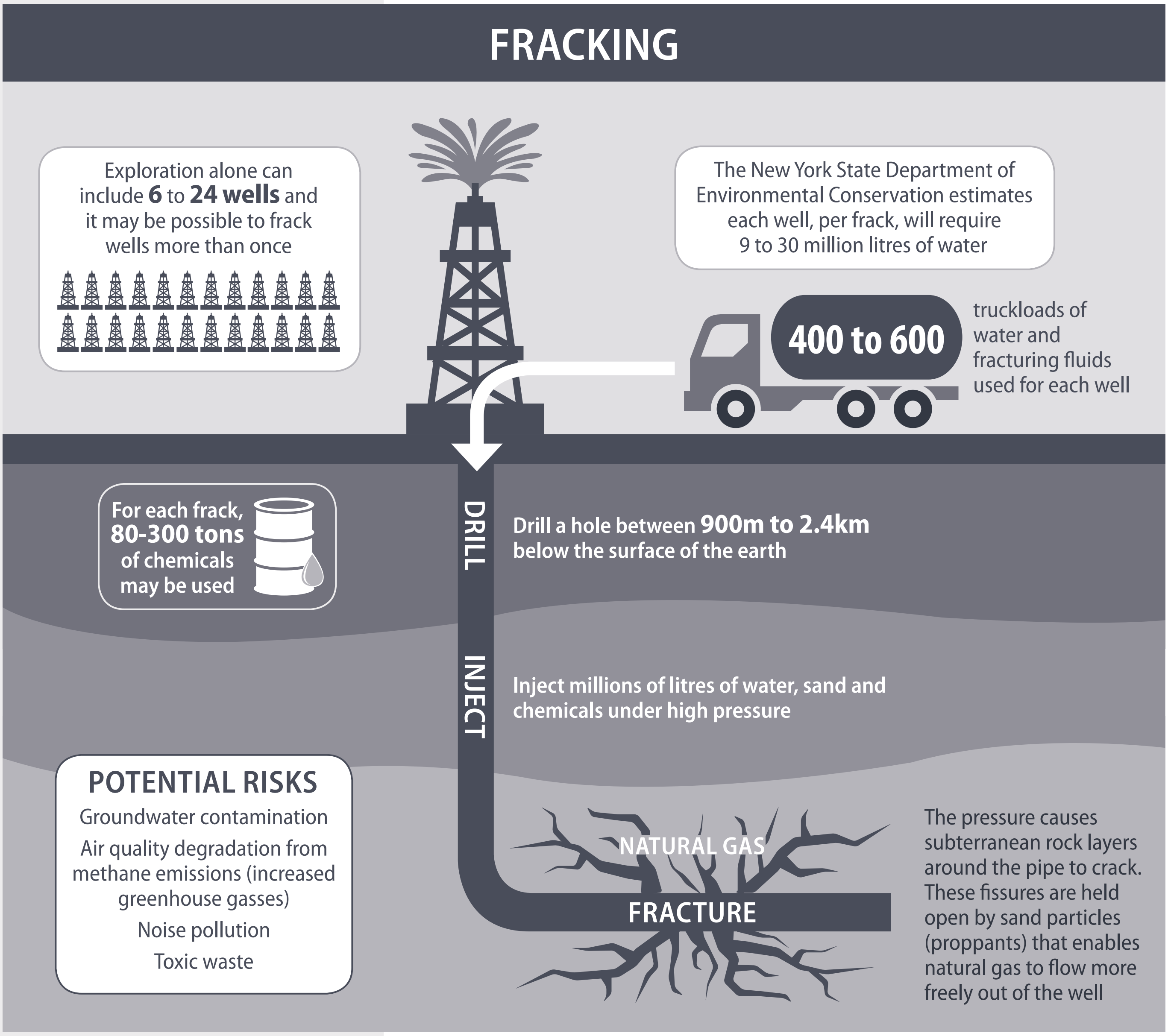
- A comprehensive groundwater monitoring program (quantity and quality) is urgently needed. A partnership between the local DWA and SANParks should to be established to kick start the process
- A fish species inventory needs to be undertaken to establish the presence or absence of expected and recorded species
- A water quality and fish baseline needs to be developed to evaluate the effects of potential pollution upstream on the local fish species

Resource use

L

Seventeen resources were reported to be used from the park. As part of herbivore population management, the park contributes animals for translocation to understocked parks or for genetic supplementation. Karoo National Park sells animals to cover the costs of capture and census operations and uses some to feed predators kept in bomas. A small amount of money is generated in some years through the sale of venison from ostriches and gemsbok. Abiotic resources including gravel and water are used by the park for management and tourism requirements. Monitoring the use of these resources is increasingly important as water security is threatened by climate change and there is ever increasing mining pressure on rocks and minerals outside of protected areas.

Quantities and specifics of unauthorised harvesting were not obtainable, but given the proximity of the town, it is possible that additional unauthorized resource use takes place. Further investigation is required to determine the impact and trends of resource use in the park.



Fracking is a process of injecting liquid (in most cases water) at high pressure into underground rocks to force open existing cracks to extract oil or gas. These statistics have been taken from the United States and demonstrate the large volumes of water involved in this process as well as some of the other associated risks.

Fracking and other future mining remains a threat throughout the Karoo and there is an increase in mining applications for a variety of resources including sand. Research has started to provide baselines. It will also be important for the park to monitor any use of abiotic resources within the park (e.g. sand and gravel for maintenance operations).

KRUGER
NATIONAL PARK

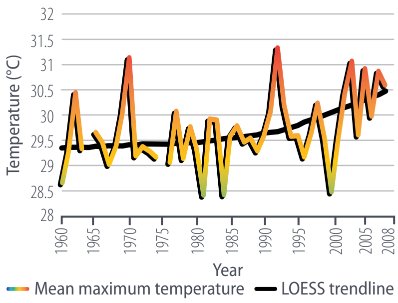
Kruger National Park (~1 899 000 ha) is the oldest and largest national park in South Africa and arguably the best known along with Table Mountain National Park. The land bordering on the park is occupied by game reserves, farms and villages. Settlements have grown and urbanisation presents a hard border on the western side with little means of expanding the park. The eastern border with Mozambique is partially fenced allowing for movement of animals. The rivers entering the park are used extensively by a variety of stakeholders before they enter the park. These include mining operations, plantations and villages, making over-abstraction and pollution of the rivers a significant concern. Kruger is one of SANParks' premier tourism destinations, and novel approaches to accommodating large numbers of tourists will increasingly be required in the changing world. Changes in climate are likely to increase the risk of floods and the siting of key infrastructure may need to be re-thought to prevent continuous rebuilding after flood damage. There are numerous alien pathways by which alien species can invade and the management of invasive species will require an ongoing effort. Kruger is increasingly implementing creative initiatives to share benefits with local communities, which may include sustainable resource use. Poaching of certain high value species such as rhinos remains a significant threat.

Climate change

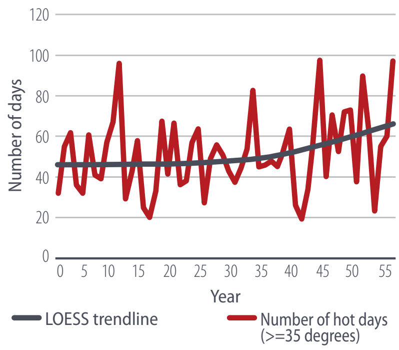
M

Temperature

In the 50 years between 1960 and 2009, average minimum and maximum temperatures have both increased by about 0.85°C at Skukuza. More recent temperatures suggest that this increase is even greater. While an increase of 1–2 degrees may seem small, we have demonstrated the effect that current increases have had on summer maximum temperatures in the figure on p. 96. During the last two summers, half the days have reached or exceeded 35°C, compared to just one quarter of summer days in the past. Further increases of between 1.3°C (best case), 2°C (intermediate) and 2.5°C (worst case) are predicted by 2050.

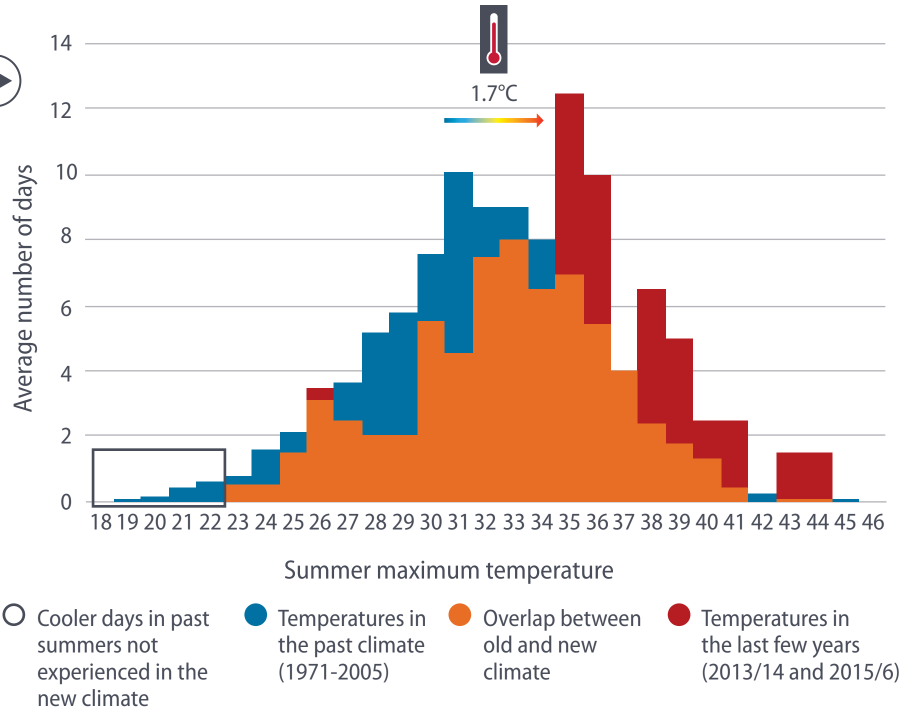


Annual average maximum temperature at Skukuza since 1960, showing a significant increase.



The number of days in the year where the temperature has reached or exceeded 35°C.

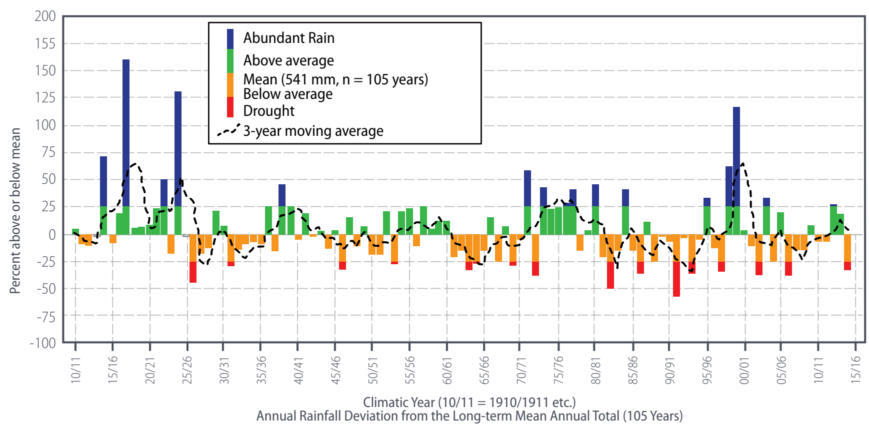
Increases in mean annual temperature of between 1.3°C (best case), 2°C (intermediate) and 2.5°C (worst case) are predicted by 2050 for the area.



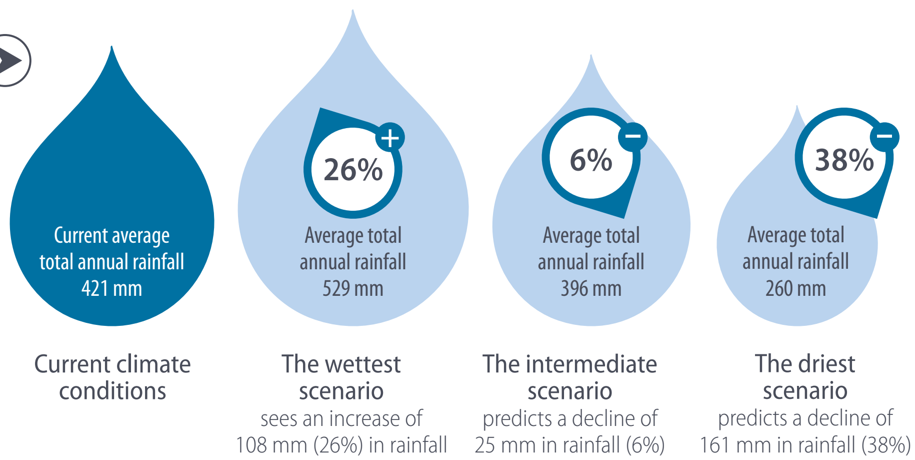
The average number of summer days reaching between 18°C and 46°C at Skukuza in the past (average conditions between 1971 and 2005) compared to the last few summers (2013/14 and 2015/16), showing how an average shift of about 1.7°C dramatically impacts on the number of hot days experienced. The last two summers have had an average of 46 days equal to or hotter than 35°C (almost half of the summer) compared to about 23 such days in the past. Far less of the cooler extremes (shown in blue) are currently experienced.

Rainfall

No changes in total rainfall were detected in the 90 year historical rainfall record for Skukuza. A decrease was detected in the size of very high rainfall events, while there was an increase in the number of rain days in a year. While these changes are hard to interpret in the light of predicted increases in the number of very large flood events, no other stations with sufficiently long and uninterrupted records were available for comparison.



An analysis of the rainfall deviation from the long-term mean annual total (105 years) [conducted by Dr Nick Zambatis using SAWS data].



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8 × 1.8 km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely, most models favour the wetter scenarios in the east of South Africa. However, the park should note that the range of predictions provided here does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events with an increase in floods and droughts).

Biome changes and impacts on vegetation types

While all scenarios still reflect conditions typical of savanna systems in general, substantially different conditions prevail in wet and arid savannas and lower rainfall conditions may more closely resemble arid savanna. The effect of carbon 'fertilization' is not included in these predictions. Atmospheric carbon dioxide (CO_2) has increased by approximately 40% since pre industrial times. Higher levels of CO_2 favour the growth of woody plants (shrubs and trees), and give them a competitive advantage over grassy plants (see next section).

Climate change adaptation (e.g. getting by with less) and mitigation (trying to prevent further climate change) are very important for SANParks.

SANParks has an important role in educating the public about the importance of greener lifestyles.

Reducing waste, including waste generated through restaurants, and increasing opportunities for recycling are critical.

Kruger can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

Kruger floods in 2014 (i) N'Waswitshaka low water bridge under water (ii) Letaba highwater bridge in flood.

Kruger drought 2016, with little forage visible for the animals.

While it may be too early to detect an increase in extreme flood events from the historical rainfall record, the floods experienced by Kruger in the last two decades have had significant ecological and financial impacts. Generally drier conditions, with an increase in flood events is predicted for the future. There may come a point where it is no longer financially viable to reinvest in rebuilding rest camps that are damaged along rivers and alternate rest camp placement may be the only solution.

A strong relationship is expected between disease outbreaks and climate. If this can be demonstrated it might be possible to predict disease outbreaks using long-term weather forecasts and climate change predictions. Assessment of disease-related risks under warmer conditions with more frequent flood events, especially in the lowveld and savanna regions could inform scenario planning for disease management.

An ongoing research project in Kruger by Prof. Stefan Grab (WITS), Dr Dave Thompson (SAEON Ndlovu Node) and SANParks aims to correlate changes in inter-annual rainfall and streamflow over 60 years for the 8 major river catchments of the park. Initial time-series analyses suggest a breakdown in the predictability of the El Niño cycle from the end of the 20th century, and that extreme flood and drought events are becoming more severe. This study will assist in understanding the interplay between river behaviour and a changing climate, and the relative impacts of climate and land-use external to Kruger on river flow.

Land-use change

H

Kruger National Park has a long and rich history. The park was established originally as the Sabie Game Reserve and proclaimed as Kruger National Park in 1926 and currently spans 1 898 857 ha, conserving 21 habitat types. There are a number of contractually included parcels of land which contribute to the expansion of the conservation estate. With the inclusion of Limpopo National Park in Mozambique, the transfrontier vision of opening boundaries and enhancing flows of ecosystem goods and services from core conservation areas is happening, although slowly.

'We know very little about "... woody vegetation in our savanna parks, and ..." how they work but everything points to massive thickening by a few supercharged shrubs and that will entirely alter the landscape of fear and the availability of forage for open plains animals'

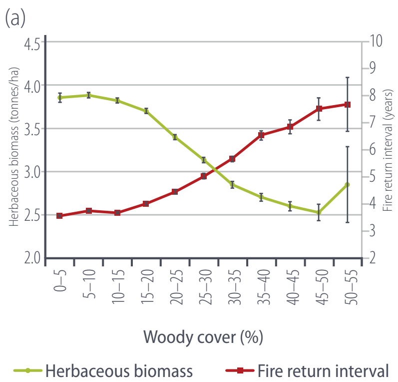
– William Bond on the future of savanna grasslands

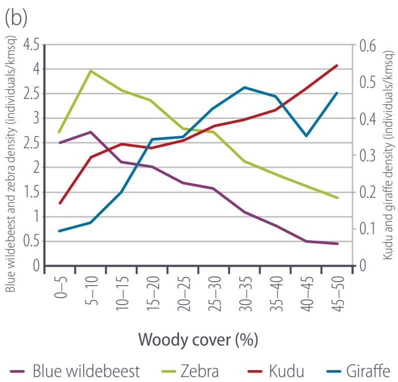
Habitat change

Higher levels of CO_2 favour the growth of woody plants (shrubs and trees), and give them a competitive advantage over grassy plants. Signs of bush encroachment are already evident in certain parts of Kruger. With less grassy habitats and burning less frequently, grazers like zebra (*Equus quagga*) and blue wildebeest (*Connochaetes taurinus*) will decrease, while browsers like giraffe (*Giraffa camelopardalis*) and kudu (*Tragelaphus strepsiceros*) will increase. This could affect predator dynamics and influence tourist game-viewing opportunities.

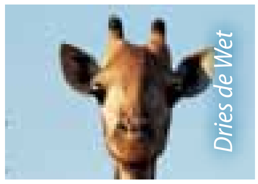
Grassland.

Zebras prefer open landscapes.





Bush thickening.



Giraffe are browsers and prefer more bushy vegetation.

Predictions for basalt soils in the Kruger National Park (a) Long-term herbaceous (i.e. grass) biomass decrease and long-term fire return period increase as woody cover increases – the denser it gets, the less grass and the longer the time between subsequent fires. (b) Grazer density (e.g. zebra and blue wildebeest) decrease and browser density (e.g. kudu and giraffe) increase along a woody cover gradient – if bush in Kruger gets denser, the species assemblage will change.

The predicted change from grazing to browsing species shows the resilience of natural systems to change. This also has implications for agricultural systems – although farming with animals like cattle and sheep will be negatively impacted, goats may do well and there will be increased potential for farming with wildlife such as kudu. The presence of elephants in drier savannas may be important to prevent woody encroachment (SAEON, 2015).

Patches of denser bush are not a threat. However, wide-scale, uniform and 'irreversible' (woody encroachment) densification threatens biodiversity and sustainable tourism opportunities and may require management intervention.

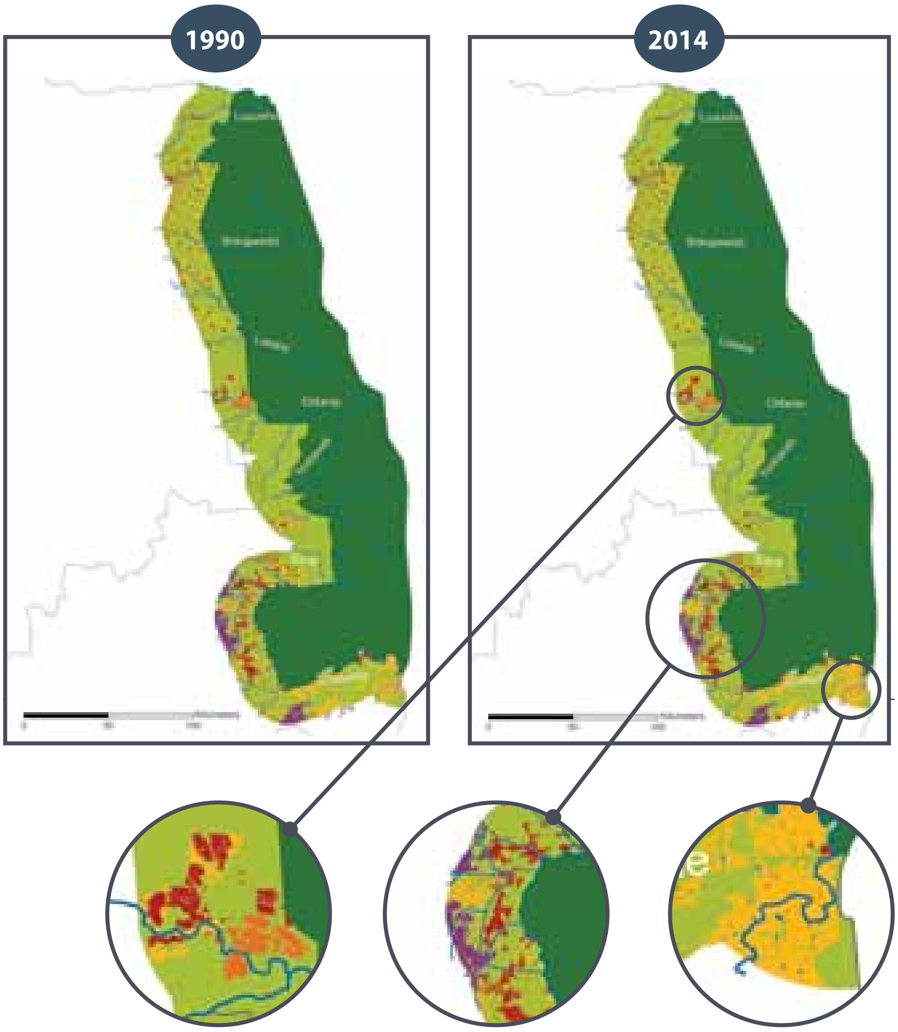
From aerial census surveys, antelope biomass has increased over the past long wet cycle, leading to an increase in lion and spotted hyenas in the past ten years. Rare antelope (roan and sable antelope) are not doing well in relation to historical population sizes. For megaherbivores (elephant and rhinos) as densities increase, population growth rates declined and this is linked to environmental variability and population densities. During previous historic intensive management interventions such as water provision and population control, herbivore dynamics have been disrupted. Currently anthropogenic disturbances such as poaching have an influence on large mammal dynamics.

Land-use outside Kruger

The main change in land-use on the western border of the park is a significant increase in urbanization and slightly less in agricultural use, mainly sugar cane and plantations. Mining on the border of the park as well as in the catchment areas of rivers is an increasing risk to the quality and quantity of fresh water reaching the park.

As urbanisation increases on the border of Kruger, less natural land is available for harvesting natural resources placing more pressure on the available resources inside the park to supply the increasing demand.

Hazyview Junction



Phalaborwa mining on the border of Kruger NP and increased urbanisation

Increased urbanisation in the Nkambeni area

Sugar cane farming in the Komatipoort area

Kruger experimented with setting high intensity fires under conditions normally deemed 'inappropriate' for management fires (i.e. under High Fire Danger Index conditions) in order to reverse bush encroachment. On a smaller scale, Expanded Public Works Programme teams selectively cut down bushes on road verges where increased woody cover occurred. These different approaches have some ecological, safety or financial trade-offs. SANParks must continue to learn if, when and how to use these (or other i.e. chemical clearing) management tools singly or in combination to effectively address bush encroachment.

Development in the buffer area around Kruger National Park is a concern, there is an increase in (i) the number of prospecting applications in buffer areas of Kruger, (ii) water spills/pollution and (iii) air pollution from industry outside the park. The rivers (water and sediment) and air (nitrogen deposition, acid rain) are impacted due to activities in buffers and beyond (e.g. coal power plants of Highveld).

Landcover

- Cultivation
- Mining
- Urban
- Plantation
- Water
- Natural
- Degraded
- National Park

Land use change between 1990 and 2014 in the 20km radius around the current park boundary. The second map, and three enlargements show land use in 2014 in the buffer zone with increases in urbanisation, agriculture (sugar cane in the south) and mining developments. The eight river catchment areas and the important rivers that enter the park are also shown.

Passive disease surveillance and data collation in a central SANParks database will provide valuable information on disease presence and changes over time. Trend analysis in disease surveillance data, also requires a measure of uniform effort. Regular scenario planning to interpret how other global environmental change factors (especially climate change and land-use change) will interact with disease is an important tool that can be used. A flexible and rapid response decision-making framework is required to be able to reactively and proactively respond to major disease events that could exacerbate the impacts of other change drivers and needs to be developed.

Disease

M

Disease is an important component of Kruger's ecology. Due to the sub-tropical climate, diversity of habitats and biota, including a large population of mega herbivores, Kruger is host to a large variety of diseases. From a national disease control perspective, Kruger is especially important in containing diseases of economic importance that have the potential to severely impact the livestock industry and international trade. These include foot and mouth disease (FMD), Corridor Disease, Bovine Tuberculosis (BTb), Brucellosis, African swine fever, and Anthrax. Kruger is therefore subject to one of the most intensive wildlife surveillance efforts in the country, if not the world. However, for various reasons, including that these diseases are often silent without overt clinical symptoms in their natural wild hosts, that wildlife are stoic in their response to disease, the lack of diagnostic tests specific for wildlife and the physical difficultly in covering a remote and extensive park like Kruger, surveillance is far from comprehensive. For example, there are about 7000 km of roads in Kruger, 2500 km of which are tourist roads and 4500 km used as management roads. These vary in condition from excellent to very poor, also depending on the season. Despite this vast road network, only 3.5% of the park is visible from all of these roads. The Kruger has a large and varied wildlife-domestic interface, with everything from peri-urban residential to communal livestock farming, irrigated sugar cane production and mining all within the 5km buffer zone. This intense interface has allowed many alien diseases such as Bovine Tuberculosis (BTb), Rabies and Canine Distemper (CD) to spread from domestic animals to wildlife. For some diseases such as BTb, buffalo have become the maintenance hosts for these diseases, with little detectable population level declines whereas for other diseases such as CD, a recent outbreak has killed off at least 1 pack of wild dogs, threatening the only viable free-ranging population of wild dogs in South Africa with localised extirpations.

Diseases such as Ecephalomyocarditis have been linked to larger climatic cycles like drought and subsequently resource availability which favours rodent explosions (especially of species like the multimammate mouse, *Mastomys natalensis*). Increasing climate variability and major events like floods and droughts could further impact rodent borne zoonotic and emerging diseases, such as plague, leptospirosis, hantavirus and arena virus.

Being downstream of large and overworked rivers, means that Kruger is not immune from the effects of freshwater pollution, flow alterations and the impacts of large dams. These factors culminated in a large scale pansteatitis outbreak in Nile crocodiles in the Olifants River.

Pollution in rivers combined with an increase in temperature create the opportunity for growth and spread of the dangerous pollutant cyanobacteria (blue green algae).

Diseases in wildlife are often diagnosed at post mortem, therefore all opportunities to sample dead and dying animals should be encouraged. Due to the endemicity of anthrax, which can be a fatal zoonosis, all ranger staff are equipped with blood slides so that they can at least make a blood smear from any unusual mortality, without having to open up the carcass. This serves as a very efficient passive surveillance system. With the advance of PCR technology, with time these blood smears alone can be used to test for various other diseases as well.

- State Veterinarians are based in Skukuza from where they conduct local and regional disease surveillance and research
- SANParks has several registered research projects conducted by internal as well as with outside researcher partners on a wide range of disease related topics

Taking a pharyngeal probing sample from buffalo for the collection of Foot and Mouth virus.

Performing an intradermal skin test in an immobilized warthog to diagnose tuberculosis.

Performing a field bronchioalveolar lavage in an immobilized lion as a tool in the diagnosis of Bovine tuberculosis infection.

Ultrasound in a white rhinoceros to determine the effects of immobilization on respiration and cardiovascular function.

Alien species

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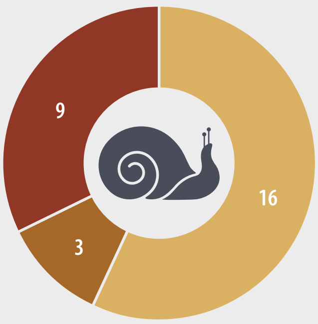
Alien species in Kruger have been particularly well researched and 414 alien species (363 plants, 28 animals, and 23 biocontrol species) have been documented in this park, the most for any of the parks.

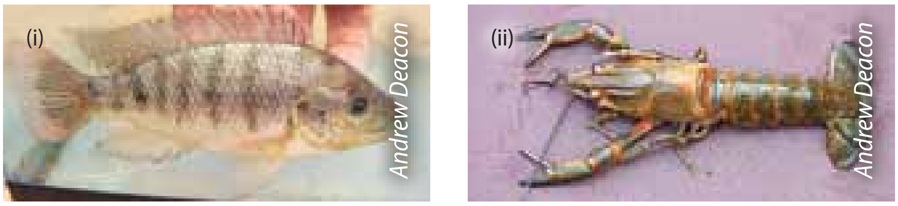
Alien Animals present: **28**



- NEM: BA Category 1
- NEM: BA Category 2 or 3
- Species not on NEM: BA

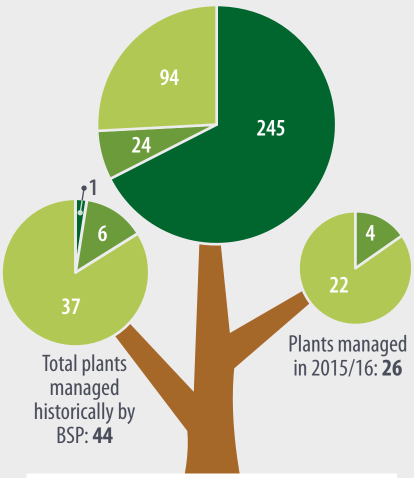
Animals

Nine NEM: BA category 1b animal species are present and require management action. These include alien fish that have the potential to hybridize with natives as well as several widespread species of alien snails, which may have substantial impacts.



Aliens in freshwater systems (i) Nile tilapia (*Oreochromis niloticus*) and (ii) Redclaw crayfish (*Cherax quadricarinatus*).

Alien Plants present: **363**



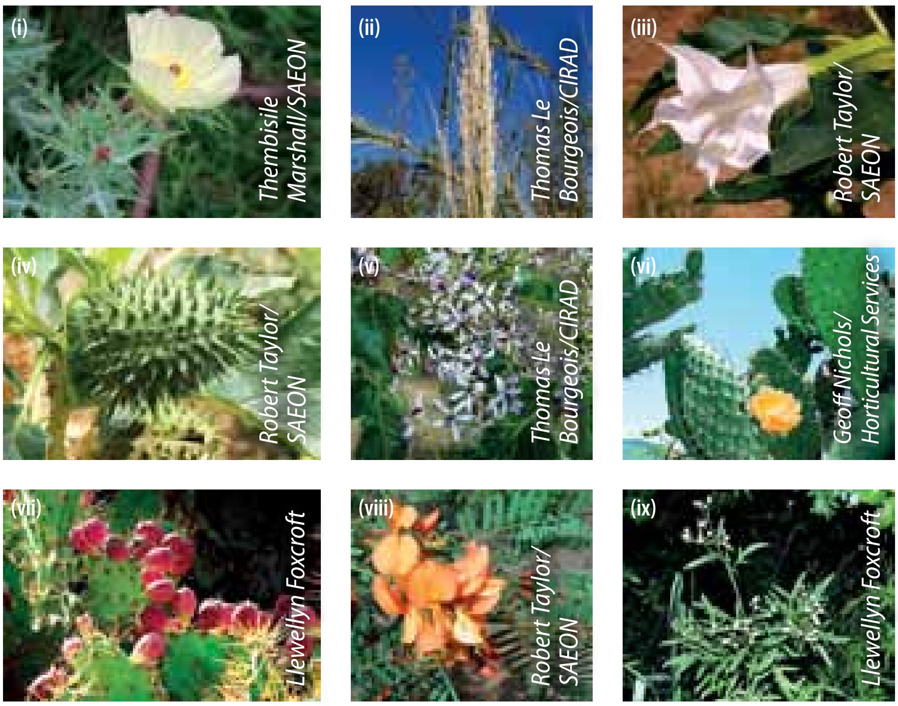
- NEM: BA Category 1
- NEM: BA Category 2 or 3
- Species not on NEM: BA

23 biocontrol agents have been used in the management of alien plants

Plants

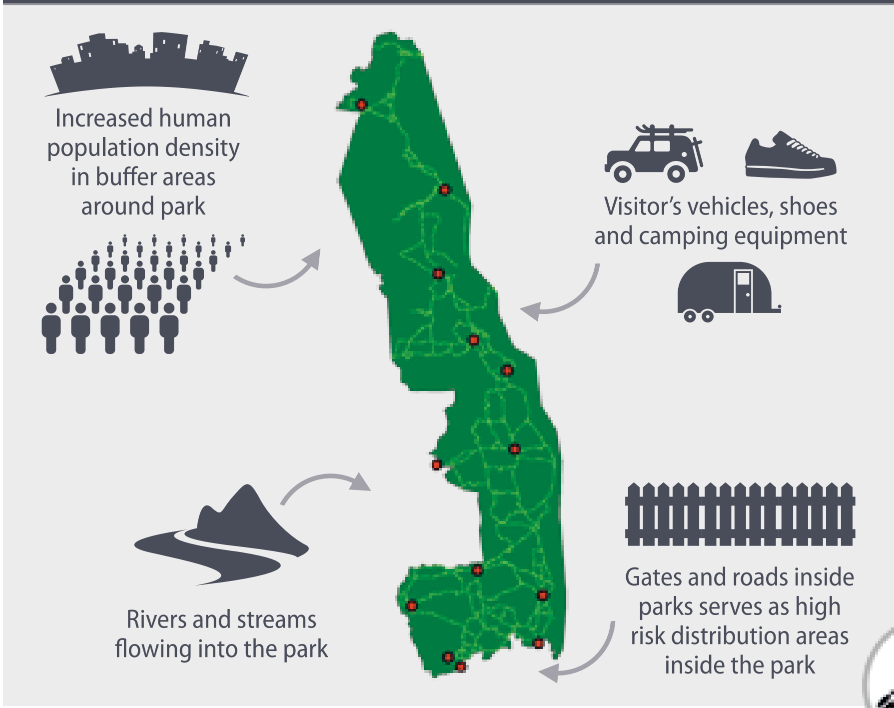
Although a high number of alien plant species have been documented, many are restricted in distribution, or are ruderal and not many are high impact species. Despite this, 94 of the species present in the park are listed in national legislation (NEM: BA regulations) under category 1. All these species require active control and management plans and significant planning will need to go into the implementation of this legislation.

The 23 biocontrol agents present in Kruger are alien animal species that have been introduced as biocontrol for management purposes on alien plants. They have no impact on the indigenous species and reduce the impact and abundance of alien plants and are an important management tool.



(i) White Mexican poppy (*Argemone ochroleuca*)
(ii) Spanish reed (*Arundo donax*)
(iii) Large thorn-apple (*Datura ferox*)
(iv) Common thorn-apple (*Datura stramonium*)
(v) China berry/seringa (*Melia azedarach*)
(vi) Sweet prickly pear (*Opuntia ficus-indica*)
(vii) Sour prickly pear (*Opuntia stricta*)
(viii) Red sesbania (*Sesbania punicea*)
(ix) Famine weed (*Parthenium hysterophorus*)

Alien species pathways into Kruger National Park



The prominent pathways by which alien species can be introduced into Kruger.

A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

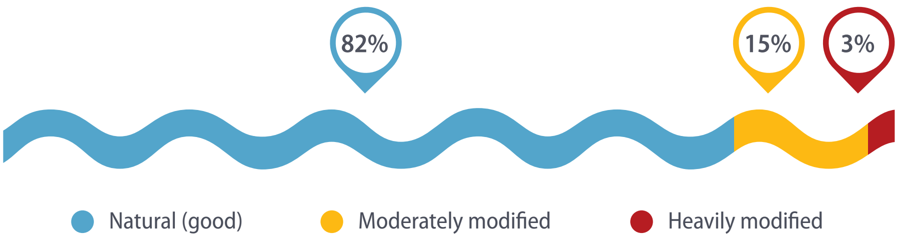
A large number of the plant species were introduced as ornamental plants or spread from ornamental plantings outside of the park. A policy to stop the planting of alien ornamental plants in gardens and rest camps has been implemented.

Freshwater

H

QUICK STATS

- Total river length in park: **2796 km**
- River Ecosystem types (of 223 in SA): **19**
- Freshwater Ecosystem Priority Areas: **49%** of river length (and a further **8%** that would qualify should the modified condition be restored), while **8%** of river length is a fish support area
- A team are working on the development of a wetland inventory using a combination of various map and field-based strategies to determine the best approach for the task



Condition of all rivers in Kruger National Park (as per the National Freshwater Ecosystem Priority Assessment).

The Luvuvhu River

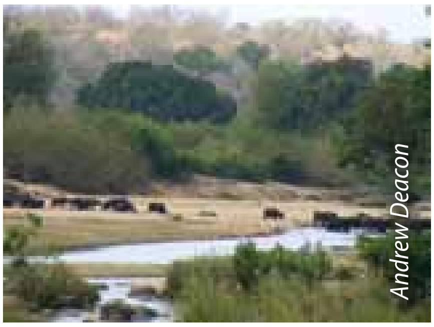
WHAT IS THE ECOLOGICAL RESERVE?

The basic principle is that the environment, alongside people, has a basic right to water and this is stated in the National Water Act. The amount each river requires as a 'reserve' is determined based on a comprehensive analysis of the bio-physical attributes of a river. SANParks continuously monitors river flow into the park and negotiates with external stakeholders to ensure that each rivers' ecological reserve is implemented, this ensures that the seasonal and inter-annual variability that mimics natural processes is maintained.

Bosveld Phosphates spillage on the border of Kruger National Park. Mine officials treat acid water with lime to reduce pollution into the park.

The ecological viability of rivers is maintained through the implementation of the ecological reserve. However maintenance of this for protected areas may have unintended consequences for river ecology upstream due to the reliance on dams and releasing high water volumes in the dry season upstream, which we call reversed seasonality, to supplement low river flows downstream. Research is required to understand the upstream impacts of ecological reserve implementation downstream in Kruger.

video clip: http://carteblanche.dstv.com/player/1101044/ (Cry me a river).



The Sabie River

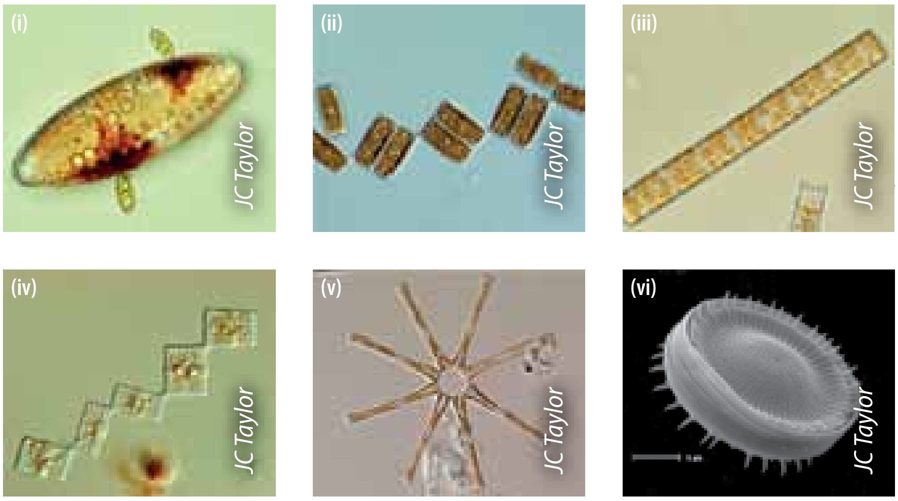
The Olifants River

Five National Parks overlap with strategic water source areas: Bontebok, Garden Route (by far the largest contributor) Golden Gate Highlands, Table Mountain and Kruger National Parks. Only three free-flowing rivers in the country have their entire length fully protected, the Groot River in Garden Route and Mbyamiti and Nwanedzi-Sweni Rivers in Kruger.

One of the key threats to the park, is that most of its perennial rivers have their sources outside of the park, and are vulnerable to an array of upstream external pollution effects impacting on river water quality as well as modifications to river flow from upstream abstractions. Working with external stakeholders is essential and Kruger has made good strides in this regard in several catchments.

When rivers are dry or have low flow, the contribution of groundwater to river base flow increases in importance. This can elevate the risk from pollution to the aquatic environment in areas where mining has been present for long periods and underground seepages have a high level of accumulated contaminants. Pollution spills occurred in the Selati River in 2013/2014 after heavy rainfall and the mining company was fined. Continued monitoring of the rivers in the Phalaborwa Mining Complex is conducted by SANParks and the relevant stakeholders.

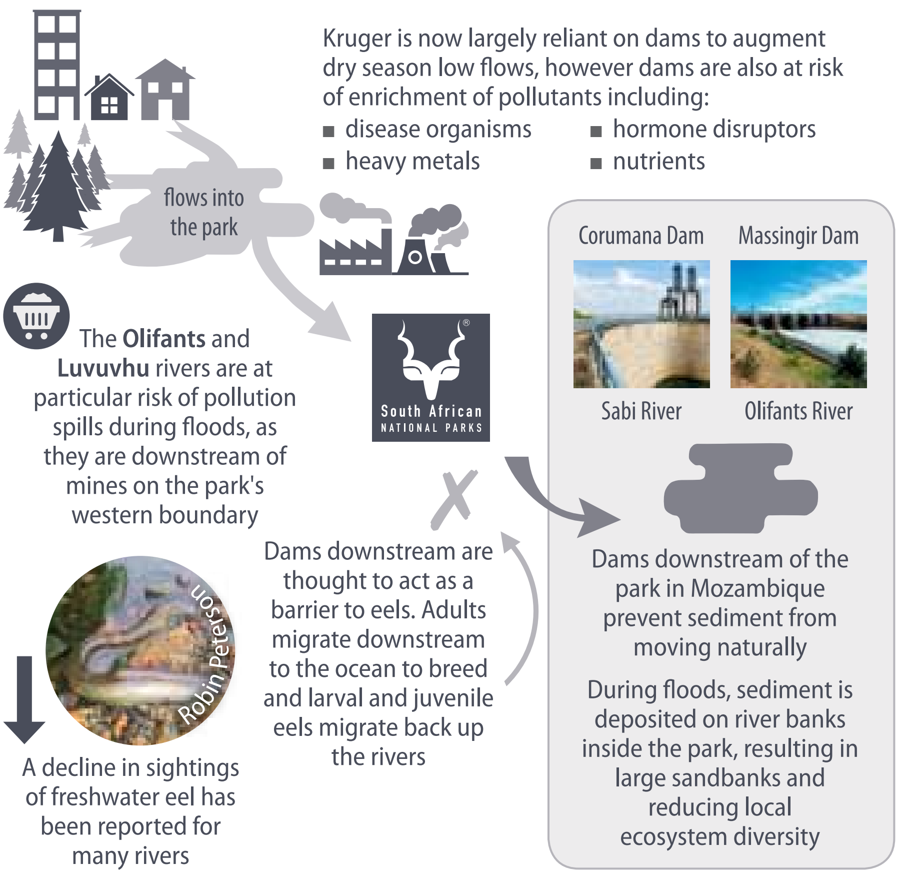
- A comprehensive ecological reserve has not yet been determined for the **Luvuvhu River**, which is currently being managed to provide a static monthly 'Instream Flow Requirement'. This does not allow for natural fluctuations and the management needs to be updated using a more modern and variable ecological reserve to ensure optimal functioning.
- Resource quality objectives (RQOs) are used by the Department of Water and Sanitation to classify and manage water resources. Once classified, a variety of biological and abiotic water quality factors need to be maintained within the bounds of that classification. Capacity constraints across departments, funding and expertise is the present challenge to ensure successful implementation of the RQOs.
- Native tilapia fish species are threatened by hybridization with the alien Nile tilapia (*Oreochromis niloticus*) in many perennial rivers. Refugia of viable unimpacted populations of indigenous tilapia are required.
- There are many freshwater invasive alien species (e.g. Redclaw crayfish (*Cherax quadricarinatus*), and Melania Snails (*Terebia* sp.)), which have the potential to impact aquatic ecosystems through modification of natural habitats, direct predation, competition with native species and the introduction of diseases.



Images of a diatoms (i) *Surirella* sp. (ii) *Diatoma* sp. (iii) *Aulacoseira*sp. (iv) *Tabellaria* sp. (v) *Asterionella* sp. (vi) *Stephanodiscus* sp.

Diatoms are very good indicators of water quality as different species thrive under different nutrient conditions, so diatom abundance and composition can assist in pinpointing the presence of pollutants such as phosphates and nitrates. They also enable the building of useful timelines of changes in pollutants as communities can be compared over time between seasons, years and even decades, as samples are available from the 1980s. Furthermore, diatoms can be monitored during low flows when conducting routine monitoring is often not possible

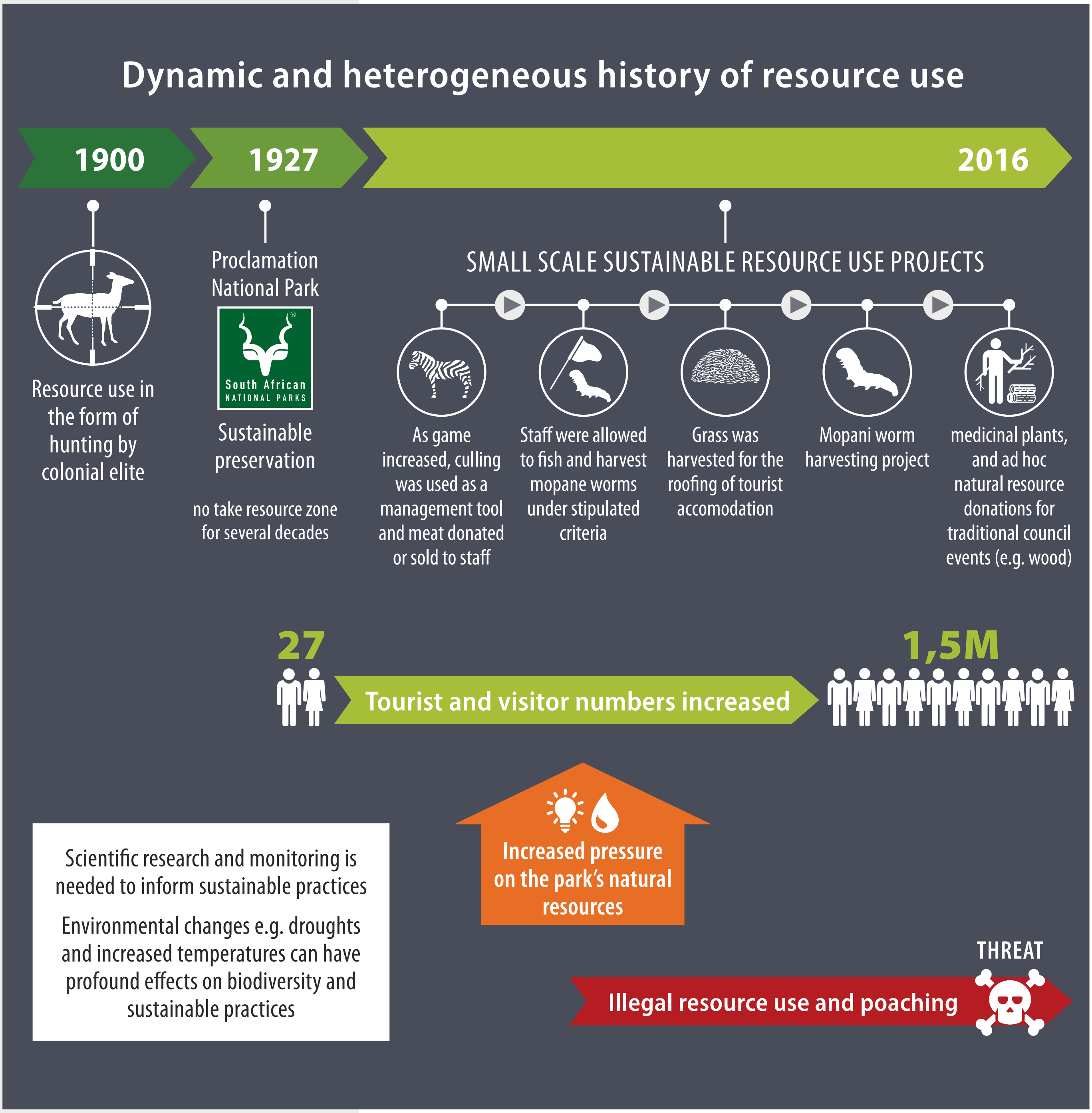
The influence of dams upstream and downstream of Kruger



The influence of dams upstream and downstream of Kruger.

eDNA (Environmental DNA, or scraps of DNA from plants and animals that are found in water) can be sampled and used to detect / monitor invasive alien species. An external project was piloted to determine movement of the alien carp from the Massingir dam. There are many additional applications, including the potential to monitor aquatic species abundances; this will reduce the uncertainty in the catch-per-unit effort approach that is currently been used

- Kruger is working well with external stakeholders and making progress on operational river management that provides rapid response/feedbacks for river flow and quality
- The standard bio-monitoring approach is being refined beyond national programme requirements to include monitoring of local change drivers that enable scientists and managers to determine the cause and effect of any observed changes. The revised programme is currently in its first year, but is expected to yield very useful data



Although only 22 resources were officially reported to be harvested from the park during the GEC survey (2012), this is an underestimate in that it excludes amongst others, the specific species for which seeds are harvested for the nursery as well as several species being harvested illegally.

Subsistence poaching in the form of fishing, firewood, snaring and hunting remains a challenge in Kruger with confirmed records of 16 mammal species (excluding rhino and elephant) having been poached over a 5 year period.

1. Thatch grass harvesting project

Thatch grass used for the roofing of tourist facilities has been harvested from the park for several decades. In an average season, thatch harvesting contributes approximately 34% to total household income during the months of harvest for the 30 mostly unemployed participants.

Grass harvesting for thatching.

2. Mopani worm (*Gonimbrasia belina*) harvesting

Mopane worms have been harvested twice since the projects inception in 2010, and in each season have contributed approximately 47% of additional income to 200 households during the months of harvest.

- Kruger needs a systematic evaluation process to determine the potential for mopani worm harvesting based on outbreak size which must be cognisant of making trade-offs between poaching risks versus not allowing subsistence resource use
- Continued harvesting with or without Mopani worm outbreaks will allow community members to be part of worm outbreak-size monitoring which builds shared ownership and decision making

Mopane worm

3. The pepperbark (*Warburgia salutaris*) sapling project

- The pepperbark is an endangered tree that is harvested for medicine. Research has shown that the leaves and the bark have a similar chemical composition, which suggests that more sustainable harvesting options are possible
- Positive engagement with 170 traditional health practitioners has led to the sustainable distribution of 1000 pepperbark saplings for sustainable use
- Monitoring has revealed good survival and growth rates of planted saplings in homesteads and participants are currently using these plants in their healing practise on a daily basis

Pepperbark tree sapling project.

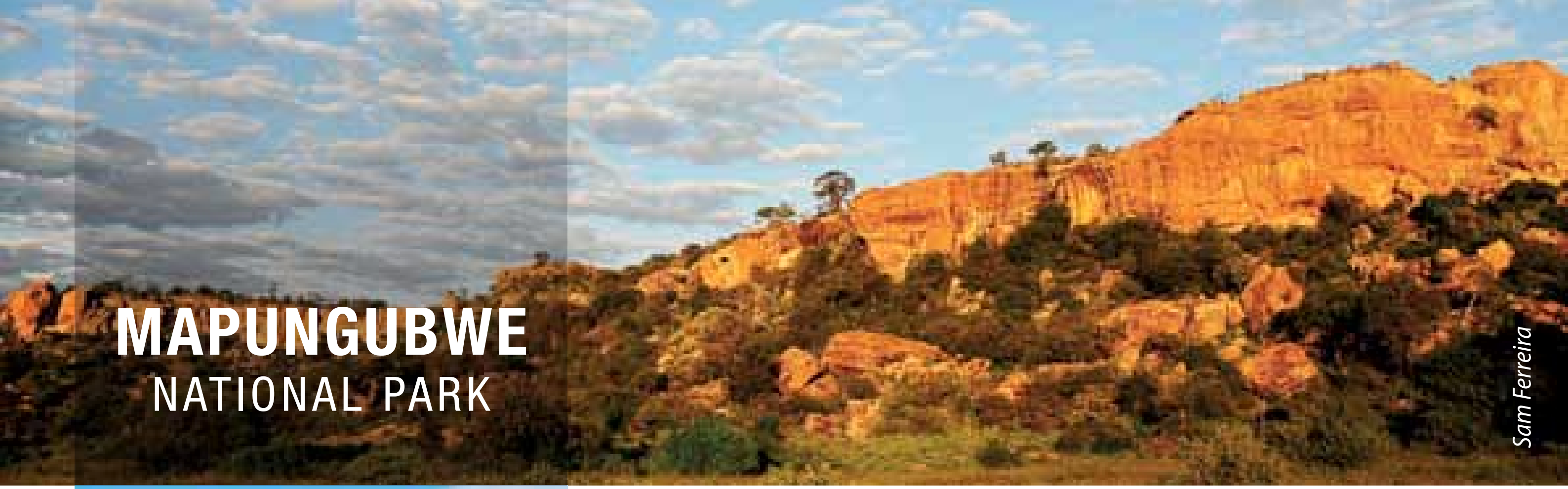
- Rhino (and more recently elephant) poaching poses a significant threat to the species, to conservation management as well as causing both positive and negative social and economic impacts in and around neighbouring areas. Recent occurrences of poison-related bird and animal deaths are believed to be linked to possibly both poaching activities as well as the local and urban trade in traditional medicine
- Poor media coverage of SANParks approach to resource use at general and project levels can result in an increase of illegal harvesters or negative perceptions from the public
- There is limited knowledge of the species and quantities illegally harvested for the medicinal plant trade in Mpumalanga and Limpopo. Previous studies (~2001) have identified 176 species being sold in local markets on the western Kruger boundary. While many of these species come from elsewhere, it is not known exactly how many of these come from the park

- The processes of negotiation and discussion regarding resource harvesting is just as important as the actual resource being harvested
- Formation of an internal Kruger National Park resource use committee, with representation from all departments to coordinate our efforts is needed

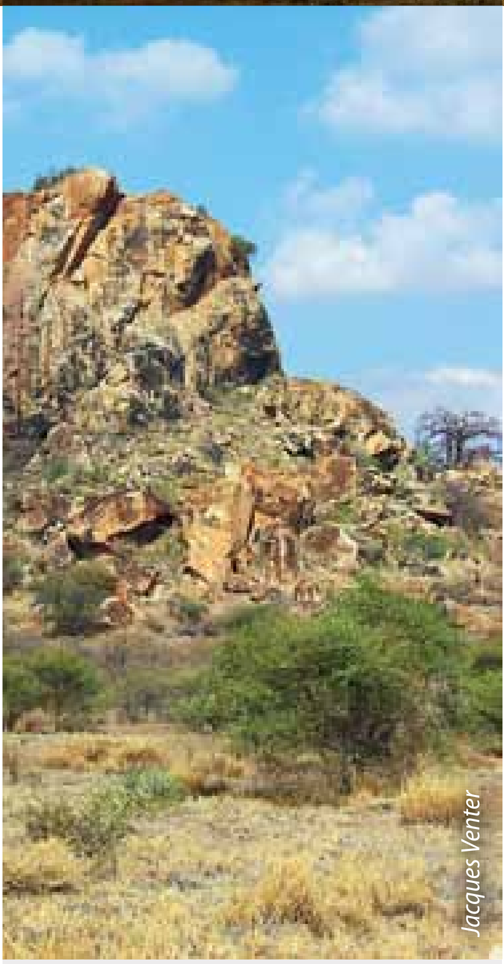
How can we share conservation benefits with the people living adjacent to our park, in order to build shared ownership for protecting biodiversity?

- Resource use provides tangible benefits that address basic human needs at a local level
- Small scale resource use projects are effective leverage points for sharing benefits, being cost effective in that they are seasonal and require very little input from SANParks, but have a lasting positive outcome on relationships
- Positive opportunities for relationship building and engagement can arise through addressing threats associated with illegal resource use (e.g. pepperbark project)
- There is an opportunity for other formalised resource use projects such as marula fruit, firewood harvesting, and animal products stemming from DCA off takes, particularly in the resource use zone which can have a positive impact on relationships between Kruger and neighbouring communities
- In an internal research report, Louise Swemmer (SANParks) documented the various resources used by communities surrounding Kruger and emphasised the importance for understanding sustainable resource use principles and needs for SANParks

Kruger lion



MAPUNGUBWE
NATIONAL PARK



Mapungubwe National Park (~19 700 ha) is a World Heritage site and transfrontier conservation area (TFCA). It is a unique park which reflects the important connections between people, their heritage and biodiversity in the landscape. The park is surrounded by different stakeholders and concession areas. There is a strong emphasis on the building of partnerships between stakeholders, good neighbourliness and the effective management of the park and surrounds. Water usage and management of water upstream, especially from the Limpopo River which forms the international boundary with Botswana and Zimbabwe and groundwater abstraction by agricultural and mining activities are key concerns for management. Mapungubwe is an arid park and depends on groundwater and wetland functions. The different land-uses around the park have influenced how many mesoherbivores are now using the landscape, especially elephants and the compound effect this has on the unique riverine forest. Large trees are disappearing and recruitment is very low in these areas. A significant challenge is the establishment of a functional buffer zone that can protect the World Heritage site from external developments, in particular mining.

Climate change

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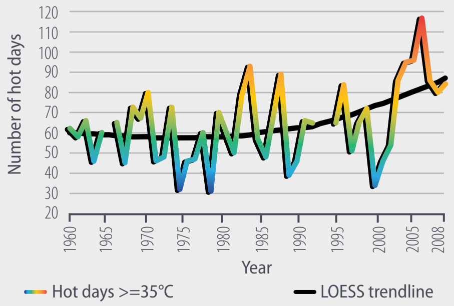
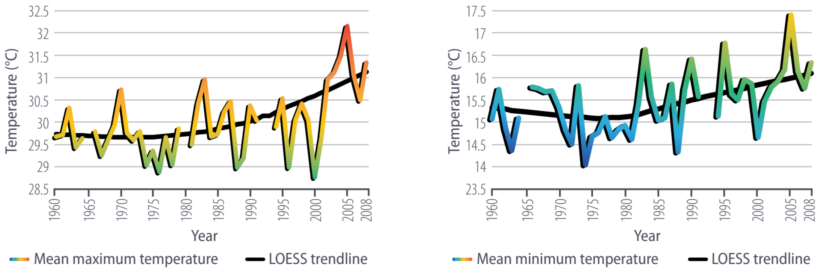
Temperature

Between 1960 and 2009, absolute minimum temperatures increased by 3.05°C, average minima by 1.2°C and average maxima by 1.25°C at the Musina weather station. These increases have resulted in an increase of an extraordinary 22 additional days per year where the temperature exceeds 35°C (compared to 1960). Further increases of between 1.3°C (best case), 2.2°C and 2.7°C (worst case) are predicted by 2050, which will further exacerbate prolonged hot conditions in summer and overall warmer weather. Under the worst case scenario, up to 60% of summer days might be hotter than 35°C.

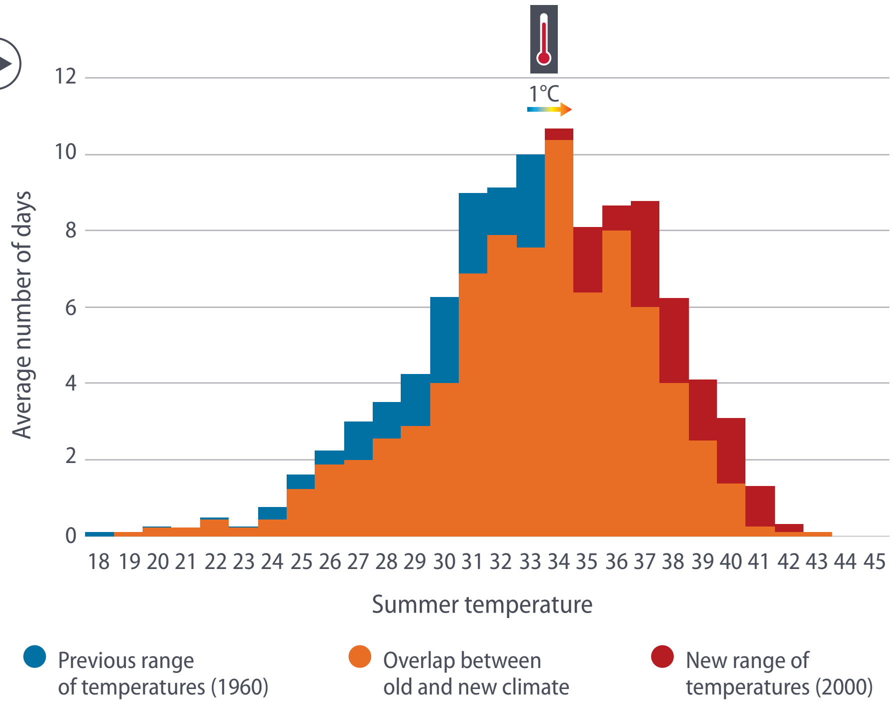


Where there used to be approximately 60 days in the year with temperatures above 35°C in the 1960s, there are now roughly 80 such days and in some years as many as 109 (recorded in 2005, the hottest year on record at the time). There are also only about 50 days in the year where the maximum temperature does not reach 25.



Annual average maximum and minimum temperatures at Musina since 1960, showing a significant increase.

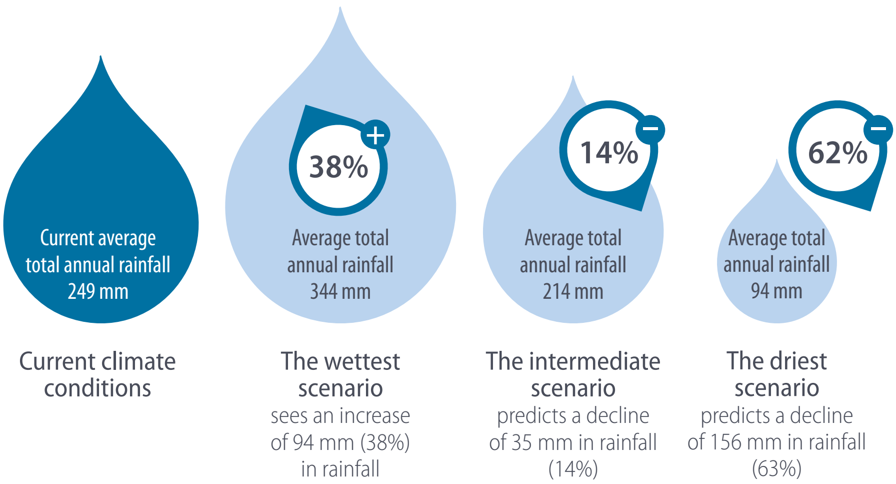
Further increases in mean annual temperature of between 1.3°C (best case), 2.2°C and 2.7°C (worst case) are predicted by 2050.



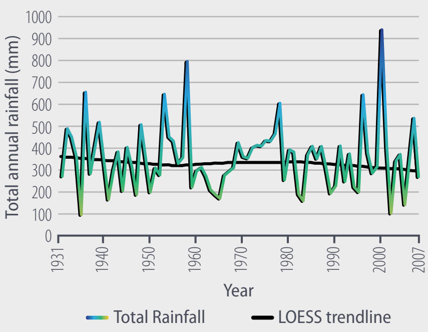
The average number of summer days reaching between 18°C and 45°C at Musina in the 1960s compared to the 2000s, showing the shift from less cool days to many more hotter days.

Rainfall

No changes in total rainfall were detected in the historical rainfall record for the past 83 years.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely, most models favour the wetter scenarios in the east of South Africa. However, the park should note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events).



Total annual rainfall at Musina since 1927.

Biome changes and impacts on vegetation types

No major changes in the distribution of the Savanna biome within the park are predicted, but see the Kruger National Park for an explanation of the potential bush encroachment impact of higher CO_2 levels. In addition, Savanna currently encompasses one of the broadest range of climatic conditions, with substantially different conditions in wet and arid savannas which might mask the effects of changing climate.

Climate change adaptation and mitigation are very important for SANParks.	Reducing waste and increasing opportunities for recycling are also critical.
Mapungubwe can save water and electricity in a number of ways including low flow toilets, low pressure shower heads, solar geysers and geyser timers, rainwater harvesting and tourist and staff awareness programmes.	Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

Continued monitoring of tree mortality, recruitment and elephant impacts is needed.

Land-use change and fresh water challenges H

Mapungubwe has the potential to become a large conservation area and has already expanded by 17 864 ha since declaration in 1998 to a total of 19 742 ha, and the conservation of habitat types increased from 13 to 21. The park was awarded World Heritage status in 2003. The core area of the World Heritage site comprises of 28 169 ha. A further 4 490 ha of privately-owned land is managed under contract by SANParks and 12 703 ha of privately-owned land, not managed by SANParks, is present within the core area of the World Heritage site. Various privately-owned properties make up the buffer zone, which, added to the core comprise some 100 000 ha.

Mining and agriculture close to the park constrain many of the ecosystem processes and could have detrimental effects on the freshwater and groundwater inside the park. The Lowveld Riverine Forest on the banks of the Limpopo River is a unique vegetation type, an important biodiversity component and part of the ambience of the cultural heritage site. The large riverine trees are evaluated every year for elephant, flood and drought damage. The lack of new recruits is of concern and various approaches of excluding elephants have been tried. A way forward has been proposed that will allow additional tourist opportunities as well as research on recruitment, regeneration and spatially focussed protection of the forest (see infographic).

Sufficient data collection and positive relationships with the Venetia diamond mine is important if management goals for the forest are to be achieved. The mine's supportive commitment to the guidelines with regard to water abstraction is crucial if the forest is to survive in the longer term.

Coal reserves have been identified in the park and on neighbouring properties. Mining activities are known to have detrimental effects on natural land and water resources.

Elephant exclosures previously used in Mapubgubwe – plans are underway to redesign these. Maintenance of elephant-proof fencing around highly palatable tree species remains a challenge in areas with high localised elephant densities.

Where have all the big trees gone?


Unique vegetation type of Riverine forest


Mapungubwe is rapidly loosing big tall canopy trees >20m With no signs of abatement

Three independent research groups monitored 5 species of large trees

2007–2012

- drought stress
- herbivory (small and meso herbivores)

40% Ana & Fever trees died

20% Fig trees died

80–90% of trees show elephant damage (Bark stripping/ feeding)

1990–2005

Elephants only present from **2007**

- 1991/1992 drought
- 2000 floods
- combination of drought and creepers

25% trees died

2010–2015

23% Fever trees died

15% Ana trees died

50% or more of the trees show debarked trunks and main stems pushed over or snapped

severe damage

Droughts and floods also have a negative effect on the growth of trees

Water stress either natural and abstraction needs to be understood

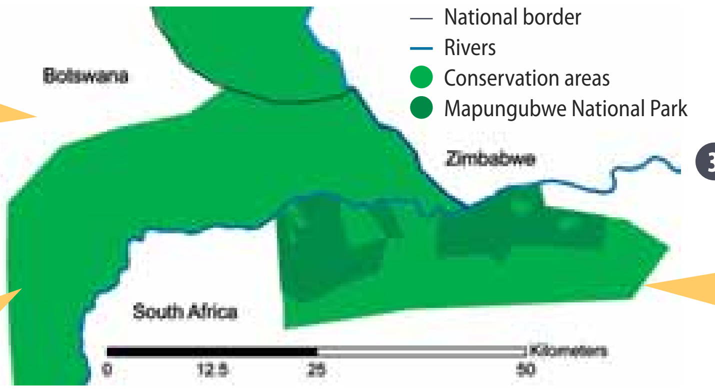
Elephants are a major cause of tree loss BUT not the only reason

Trees may have reached the end of their life time

Scenario planning by managers and scientists is needed to consider the trade-offs between the different objectives in the park and the way forward

The way elephants use the land is influenced by:

1. Hunting and poaching in the Tuli Block and in Zimbabwe
2. Artificial water provisioning from neighboring game farms (Botswana)
3. Agricultural development on either side of Mapungubwe could channel the movement of elephants and localised impact on trees



The outcomes of research by Tim O'Connor (1990–2005), Organisation of Tropical Studies (OTS) (2007–2012) and SANParks & SAEON (2010–2015) on the loss of large trees in the riverine forest habitat in Mapungubwe. A SANParks internal report by Corli Coetsee and colleagues in 2016 contains more information.

Freshwater

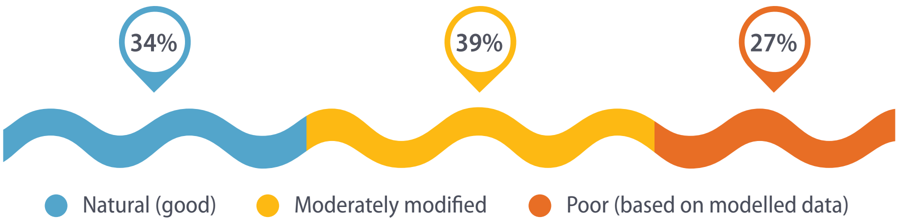
H

The Limpopo River flowing at Poacher's corner.

The Limpopo River flowing at the confluence.

QUICK STATS

- Total river length in park: **35 km**
- River ecosystem types (of 223 in SA): **4**
- River length in good condition: **34%** (remainder moderately modified, **39%**, or poor condition as modelled by available data, **27%**)
- Freshwater Ecosystem Priority Area (FEPA): currently no river length is considered a FEPA, although **27%** would be considered a FEPA should the modified condition be restored
- A team is working on the development of a wetland inventory using a combination of various map-based and field-based strategies to decide how best to approach this task



Condition of all rivers in Mapungubwe National Park (as per the National Freshwater Ecosystem Priority Assessment).

As with Kruger, many of the freshwater challenges have to do with upstream dams and land-use (particularly mining and farming) that impact on water quality and flow within the park. Working with external stakeholders and across international borders is therefore a priority (see infographic).

- Risk of over-abstraction of water from groundwater and the Limpopo River for agricultural and mining practises surrounding the park
- Future construction of dams, irrigation projects and mines in South Africa (Limpopo catchment), Botswana (Maloutswa catchment) and Botswana/ Zimbabwe (Shashe catchment) could threaten water quality and flow in the park. For example, a large irrigation scheme is being planned in the Tuli block, Botswana, while there are reports of mining development within the Shashe catchment in Zimbabwe. On the South African side of the park, there is already a diamond mine, as well as a coal mine to the east and another mine planned to the west of park
- Pollution or other environmental changes associated with upstream activities may very well have health impacts on ecosystems of the area

- Engagement on water management issues with stakeholders from surrounding mines (e.g. Venitia mine, which has infrastructure in the park) has been initiated
- Long-term groundwater monitoring sites have been established in the park in collaboration with the Department of Water and Sanitation. To date the relationship has worked well and the water table has remained relatively constant since 2009

Maintain engagement with surrounding national and international stakeholders regarding freshwater management.

A hydro-census to collect, review and archive baseline information on the existing groundwater resources and threats in the park is required. Thereafter a simple groundwater monitoring programme should be established.

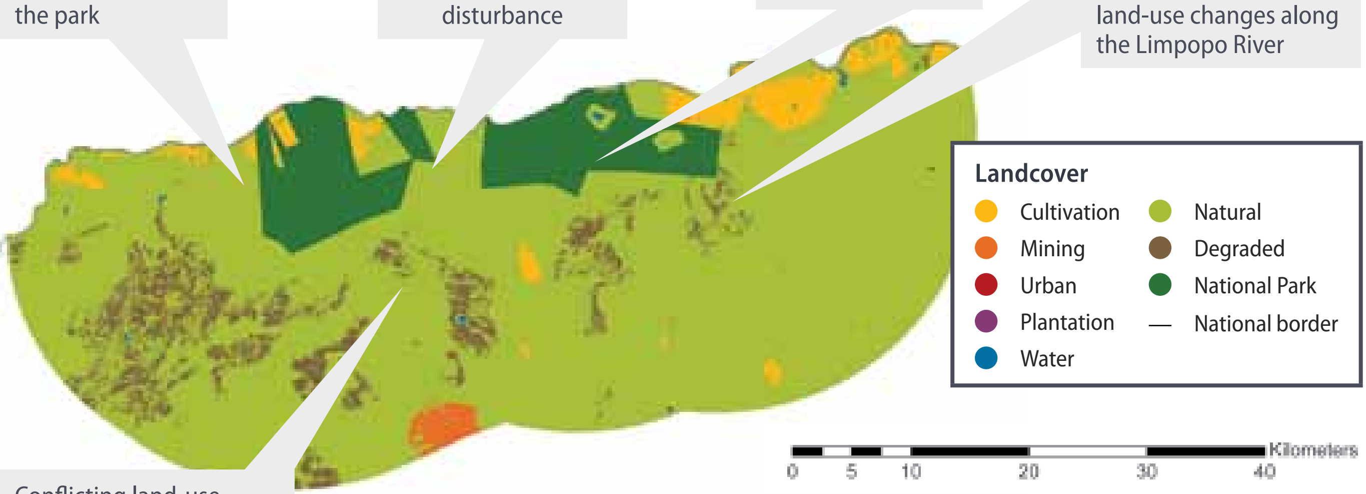
Fresh water challenges for Mapungubwe National Park

The Limpopo River is severely stressed and over used before it reaches the park

The park is an arid and water driven system and vunerable to disturbance

Groundwater is a critical component of the water cycle in the park

Groundwater-dependent ecosystems such as wetlands, have been impacted by land-use changes along the Limpopo River



Conflicting land-use practices and water usage outside the park:
- Mining
- Agriculture

International dialogue is important to ensure flow in a shared river such as the Limpopo and Shashe Rivers

SANParks must play a significant role in Limpopo-wide river negotiations

Including the proposed Dikgatlhong dam on the Shashe River, 80 km upstream in Botswana

No in-stream flow requirements or ecological reserves exist

The park cannot only focus on managing water inside the park, and will have to play an active role in influencing water usage regionally

The number of habitats in MpNP is water dependent and surrounding land-use i.e. mining and agriculture produce contaminants that are flushed into the system with the onset of rains

Groundwater influences:
- river flow
- riparian forest
- Kalope wetland

Which in turn are influenced by numerous

✗ human and ✗ natural influences

Wetlands have been impacted and result in:

Erosion and sedimentation in catchment areas

Recent impacts include exposure to high elephant concentrations and conservation interventions such as water transfer for ecological purposes

Artificial water provisioning and dams with alien fish pose a great threat to the resilience of the system

Artificial water also determines the movement patterns and usage of landscape by herbivores

✗ damming upstream

✗ abstraction for mining

✗ irrigation purposes

✗ landcover transformations

✗ natural processes (drought and floods)

Disease

M

Disease, specifically Foot and Mouth Disease (FMD) regulations currently threaten Mapungubwe National Park expansion. Plans to shift the park boundary fence southward to include the Venetia property will impact neighbouring farms in terms of disease zonation and expand the country's FMD surveillance zone. This has financial implications for surrounding farmers, in particular the rare and valuable game breeders. The number of breeders has increased rapidly in the province and in-depth stakeholder engagement will be required before any decisions can be taken.

Though the park is considered FMD free, state veterinary services in Zimbabwe have been eroded and veterinary disease control and surveillance efforts are minimal so that the risk from livestock entering from Zimbabwe is unknown. Additionally, under the current conditions, new diseases and disease vectors can enter the park and the park could serve as a conduit for diseases of agricultural importance including FMD, Tsetse fly associated Trypanosomiasis, Bovine tuberculosis, Contagious Bovine Pleuro Pnemonia, pestis de petit ruminant. Due to civil and legal responsibilities, the park should have a basic monitoring system for detection of diseases of veterinary concern.

- Due to the Mapungubwe's fragmented nature, multiple surrounding land-use practices and intensified agriculture, the park presents an intense interface for disease transfer between livestock, people and wildlife
- Disease surveillance (specifically FMD) is currently weak and will need to be bolstered as an early warning system for disease and vector introduction given the poor state of veterinary services in Zimbabwe
- Future park expansion plans are impacted by FMD zonation, and therefore wider public consultation and buy-in is required
- The conservation and veterinary committee established for the GMTFCA is not functional and this poses a risk to disease preparedness plans for the country

Alien species

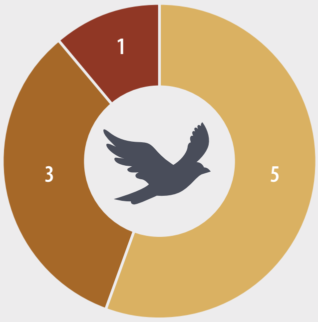
L

Animals

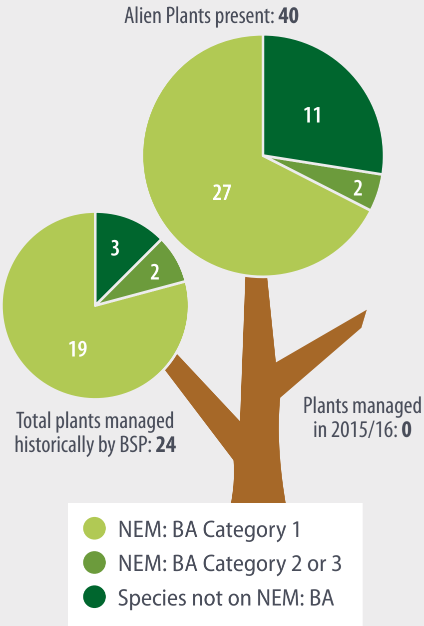
Donkeys, goats, cattle, cats and dogs are known to enter the park. Nile tilapia are present in the river, although the river does not flow all year. Invasive birds such as the Indian myna are also found in the park.

The invasive rock doves (*Columba livia*), Indian mynas (*Acridotheres tristis*) and house sparrow (*Passer domesticus*) are present in Mapungubwe.

Alien Animals present: **9**



- NEM: BA Category 1
- NEM: BA Category 2 or 3
- Species not on NEM: BA



Plants

Although there are some highly invasive alien plant species with the potential to have significant impacts in the park (e.g. Spanish reed (*Arundo donax*), Prickly pear (*Opuntia* species), Chinaberry (*Melia azedarach*), Fountain grass (*Pennisetum*) and *Sesbania*) there are currently no signs of spread in these species, but urgent and focused attention is required.

Prickly pear (*Opuntia* sp.)

Fountain Grass (*Pennisetum* sp.)

Resource use

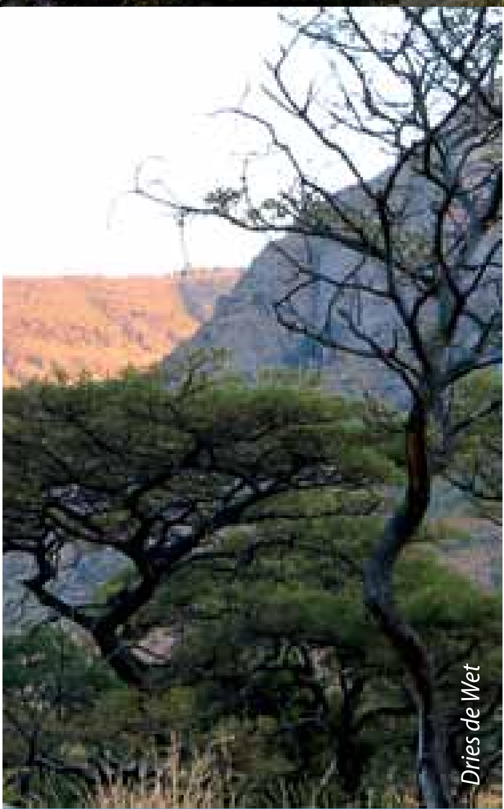
M

Only 15 resources were reported to be harvested from the park, including game species, birds, firewood, baobab and marula fruit and mopani worms harvested by neighbouring communities. Abiotic resources used include gravel, rocks and water. Snares are known to be used in the park, but only one snared species was reported. Snares would however impact on many additional species, including non-target species. The park is found at the confluence of three countries and has a lot of people moving through it. As a result resource use is likely higher than the 15 resources reported.

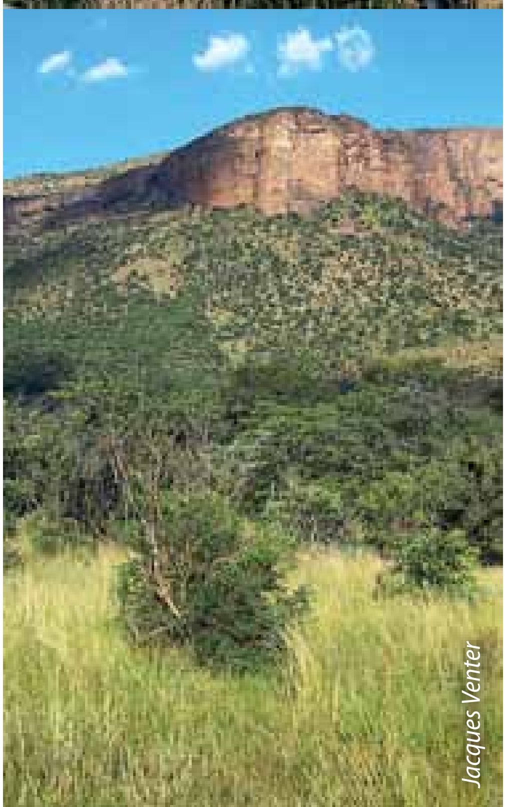
Gravel collection for roads inside the park.

MARAKELE
NATIONAL PARK

Dries de Wet



Dries de Wet



Jacques Venter

Marakele National Park (~65 000 ha) is one of the younger national parks in South Africa. It was proclaimed in 1994 as the Kransberg National Park. Through subsequent expansions and contractual agreements Marakele National Park expanded to its current 65 000 ha and has considerable conservation value. It lies on the edge of the SANBI delineated central bushveld biodiversity hotspot. Altitudes range from 2 088 m in the Waterberg to 1 050 m on the plains surrounding the Waterberg mountain range. The strongly undulating plateau of the Waterberg mountain range rises above the surrounding countryside and is an important catchment area for the Sunday, Mamba, Matlabas and Sand Rivers as well as many other smaller streams. Because the Waterberg represents an important transitional zone in the distribution of mammals, it is capable of maintaining a high diversity of species. Land-use in the region is dominated by mining activities as well as agricultural and game farming enterprises. There has been a shift towards wildlife-based ecotourism and hunting in the surrounding areas.

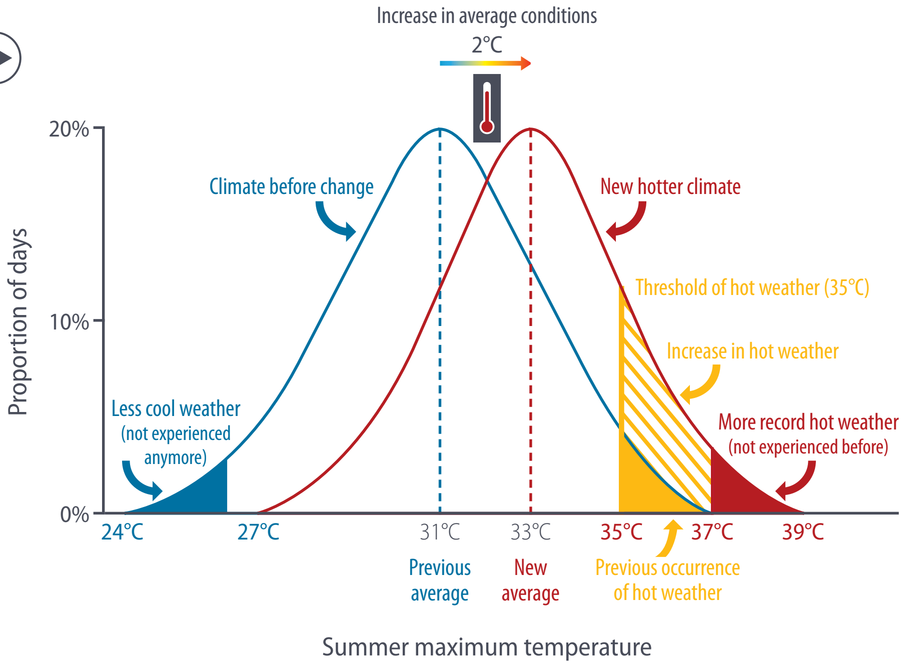
Climate change

M

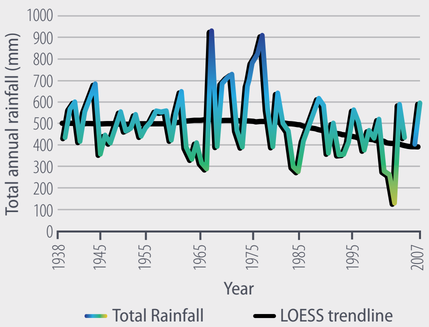
Temperature

No temperature data were available from the South African weather service at the time of the analysis. However, future increases in mean annual temperature of between 1.4°C (best case), 2.3 and 2.9°C (worst case) are predicted by 2050. While predicted increases may seem small, we have demonstrated the effect that a 2°C increase would have on the relative proportion of days above 35°C for a hypothetical park where average summer maximum temperatures are about 31 degrees (see figure on p. 118). The effect on extreme temperatures is expected to be much more dramatic than this for Marakele, as even the intermediate scenario, predicts an increase of 2.3°C.

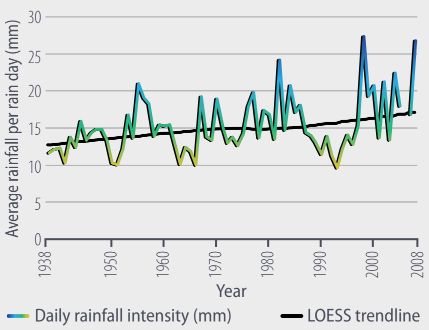
Future increases in mean annual temperature of between 1.4°C (best case), 2.3°C and 2.9°C (worst case) are predicted by 2050 for the area.



This figure shows the number of summer days reaching between 24°C and 39°C for a hypothetical situation where the historical average maximum summer temperature was 31°C, compared to the range of summer temperatures if average conditions increased by 2°C. Under the previous climate there would be an average of 4 days per summer that get to 35°C or hotter and it would never get hotter than 38°C, whereas there are about 17 days over 35°C under the new climate that has warmed on average by 2°C and 3 days reach 38°C or more – conditions not experienced under the previous climate. The impact is expected to be even greater in Marakele, where temperatures are predicted to rise by more than 2 degrees.



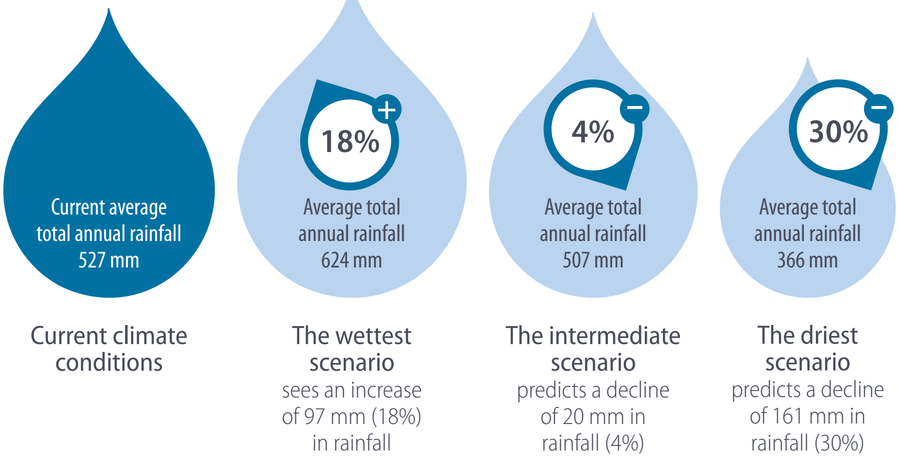
Total annual rainfall at Hoopdal since 1937, showing no significant trend.



Daily rainfall intensity (average amount of rain falling on days when rain did fall), showing a significant increase since 1938 at Hoopdal (i.e. when it does rain, more rain falls).

Rainfall

No changes in total rainfall were detected in the historical rainfall record for the past 73 years. However the way in which rain is received has changed. There are now fewer days of rain recorded (i.e. longer dry spells), but with more rain when it does rain.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely, most models favour the wetter scenarios in the east of South Africa and drier scenarios in the west. However, the park should note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events).

Possible future scenario: much drier conditions, with more irregular heavy rainfall events. Continuous high rainfall over an extended period may cause the soil to become water logged and in turn cause increased water run-off.

Biome changes and impacts on vegetation types

Rainfall declines accompanied by increases in temperature would likely see the Grassland portion of Marakele becoming more savanna like, which may be exacerbated by the effects of carbon 'fertilization'. Higher levels of CO_2, currently being experienced globally, favour the growth of woody plants (shrubs and trees), and give them a competitive advantage over grassy plants. Fire, grazing and rainfall play an important role in Marakele with annual occurrences of veld fires due to lighting. Although natural fires are needed in savanna landscape most of the areas experiencing bush encroachment are difficult to burn as the herbaceous layer has been lost. In woody communities with enough biomass, appropriate fire regime will have to be implemented as fire intensity might increase resulting in hotter fires.

Marakele is experimenting with the manual removal of woody plants in old cultivated lands colonised by sicklebush (*Dichrostachys cineria*) and in natural habitat experiencing bush densification. The approach seeks to assess the impact of bush encroachment on both woody and herbaceous composition.

SANParks has an important role in educating public about the importance of greener lifestyles.

Reducing waste and increasing opportunities for recycling are also critical.

Marakele can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

Land-use change

L

Since declaration in 1998, the park has doubled in size, expanding by 31 121 ha and conserves 3 habitat types. The expansion of Marakele is important in an attempt to establish an ecologically viable protected area in the western Waterberg Mountain catchment area and thus to conserve the Waterberg bushveld landscape, around the Matlabas-Mamba River catchment with its associated ecological patterns and processes through a mosaic of cooperation agreements and public private partnerships.

Past land-use resulted in transformed landscapes and succession in affected areas resulted in bush encroachment. High levels of CO_2, fire regime and climate change also play a significant role in the transitional change between the woody and herbaceous vegetation in Marakele.

Cathy Greaver

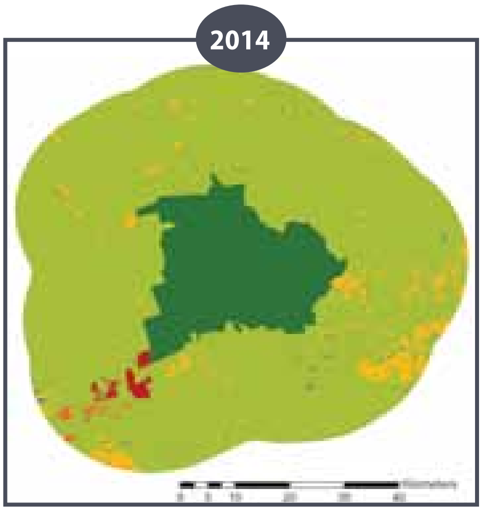
Road verge clearing of sicklebush (*Dichrostachys cinerea*) in Marakele.

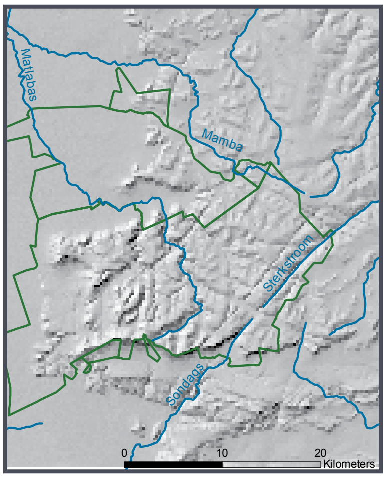
It is likely that conditions in the park will change, becoming more bushy and dense and appropriate management interventions may need to be considered such as mechanical clearing or burning.

The possibility of the emerging biosphere reserve concept (the Waterberg Biosphere Reserve is registered with UNESCO) and recent developments and upswings in nature-based tourism opportunities (including ecotourism and hunting) as an alternate long-term socio-economic driver within the region.

Landcover

- Cultivation
- Mining
- Urban
- Plantation
- Water
- Natural
- Degraded
- National Park





Land use in a 20 km radius around the park as at 2014. The largely natural areas are used for game farming. The town of Thabazimbi lies to the south-west of the park. The second topographical map shows the Waterberg as an important rainfall catchment area for the region.

Transparent, trusting co-operative, collaborative and mutually beneficial relationships with the conservation community are essential to the sustainability of Marakele National Park.

The current park size of 65 445 ha includes the contractually-managed private land of Marakele Pty Ltd. There was a slight shift towards wildlife-ecotourism and hunting practices in the area and the immediate land-use adjacent to the park is largely compatible with conservation, although the high density at which game is kept in some cases ('feedlot' farming) could have biodiversity impacts. Urbanisation in the south west area around the town of Thabazimbi is increasing and mining has also increased its footprint by 5.5 km^2 in the 20 km radius around the park. The Waterberg Mountain is an important catchment area for rivers in the park and an important ecosystem service provided by the park to downstream users.

Disease

M

There is a general paucity of data on diseases in Marakele. Only 5 diseases have actually been detected in the park (African swine fever, malignant catarrhal fever/snotsiekte, Heartwater, Corridor Disease and Shuni Virus), while another 12 diseases of economic significance are speculated to be circulating. This is partly due to the fact that most of these diseases are 'silent' in their endemic wild hosts and therefore not picked up with general observations. Disease detection relies on incidence of the disease and the level of awareness and either or both of these factors could contribute to underreporting. The 2 disease incidents in Marakele's recent history highlight why diseases can have huge implications for the park, both in terms of financial costs and stakeholder relationships.

Surrounding game farms ensure conservation friendly land-use practises however illegal introductions and movement of buffalo could pose disease risks e.g. introduction of TB, corridor or even Foot & Mouth disease in the area.

The detection of Corridor Disease in 2008 in Marakele's buffalo (*Syncerus caffer*) population and the subsequent removal of all buffalos, re-testing and reintroductions, has cost the organisation millions of rands and had derailed the proposed park expansion plans with Welgevonden.

The Shuni virus outbreak in 2010/2011 was linked to degraded areas in the park and intensification of wildlife farming in the surrounds.

All buffalo were removed from Marakele and disease free buffalo were re-introduced in 2011.

Alien species

Animals

Feral cats are known to enter the park and there are two NEM: BA listed invasive fish species, the Nile Tilapia (*Oreochromis niloticus*) and carp (*Cyprinus carpio*) present in the rivers. The common Indian Myna (*Acridotheres tristis*) is also found in the park.

Indian myna (*Acridotheres tristis*)

Plants

Several potentially high impact alien plant species occur in the park, including *Lantana*, Queen of the night (*Cereus*), guava (*Psidium*) and Australian blackthorn (*Acacia melanoxylon)*, but their extent is uncertain. Pom-pom weed (*Campuloclinium*), which currently has localised high impact, is however spreading and a cause for concern in the park.

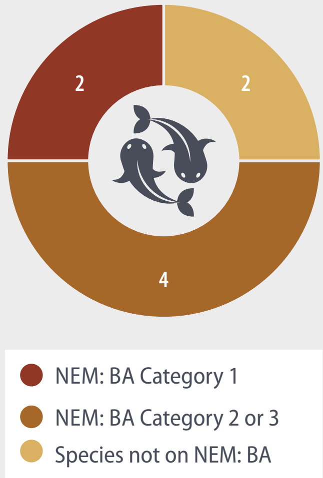
Pom pom weed (*Campuloclinium macrocephalum*)

Freshwater

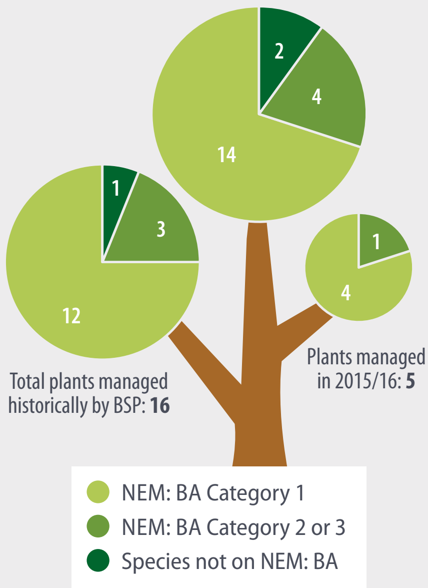
The Matlabas River

Aerial photo of the Matlabas River.

Alien Animals present: **8**



Alien Plants present: **20**



A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

- Flow of several rivers has been altered as a result of earthen dams constructed by previous landowners. Large dams with cement walls were built in the Matlabas River. Several of the earthen dams are in disrepair, perpetuating erosion risk
- There is a potential threat of invasive fish species (bass) on the indigenous fish species

Due to the fish sanctuary status, a fish species inventory needs to be undertaken to establish the presence or absence of expected and recorded species.

- The Matlabas, Sondags and Mamba Rivers are important water supply areas for the surrounding environment and downstream users. To ensure a continuous supply of good quality water to the surrounding environments and downstream users, the evaluation of the current river condition needs to be undertaken, focusing on the collation and evaluation of the Department of Water Affairs and Sanitation flow and quality data to make a first attempt at setting flow Threshold of Potential Concern for Marakele's contribution to the delivery of these ecosystem goods and services
- The rehabilitation or removal of damaged or redundant structures impacting flow and other ecosystem processes along the Matlabas and Mamba Rivers needs to be prioritized to improve their status to 'Category AB' to qualify as Freshwater Ecosystem Priority Areas under Phase 2
- All wetlands, rivers, dams, waterholes and boreholes need to be inventorized and all man-made structures impacting negatively on these systems should be prioritized for phased removal
- Where possible alien fish species (bass) need to be controlled or eradicated

QUICK STATS

- Total river length in park: **67 km**
- River Ecosystem types (of 223 in SA): **9**
- River length in good condition: **27%** (remainder moderately modified)
- Freshwater Ecosystem Priority Area (FEPA): **27%** of river length (a further **62%** would qualify if FEPA modified condition restored)

Condition of all rivers in Marakele National Park (as per the National Freshwater Ecosystem Priority Assessment).

Marakele lies on the extreme south-western quadrant of the Waterberg mountain range and its adjoining lowlands. The Waterberg mountain range is a vital catchment area for the Sondag, Mamba, Matlabas and Sterkstroom Rivers as well as many other smaller streams which provide water to surrounding environments and downstream users. The Matlabas River is a Phase 2 FEPA where the present river condition (moderately modified) needs to be improved to the category natural or good condition. There are no free flowing or flagship rivers in the park, but there are fish sanctuaries bordering/inside the park.

Earthen dam in Marakele.

Large cement dam in Marakele.

Resource use

L

Only 10 resources were reported to be harvested from the park, including 3 species of alien fish (Nile tilapia (*Oreochromis niloticus*), largemouth bass (*Micropterus salmoides*) and common carp (*Cyprinus carpio*). Warthogs (*Phacochoerus africanus*), kudu (*Tragelaphus strepsiceros*), milk plums (*Englerophytum magalismontanum*) and sickle bush (*Dichrostachys cinerea*) are used as well as abiotic resources such as water and rocks. All these resources, with the exception of the milk plums, were used as part of management actions. It is therefore unclear to what extent other resource use activities might impact on the park. Capture and movement of game quotas are informed by ongoing research, monitoring and evaluation and adaptive management principles to ensure ecosystem integrity. Based on information from the resource use survey it is not possible to estimate the extent and impact (positive or negative) of resource use in the park.

MOKALA
NATIONAL PARK

Dries de Wet

Dries de Wet

Dries de Wet

Mokala National Park (~28 500 ha) offers significant biodiversity, interesting habitats with diverse ecosystem processes within a transition zone between the Karoo biomes and arid savanna bushveld. A variety of herbivore species are found in Mokala including high value species such as black rhino (*Diceros bicornis*) and a population of disease-free buffalo (*Syncerus caffer*). A number of rare or high value species such as roan (*Hippotragus equinus*), sable (*Hippotragus niger*), white rhino (*Ceratotherium simum*) as well as the endangered tsessebe (*Damaliscus lunatus*) are also present. The only flowing river in Mokala is the Riet River bordering the park. The river is heavily utilised by other stakeholders such as mining and agriculture. Pollution of the river remains a threat for Mokala.

Climate change

L

Temperature

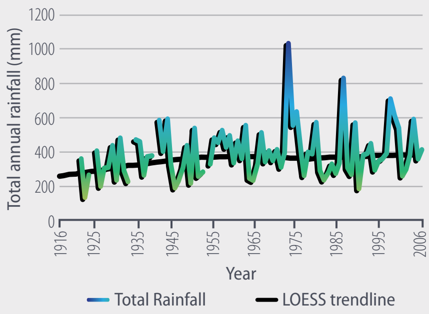
No temperature data of a sufficiently long timespan were available from the park and no average changes were detected in Kimberley temperatures over the past 19 years (although this is a relatively short time series). There are however significantly less days each winter where the temperature drops below 0. Not getting as cold as it used to might have implications for pest organisms and alien species that were previously kept from spreading by cold temperatures in the winter.

By 2050, average temperatures in the park are expected to increase by between 1.6 (best case), 2.3, and 2.8°C (worst case). While predicted increases may seem small, we have used data from Kimberley to demonstrate the effect that a 2.8°C increase in summer temperatures would have on very hot days (see figure on p. 124). An increase in such hot extremes will have negative impacts on plants, animals, tourists and staff who have to work outdoors.

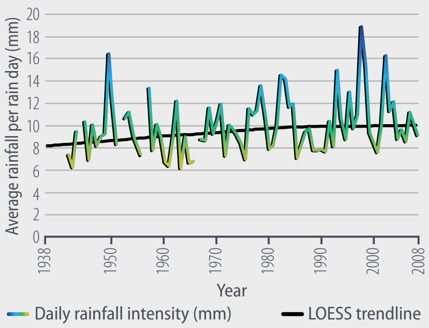
Future increases in mean annual temperature of between 1.6°C (best case), 2.3°C and 2.8°C (worst case) are predicted by 2050 for the area.

The average number of summer days reaching between 20°C and 45°C in Kimberley in the past (1991–2005) compared to a hypothetical summer where temperatures have increased on average by 2.8°C, showing how this shift impacts on warm extremes. In the past, about 22 days per summer would reach 35°C or hotter. With a 2.8°C increase, 40 or more days (i.e. almost half of summer time) could get this hot, while cooler temperatures will become less frequent. In addition, temperatures over 40°C, which hardly ever occurred previously will be much more frequent.

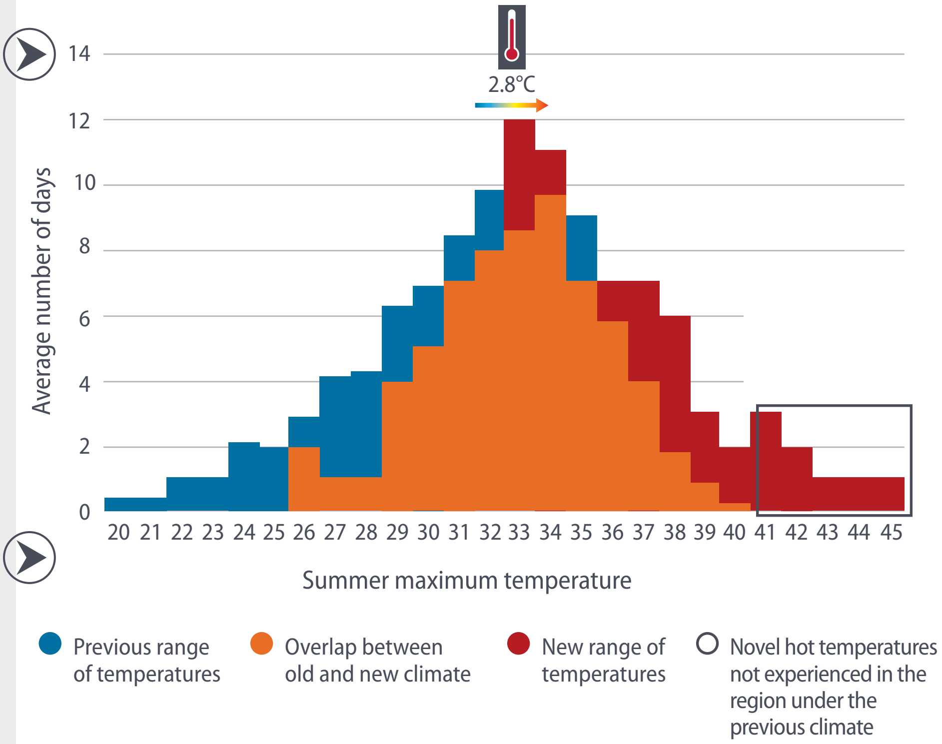
A decrease in cold temperatures could result in new diseases or higher prevalence of existing diseases in years to come. It will be important to keep monitoring the status of rare antelope in particular.



Total annual rainfall at Eureka station, just outside of the park (near Lilydale) since 1914, showing a slight, but significant increase.

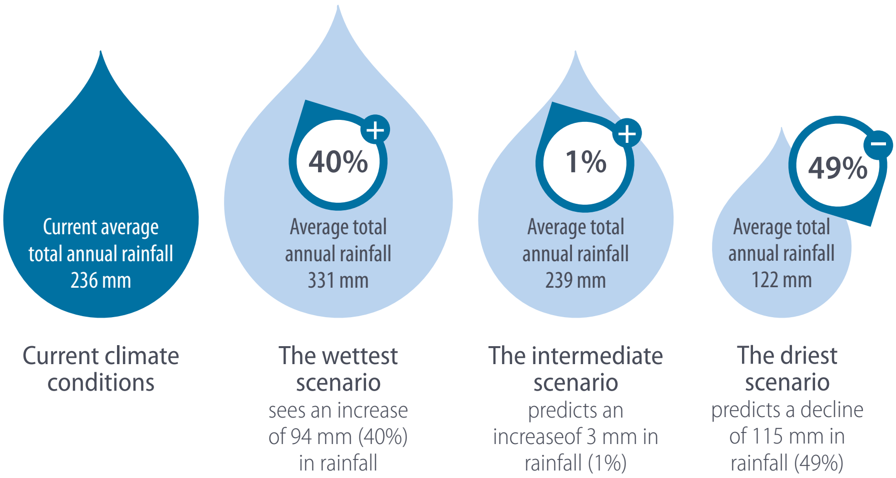


Daily rainfall intensity (average amount of rain falling on days when rain did fall), showing a significant increase since 1916 at Eureka, near Lilydale (i.e. when it does rain, more rain falls).



Rainfall

An average increase in annual rainfall has been observed at the Eureka weather station, just outside the park since 1914 and appears to be driven by heavier rainfall events. Unpredictable rainfall could still have negative biodiversity consequences in the future, even if on average, across years, rainfall increases or does not change. Mokala is one of only three parks where no change, or a very slight increase in rainfall is predicted by intermediate models of future conditions for 2050, which is supported by the trends that observed at Eureka.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely, current rainfall records suggest that rainfall has marginally increased over the last century. This along with the modest change predicted for the intermediate scenario suggest that rainfall totals in the area may be more stable than elsewhere. However, the park should note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events).

Biome changes and impacts on vegetation types

Under changed conditions of increased temperature, conditions in Mokala will more closely resemble those of arid savanna than Nama-Karoo. Higher levels of CO_2, currently being experienced globally, favour the growth of woody plants (shrubs and trees), and give them a competitive advantage over grassy plants. Prior to the proclamation of the national park the landowners in the area had made use of herbicides to control 'bush encroachment' SANParks management may need to consider ecologically friendlier methods of controlling increasing bush density if it begins to impact on tourism and wildlife.

Some parks have explicit or dramatic climate changes predicted, while for others, like Mokala, at least in the case of rainfall, the level of future change may be less certain or dramatic.

All parks should however contribute to climate change mitigation measures to ensure a more sustainable future.

Water, energy and waste saving measures are good starting points and include things like use of geyser blankets, geyser timers and/or solar geysers, low-flush toilets, grey-water systems and recycling.

The changing climate presents SANParks with an opportunity to educate the public and showcase methods for sustainable living.

Opportunities for recycling waste generated through tourism activities should be actively investigated.

Natural ways of cooling accommodation and the levels of tourism that will be feasible under future conditions should be assessed.

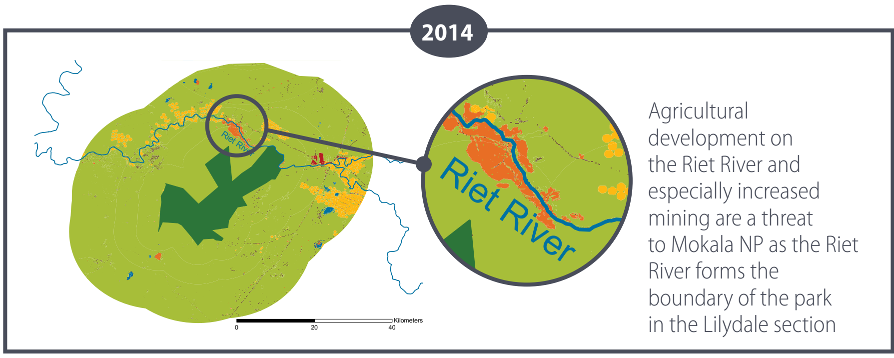
Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

Land-use change

M

Since declaration in 2007, Mokala has expanded by 8 279 ha and now conserves 4 habitat types. The planned expansion of the park would make a significant contribution in the conservation of Northern Upper Karoo, Kimberley Thornveld and Vaalbos Rocky Shrubland. The main land-use surrounding the park is game and livestock farming and the vegetation is largely natural. No major changes in formal land-uses were detected in a 20 km radius of Mokala National Park boundary since proclamation. The major current threat is diamond mining on the Riet River right opposite the Lilydale section of Mokala as well as on a farm north of Vaalbospan.



Landcover

- Cultivation
- Mining
- Urban
- Plantation
- Water
- Natural
- Degraded
- National Park

Land-use in a 20 km radius around the park as at 2014. The largely natural areas are used for livestock and game farming, while there is some cultivation and increased mining along the Riet River.

Rift Valley fever virus (RVFV) is an emerging zoonotic disease of significant public health, food security, and overall economic importance, particularly in Africa and the Middle East. In infected livestock such as cattle, sheep, goats and camels, abortions and high death rates are common. In people (who can get the virus from handling infected animals), the disease can be fatal. Given the role of mosquitoes in transmission of the virus, changes in climate continue to be associated with concerns over the spread of RVFV. Major RVF outbreaks have occurred mostly on the inland plateau of South Africa in 1950, 1974, 2008 and 2010–11. Smaller outbreaks have occurred throughout the rest of the country. The most recent outbreak in 2010–11, in the surrounds of Mokala, involved a large number of cases in people (278 cases and 25 deaths). The role of wildlife (extensive and intensive farming systems) in the inter-epidemic period and viral-overwintering in endorheic pans is currently being investigated.

Black rhino (*Diceros bicornis*)

A buffalo (*Syncerus caffer*) from the disease free breeding project.

Disease

M

Disease is a concern for the rare antelope that are bred in the park. The Northern Cape, being the most sparsely populated province in South Africa and having a climate that does not support the overwintering of many tick species, means that it is generally suited to the breeding of high value game species in a relatively vector-free environment. As a result it has seen an increase in commercial game farms, including those carrying disease-free buffalo, roan, sable and tsessebe. However, future climate warming scenarios may support a range expansion and increase of various tick species with the associated diseases they carry, requiring integrated disease monitoring system of both the vectors and their vertebrate hosts. The Northern Cape is however good at surveillance, so early warning should be in place for emerging diseases. Increased temperatures accompanied by consistent or increased rainfall would present novel conditions for the spread of disease, so continual monitoring will be important. Notifiable diseases that are thought to occur in the park include African horse sickness, malignant catarrhal fever, Crimean-Congo haemorrhagic fever and botulism. Anthrax has also been recorded in the close proximity of the park.

Mokala is located close to the escarpment of the Ghaap plateau in the Northern Cape which is considered an Anthrax endemic region. Although there has not been any anthrax detected in Mokala itself, the fact that it has a breeding population of White-back vultures, means that the potential for contamination with spores and therefore anthrax, exists. It is therefore important that a disease surveillance system be in place for dead and dying animals.

- Mokala holds a large and significant population of disease-free buffalo that originated from Kruger's disease-free breeding project. This is a valuable resource in terms of genetics and conservation value and therefore strict biosecurity is needed to maintain this disease-free status. A large number of game farms in the area are registered to keep buffalo, making good fence maintenance essential to prevent any stray buffalo breaking in and inadvertent introduction of diseases. There have also been a number of Bovine Tuberculosis cases reported in the region and biosecurity is needed to prevent the introduction of BTb through paratenic or spillover hosts such as warthogs, kudu and mongoose
- Malignant Catarrhal Fever (Snotsiekte) is becoming an important interface disease in the country. The virus is endemic in wildebeest (and sheep) with no clinical symptoms seen, but can pose a risk to cattle in surrounding farms. Research into the factors driving viral shedding and transmission is required in order to minimize contact during high risk periods
- High value species need to be vaccinated during Anthrax outbreaks

Valuable game on Mokala, tsessebe (*Damaliscus lunatus*).

Roan antelope (*Hippotragus equinus*).

Alien species

H

Thirty-three alien species (6 animals and 27 plants, including 22 NEM: BA-listed species; 16 Category 1b) have been documented in Mokala.

Animals

Many extralimital ungulates occur in the park. A major concern is hybridization of related species, for example blue (*Connochaetes taurinus*) and black wildebeest (*Connochaetes gnou*), while other species such as nyala (*Tragelaphus angasii*) are thought to out-compete smaller antelope due to the high densities which they reach in areas where vegetation is thick.

Plants

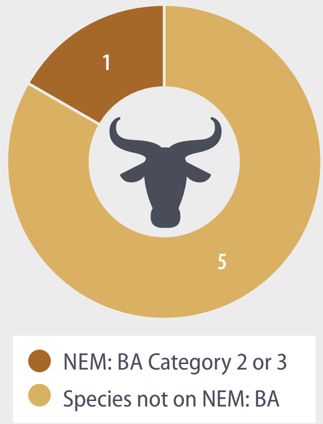
Plant species with potentially high impact include prickly pear (*Opuntia* sp.), fountain grass (*Pennisetum setaceum*), mesquite (*Prosopis* sp.), Chinaberry / Seringa (*Melia azedarach*) and guava (*Psidium guajava*), but no information was available on the extent of their range.

Prickly pear (*Opuntia* sp.)

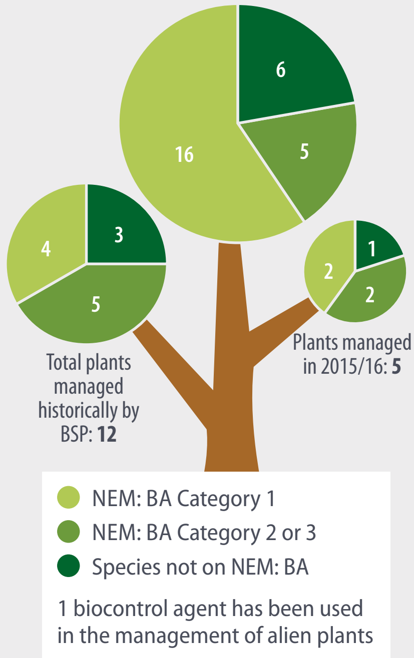
Fountain grass (*Pennisetum setaceum*)

Chinaberry / Seringa (*Melia azedarach*)

Alien Animals present: **6**



Alien Plants present: **27**



A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

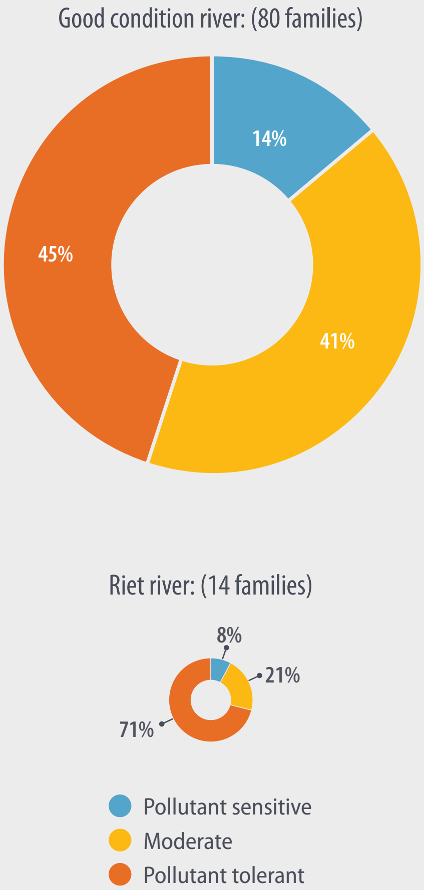
Freshwater

H

- There is a need to develop a wetland inventory
- There is a big difference in demography (based on pollution sensitivity) on sampled macro-invertebrates in Mokala compared to the ideal situation. This requires a better understanding of the river
- Increased research and monitoring of the Riet River is needed

- Macro-invertebrate monitoring has been implemented since 2014
- There is currently a registered research project intending to assess the: fish health and diversity, potential impact of alien fish on the indigenous ones, presence of fish parasites within the Riet River, presence of macro-invertebrates within the wetlands of Mokala and amphibian diversity within the park

Riet River



Comparison between the Riet River and the conditions expected in a river classified as a good condition river.

QUICK STATS

- Total river length in park: **8.41 km**
- River Ecosystem types (of 223 in SA): **1**
- River length in good condition: **0 %** (100% moderately modified)
- Freshwater Ecosystem Priority Area (FEPA): **0%** of river length is a FEPA
- The development of a wetland inventory is a high priority

Condition of all rivers in Mokala National Park (as per the National Freshwater Ecosystem Priority Assessment).

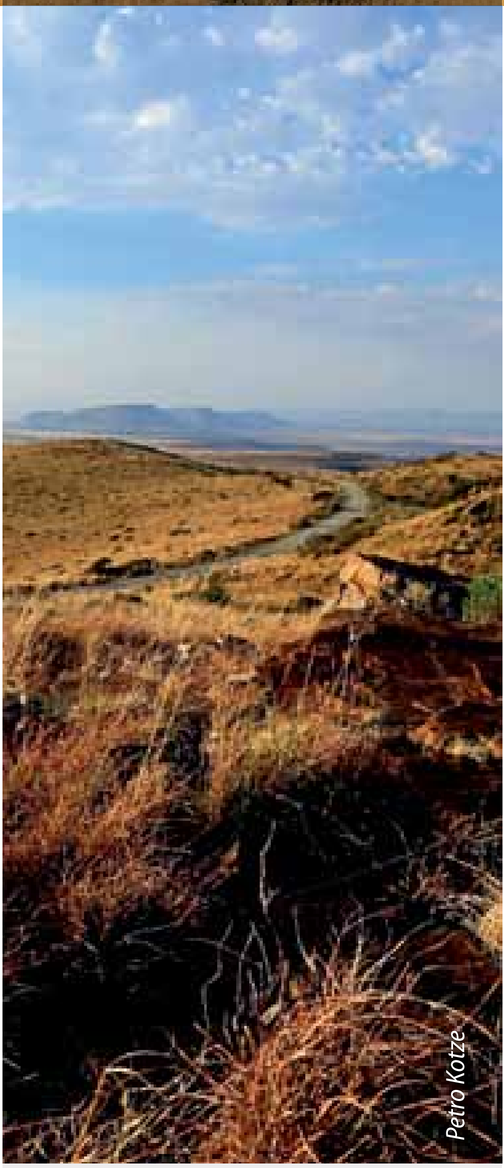
A river in a good condition has a high diversity of macroinvertebrate species (80 families) and more species sensitive to pollution. SANParks scientists have been monitoring the Riet River for macro-invertebrate demography. Their findings indicated that the Riet River has more pollutant tolerant species (71%) present than expected in a good condition river (45%), see figures on left.

Resource use

L

The only resource use that takes place in Mokala is related to park management and includes the use of abiotic resources (rocks, gravel, water and soil) and the capture and sale of game species. No illegal resource use is known to take place in the park and with the park being reasonably isolated and surrounded by farms, use levels are likely to be low and stable. Selling game is a valuable source of income and Mokala has many valuable species that are auctioned. The capture and selling quotas are informed by ongoing research and adaptive management principles to ensure ecosystem integrity. Culling for venison for the Mokala restaurant is approved according to quotas determined by monitoring and research outcomes and needs.

MOUNTAIN ZEBRA NATIONAL PARK



Mountain Zebra National Park (~28 500 ha) is situated on the northern slopes of the Bankberg mountain range in the Eastern Cape. It was proclaimed in 1937 for the purpose of protecting a remnant population of the Cape mountain zebra (*Equus zebra zebra*), but has now grown beyond a species park to focus on conserving the biodiversity of the region. All of the major vegetation types represented in the park are poorly conserved elsewhere in South Africa. Mountain Zebra is a transition area between biomes which allows for an interesting mix of flora and fauna, as well as important ecological and landscape processes. Climate change, the development of conflicting land-uses, inappropriate management of large herbivores and fire present the biggest threats to the park's vital attributes.

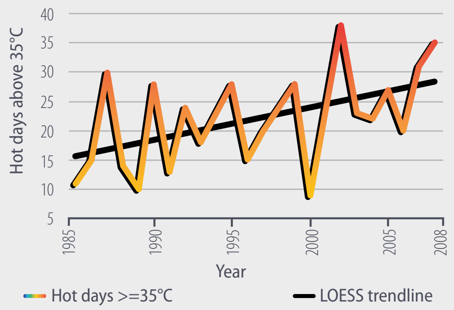
Climate change

M

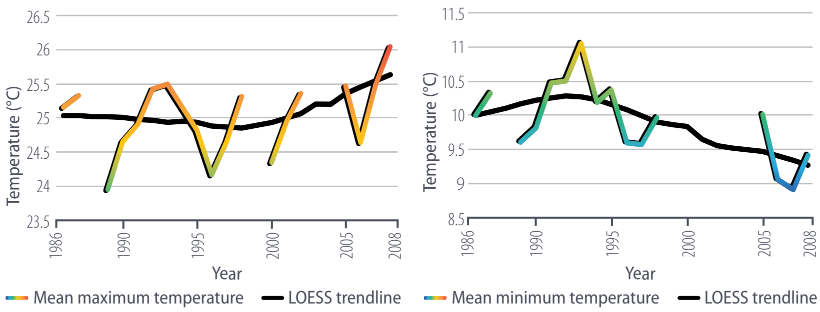
Temperature

Only a relatively short historical temperature record was available for the area (25 years of data from Cradock). This was the only park where any temperature decrease was detected: a decrease in average minimum temperature of 1.15°C in 25 years was detected at the Cradock station. Missing data could however have influenced this trend. Although no trend is clearly detectable in maximum temperature, the number of very hot days (>35°C) in Cradock appear to be increasing.

Increases of between 1.3°C (best case), 1.9°C and 2.4°C (worst case) are predicted by 2050. While the predicted changes seem small, we have demonstrated the effect that a 2°C increase in summer temperatures would have on very hot days for a hypothetical park where average summer maximum temperatures are about 31 degrees (very similar to the current averages for Mountain Zebra; see figure on p. 130). The effect of a 2.4°C would be even more dramatic, and under this scenario, it is likely that the number of days reaching 35 degrees would almost double by 2050.

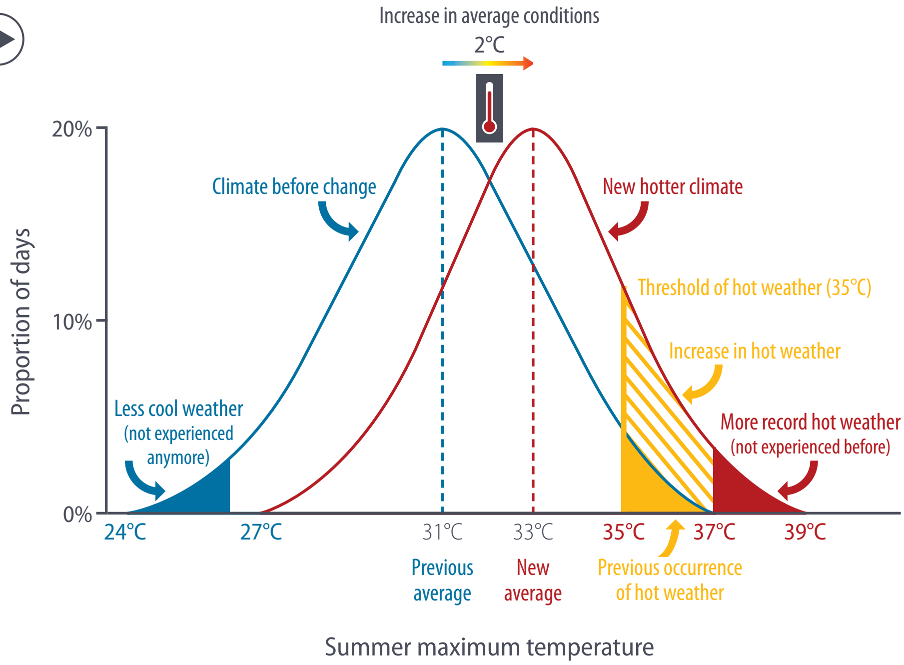


The number of days above 35°C at Cradock since 1986 showing a positive, but not significant trend.



Annual average maximum and minimum temperatures for Cradock since 1986, showing an increase in maximum temperature and a significant decrease in minimum temperature.

Future increases in mean annual temperature of between 1.3°C (best case), 1.9°C and 2.4°C (worst case) are predicted by 2050 for the area.



This figure shows the number of summer days reaching between 24°C and 39°C for a hypothetical situation where the historical average maximum summer temperature was 31°C, compared to the range of summer temperatures if average conditions increased by 2°C. Under the previous climate there would be an average of 4 days per summer that get to 35°C or hotter and it would never get hotter than 38°C, whereas there are about 17 days over 35°C under the new climate that has warmed on average by 2°C and 3 days reach 38°C or more – conditions not experienced under the previous climate.

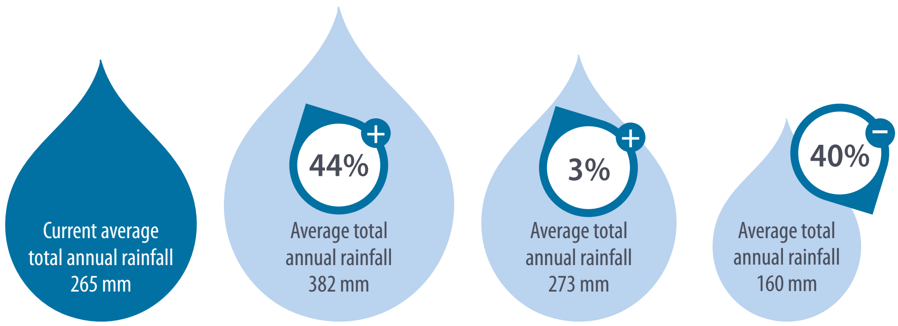
Biome changes and impacts on vegetation types

Because Mountain Zebra naturally contains elements of a number of biomes, the impacts of a changing climate are hard to model, although under future conditions the climate could resemble anything from a Grassland climate to a Savanna or Nama-Karoo climate depending on the direction and magnitude of change. The effects of carbon fertilization also need to be considered as bush encroachment could compound problems for grassland and Nama-Karoo.

Landscape of Mountain Zebra.

Rainfall

The rainfall data initially available from SAWS was too short for any meaningful analysis. Mountain Zebra is one of only three parks where no change, or a very slight increase in total rainfall (in this case 8mm) is predicted under the intermediate model of future conditions.



Current climate conditions

The wettest scenario sees an increase of 117 mm (44%) in rainfall

The intermediate scenario predicts an increase of 8 mm in rainfall (3%)

The driest scenario predicts a decline of 105 mm in rainfall (40%)

This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. The future scenarios are quite variable and it is not yet clear which of these is most likely. Planning for a variety of different possible futures (scenario planning) is therefore recommended. Also note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of smaller steadier rain events).

Some parks have explicit or dramatic climate changes predicted, while for others, such as Mountain Zebra, the level of future change may be less certain or dramatic. All parks should however contribute to climate change mitigation measures to ensure a more sustainable future.

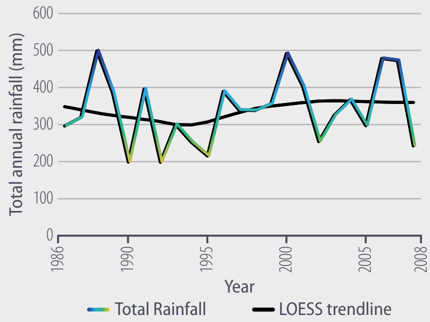
The changing climate presents SANParks with an opportunity to educate the public and showcase methods for sustainable living.

Reducing waste and increasing opportunities for recycling are also critical.

Mountain Zebra can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes, including implementation of the responsible tourism plan

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference



Cradock rainfall since 1985.

Mountain Zebra should plan for a variety of futures and continue monitoring bush encroachment as well as changes in temperature and rainfall to enable estimates of the direction of change. For example, if the changing climate moves the park into a more savanna-like system, the ecological management of fire will increase in importance.

Habitat condition

L

Large mammal numbers continue to increase in the park in response to park expansion, to such an extent that regular offtakes are required, even in the presence of 4 lions and cheetah. Although the Juriesdam area as well as the northern Nama-Karoo area of the park are still recovering from past overgrazing by domestic animals, habitat across the rest of the park fluctuates in quality and quantity in response to rainfall. The diversity and numbers of plains game in the park are sustained by the occurrence of grazing lawns in the grassland areas, which confine heavily grazed areas to these patches, leaving longer grass species in the intervening areas and in the mountains.

Juriesdam area.

Land-use change

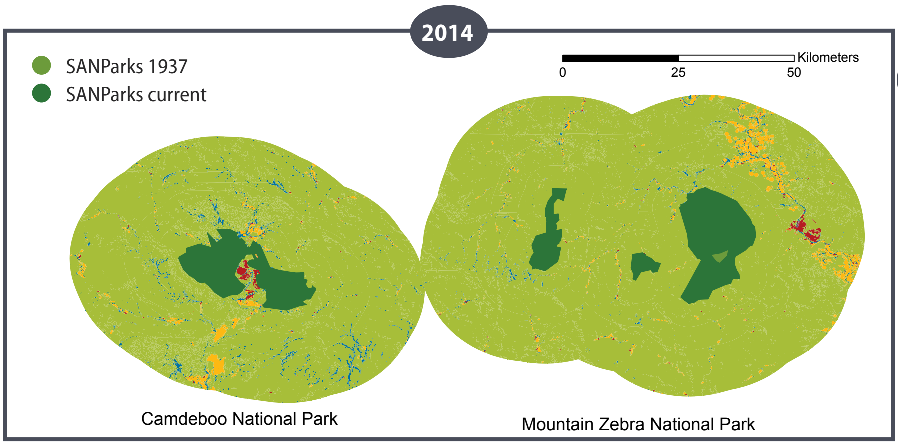
L

Since declaration in 1937, the park has expanded to ~28 000 ha (21 000 ha expansion since 1990) and conserves 3 habitat types. There are long-term plans to connect Mountain Zebra to the west with Camdeboo National Park, largely through agreements with private land-owners, who have signed up to the Mountain Zebra – Camdeboo Protected Environment, as well as the purchase of some key properties should they become available for sale. This corridor project would create a megareserve that would seek to conserve 12 habitat types in the transition zones between the Thicket, Grassland and Nama-Karoo biomes. Currently most neighbouring land is used for livestock farming, with some cultivation further from the park to the east. Very little change has taken place in land use since 1990, although cultivation to the east of the park has increased by approximately 13 km^2 (12%), while the town of Cradock has not changed significantly in size.

BSP rehabilitation work has made significant and successful contributions towards combatting soil erosion that was inherited from farms procured for park expansion. This is an example of good science-management partnerships for developing, planning and implementing conservation interventions.

Fracking and other mining remains a threat throughout the Karoo. There is an increase in mining applications for a variety of resources including sand. Research has already commenced to provide baselines, but it will also be important for the park to monitor any use of abiotic resources within the park (e.g. sand and gravel for maintenance operations).

Landscape of the park.

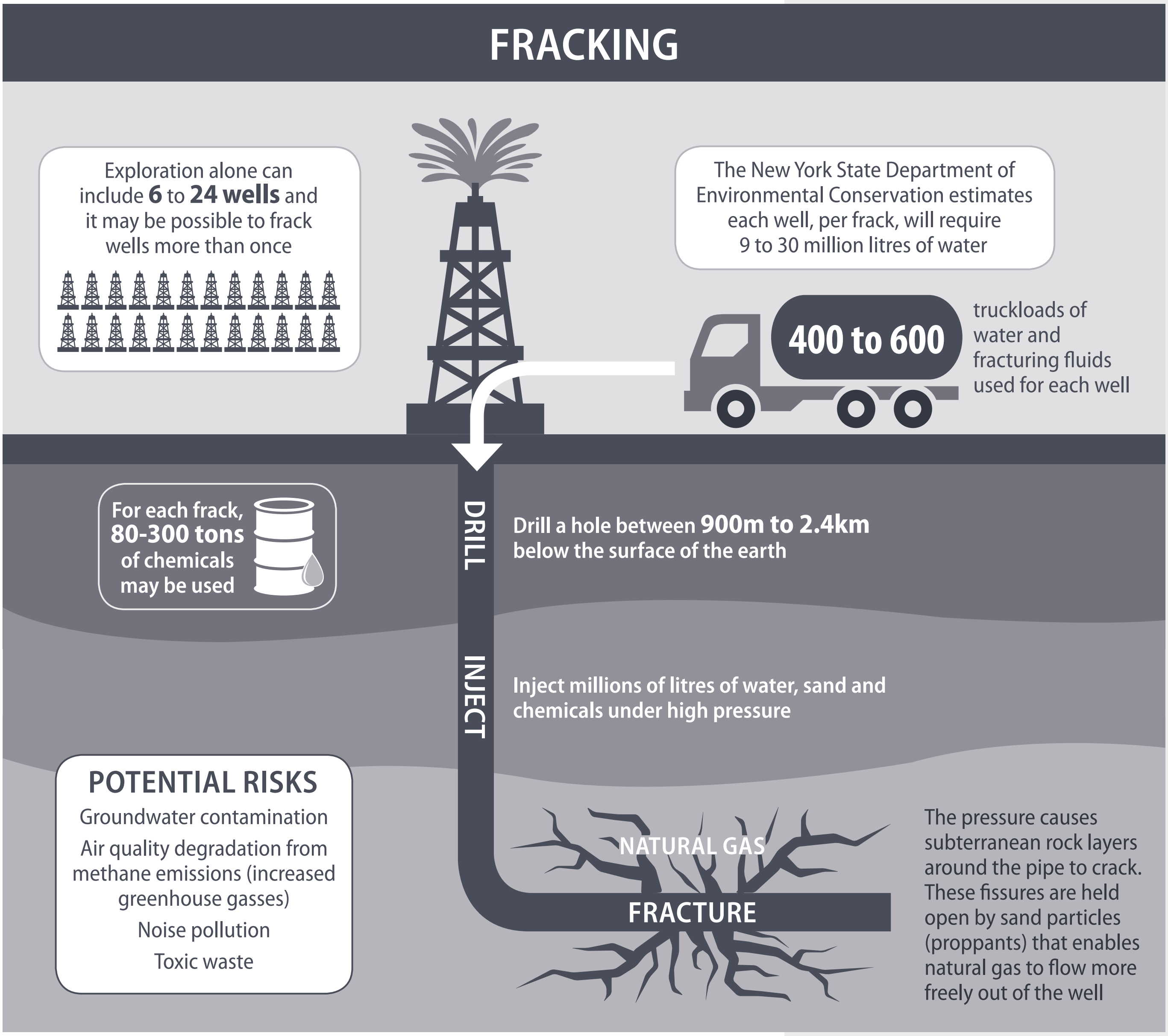


Land-use between Camdeboo and Mountain Zebra National Parks in 2014. The areas added to Mountain Zebra since 1937 are shown in a darker shade of green.

Landcover

- Cultivation
- Mining
- Urban
- Plantation
- Water
- Natural
- National Park
- Park at proclamation

The main threat from land-use is mining. Aside from the prospect of fracking in the greater Karoo area, there are also increasing mining and prospecting applications for sand and other minerals.



Fracking is a process of injecting liquid (in most cases water) at high pressure into underground rocks to force open existing cracks to extract oil or gas. These statistics have been taken from the United States and demonstrate the large volumes of water involved in this process as well as some of the other associated risks.

Disease

Disease is not currently a major threat in the park. However, the Equine sarcoid (the most common cutaneous neoplasm of Equids and a widespread disease of Equids) is present in Cape Mountain Zebra. This virus has reached epidemic proportions in two other populations (Gariep Nature Reserve and Bontebok National Park). Monitoring is therefore essential for early detection, so that management can be applied to prevent progression of lesions and spread to other animals.

In terms of notifiable diseases (those which require reporting under the Animal Diseases Control Act), only African horse sickness, malignant catarrhal disease and Botulism are known to have occurred in the park, while malignant catarrhal fever is transmitted by the wildebeest group (blue wildebeest are better known transmitters).

An acute, spatially clustered outbreak of disease in jackal was detected in August 2013, at a time when jackal densities in the park were relatively high. It is suspected that these animals died of Canine Distemper Virus as an outbreak was reported in the Cradock area in the month preceding the incident and no other carnivores seemed affected. This disease incident highlights the intense interface for potential disease transfer between wild and domestic animals around the park.

Due to costs associated with prospective disease studies, all opportunities should be taken to collect and store appropriate tissues, ticks and blood samples from any animal that is immobilized or handled for veterinary or research purposes.

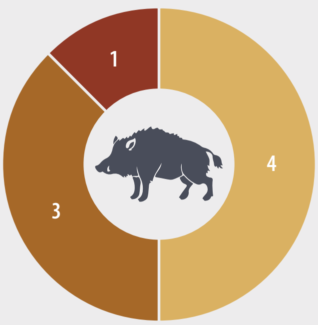
Mountain zebra (*Equus zebra*) with equine sarcoid lesions.

Alien species

Animals

A small number of extralimital warthogs (*Phacochoerus africanus*) are found in the park, while feral dogs, cats and livestock occasionally enter the park from neighbouring properties. Carp (*Cypinnus carpio*) and sharptooth catfish (*Clarias gariepinus*) are also found in the Doornhoek dam.

Alien Animals present: **8**



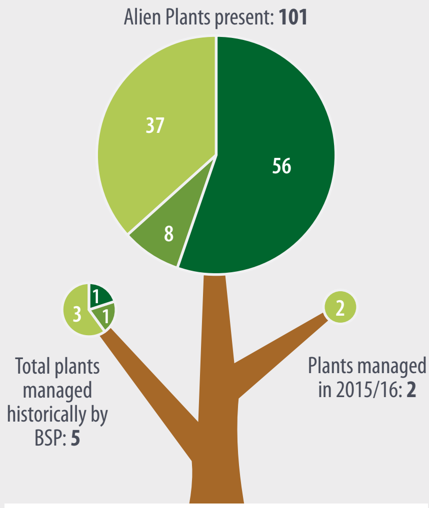
- NEM: BA Category 1
- NEM: BA Category 2 or 3
- Species not on NEM: BA

Warthog

Warthogs are of great concern as they can have significant impacts on geomorphology and the physical structure of plant communities through their rooting foraging behaviour. This is not yet a major problem and warthogs are controlled opportunistically.

Plants

The listing of alien plants is concerning and follow-up has been initiated. Published records listed 69 alien plants, while the latest park planning documents list 37, most of which were not on the previous lists. BSP have managed 5 of these species since 2002. The priority species for management include jointed cactus, *Opuntia aurantiaca* (on which biocontrol has recently been released), poplar (*Populus* sp.), Mexican poppy (*Argemone ochroleuca*), silverleaf nightshade (*Solanum elaeagnifolium*) and cockleburs (*Xanthium* sp.). Most of these species have localised impact, either in the drainage lines or in disturbed old lands, previous farmsteads or along road verges. Prickly pear (*Opuntia ficus-indica*) is extensive in pockets frequented by baboons (*Papio ursinus*), while Scotch thistle (*Cirsium vulgare*) is associated with springs in the park. Stands of pepper trees (*Shinus molle*), pine trees, eucalypts, willow trees and palm trees which were associated with former farmhouses have also been removed.



NEM: BA Category 1
NEM: BA Category 2 or 3
Species not on NEM: BA
2 biocontrol agents have been used in the management of alien plants

Dense jointed cactus (*Opuntia ficus-indica*).

Biocontrol on the jointed cactus by the cochineal insect.

A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

While climate change and 'fertilization' from increased CO_2 levels may impact the distribution of alien species in the park, biocontrol for the jointed cactus (*O. aurantiaca*) is predicted to be more successful in hotter temperatures, which could be a positive spinoff of the predicted rise in temperatures for the park.

The cochineal insect (*Dactylopius opuntiae*) is a sap-sucking insect and only feeds on a few cactus species. When feeding the host plant swells and discolours around the feeding site and eventually dies. These insects are very effective biocontrol agents on *Opuntia* sp. in South Africa.

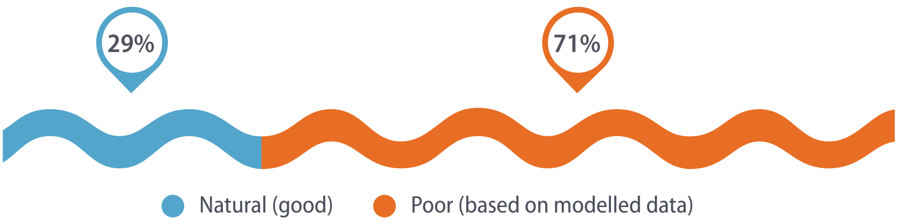
While BSP currently only work on a few species each year, NEM: BA legislation effective from September 2016 requires all 37 category 1 species to be included in plans, and may also require action for the 8 category 2 and 3 species.

Freshwater

M

QUICK STATS

- Total river length in park: **50 km**
- River Ecosystem types (of 223 in SA): **2**
- River length in good condition: **29%** (remainder – 71% – poor condition based on modelled data)
- The Wilgerboom River is the only significant river and outstanding freshwater feature of MZNP



Condition of all rivers in Mountain Zebra National Park (as per the National Freshwater Ecosystem Priority Assessment).

Upstream of the Doringhoek Dam, the Wilgerboom River and its tributaries are in an excellent ecological condition.

Downstream of Doringhoek Dam, the functionality of the Wilgerboom River has been substantially modified due to altered flow and sediment transport regimes and associated aquatic habitat availability. However, the dam has introduced new habitats for aquatic and terrestrial species and services such as an attractive viewshed for visitors, demonstrating the complex trade-offs that are typical of contemporary conservation in post-natural landscapes.

- Thorough checking of species lists and re-assessment of clearing priorities for BSP will be required in light of legislative changes and mismatches between alien species lists from different sources
- Management should keep vigilant for emerging threats, including *Nassella* grasses (present in the larger Protected Environment) and thistles

Numerous dams and boreholes, many dating back to farming days before the proclamation of the park, have increased surface water availability over time and space, which in turn allows higher numbers and more species of game. This increases the proportion of the park accessible to game and reduces refuge forage areas during droughts.

- Freshwater thinking should be incorporated into decision making, for example the development of new 4x4 trails should stay well clear of wetlands and river banks
- Water provision management is currently being investigated

- Develop an inventory of wetlands including classification and spatial mapping
- Institute monitoring for rivers, wetlands and groundwater

No river FEPAs (Freshwater Ecosystem Priority Areas) have been identified within Mountain Zebra National Park as the rivers are regarded as ecologically too modified to qualify as national conservation priorities. However, these rivers still provide critically important ecological functions and ecosystem services at the local scale and should be managed accordingly. At the same time the reinstatement of semi-natural flow and sediment transport regimes down the length of the Wilgerboom River might be considered, both in terms of restoring local ecological processes and delivering ecosystem services (sediment and water) to downstream users.

Wetlands: Several seep wetlands occur along the mountain slopes in the south of the park. The drier north of the park is characterised by numerous man-made structures for impounding runoff from rainfall events. Some depression wetlands and numerous artificial wetlands (including in-stream and off-stream dams) occur along the drier and relatively flat central and northern parts of the park. No wetland in Mountain Zebra has been identified as a national wetland FEPA, although preliminary fieldwork (March 2015) indicates that this might be an oversight as none of the seeps that occur along the slopes in the south of the park are included on the national-scale FEPA maps.

- Since the expansion of the south of the park in 2006, almost all of the source and headwaters of the Wilgerboom River are now within the park
- Through assistance of BSP, Mountain Zebra has been proactive with rehabilitation of drainage channels and other freshwater features, and has initiated biocontrol on jointed cactus (*O. ficus-indica*)
- The water-provisioning strategy for the park is currently being reviewed to establish more appropriate patterns of water availability and associated forage distribution

Resource use

L

Very little, if any, unauthorised harvesting has been documented for Mountain Zebra and currently there are no community-based resource use projects in the park. Use of resources is restricted to game sales and culling that take place as part of herbivore population management. Some animals are translocated to other parks, while in other instances income is generated through live game sales to cover monitoring and capture related costs. In the past, a small amount of money is also generated through the sale of venison following culling operations. Wood from the sweet thorn tree (*Vachellia* [*Acacia*] *karroo*) is used for brushpacking during erosion rehabilitation. This is managed to not have an impact on trees and the nutrients are returned to the ecosystem and assist in improving the habitat.

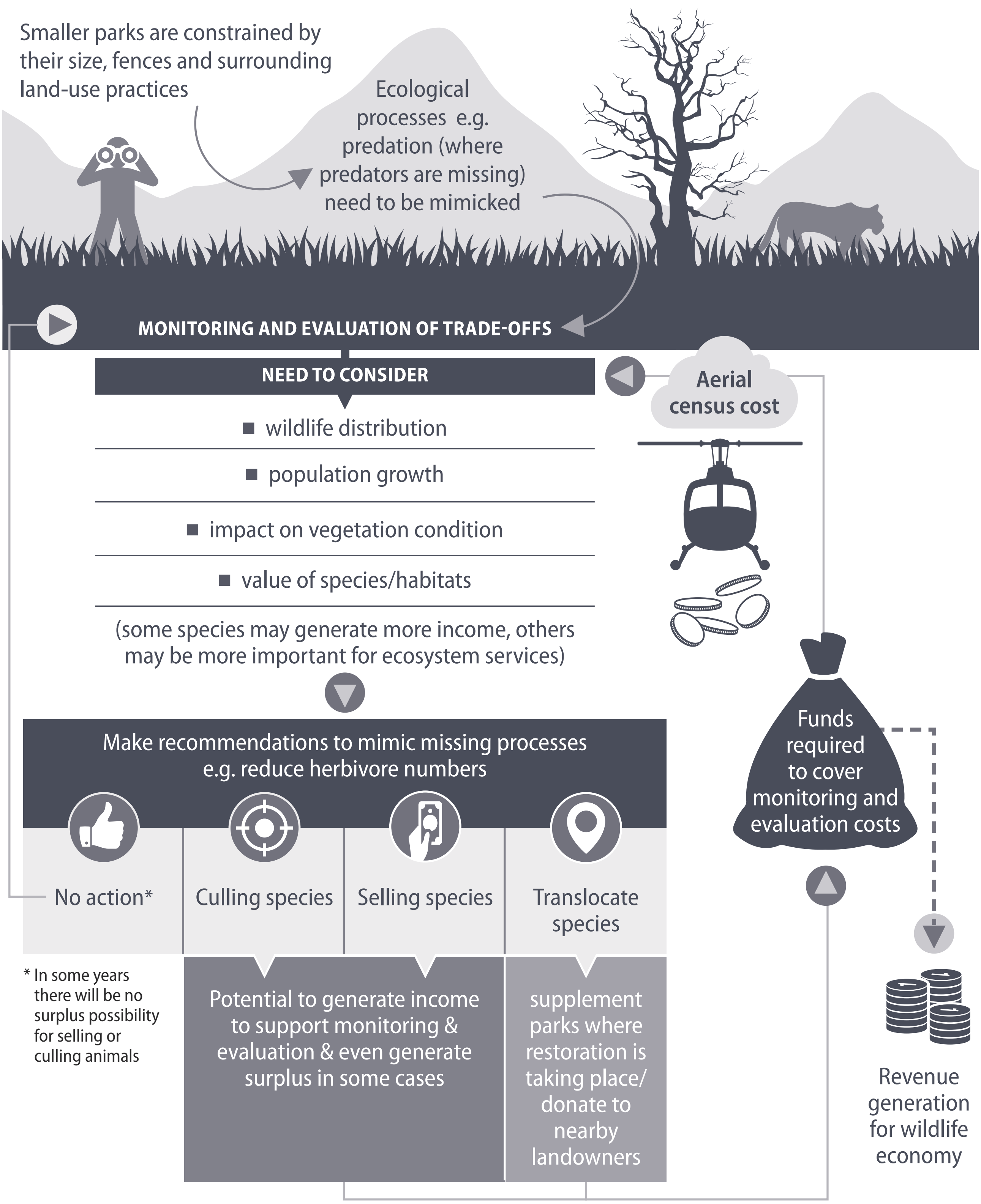
Abiotic resources including sand, rocks, gravel and water are used by the park for infrastructure maintenance and construction. Monitoring the use of these resources is increasingly important as water security is threatened by climate change and there is ever increasing mining pressure on rocks and minerals outside of protected areas.

Although game is potentially available for community-based wildlife economy projects, it will be critically important to base the species and numbers available on ecological principles to ensure long-term ecological and financial sustainability.

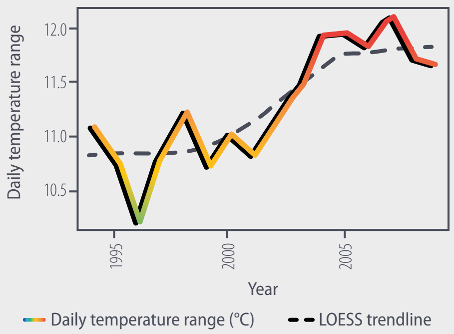
Continued monitoring to provide information on the distribution and numbers of game is critical in order to plan and undertake off-take operations, as well as to comply with legislation for determining the effects of this resource use.

Illegal resource use remains low and stable, since the park is reasonably isolated with a low density of neighbours and relatively far (15 km) from the nearest town.

The critical role of census and population status information in the wildlife economy



NAMAQUA
NATIONAL PARK



Annual average daily temperature range at Springbok since the early 1990s.

The Namaqua National Park (~149 000 ha) falls within the Succulent Karoo which appears relatively stable under all climate change scenarios, and the park is fortuitously situated in the most stable portion of this biome. The Succulent Karoo biome is identified as one of the world's 34 biodiversity hotspots and is one of three hotspots in South Africa. The relatively stable but arid climate contributed to the development of a diverse, locally adapted flora characterised by numerous bulb and succulent plant species with an exceptional species richness. Many endemic species are protected by the park. The floral richness is mirrored in its faunal diversity especially the invertebrates and reptiles although this is not the case with birds and mammals. The major biodiversity threats for Namaqua are perpetuated by human activities that include mining, overgrazing, illegal collection of fauna and flora and climate change.

Climate change

Temperature

Temperature data were available only from Springbok, which is quite far from the park, and then only 20 years of data were available. There was a significant increase in the daily temperature range (an increase of ~1.9°C in 20 years) detectable in the Springbok temperature data. Temperature increases of between 1.2°C (best case), 1.8°C and 2.4°C (worst case) are predicted for the region by 2050. While predicted increases seem small, we have demonstrated the effect that a 2°C increase would have on the relative proportion of days above 35 degrees for a hypothetical park where average summer maximum temperatures are about 31 degrees (see figure on p. 140). The shift experienced in Namaqua could be even greater under the worst case scenario, and may place multiple species at risk as water is lost faster from the environment at higher temperatures. This could worsen the effects of any changes in rainfall.

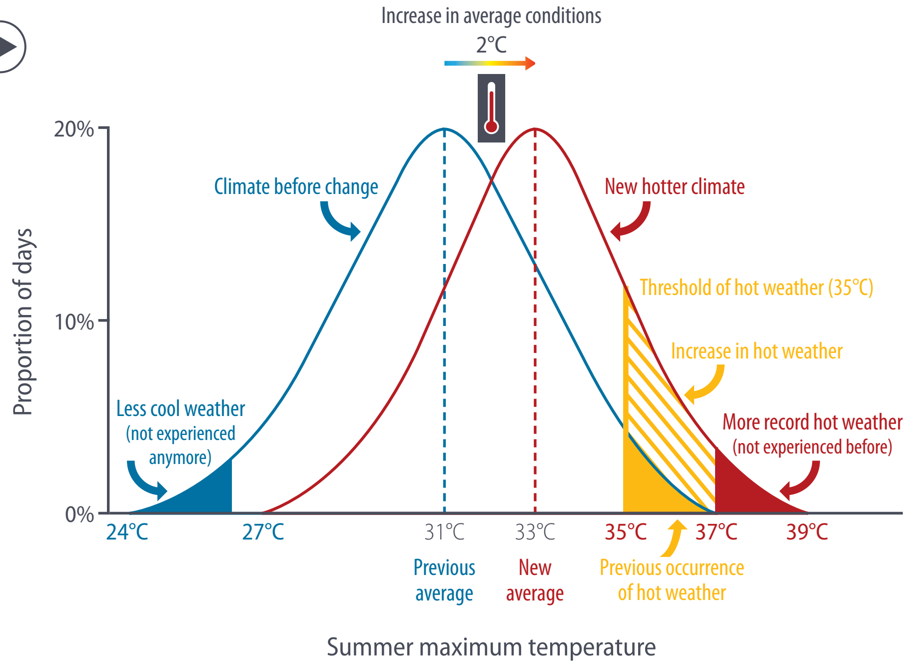
Future increases in mean annual temperature of between 1.2°C (best case), 1.8°C and 2.4°C (worst case) are predicted by 2050 for the area.

The distribution of Succulent Karoo in the region is predicted to remain quite stable within the temperature and rainfall range that are currently observed for this biome. This is in contrast with earlier climate change predictions which saw this biome being worst off. Individual species are still likely to be at risk as a result of the changes predicted.

Quiver trees (*Aloe dichtoma*) are dying out in areas with increased evapotranspiration (i.e. in places where rising temperatures cause increased water to evaporate off the earth's surface and from plants). While there is limited data to detect changes in the Namaqua area to date, it will be important to observe the response of these trees when changes become apparent.

Quiver tree (*Aloe dichtoma*)

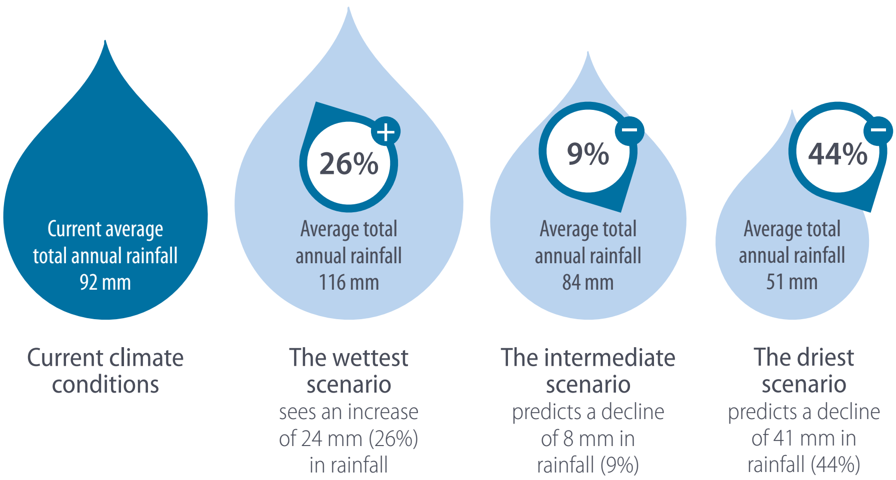
Record environmental conditions and monitor quiver tree persistence and recruitment of new plants in areas exposed to different climatic conditions.



This figure shows the number of summer days reaching between 24°C and 39°C for a hypothetical situation where the historical average maximum summer temperature was 31°C , compared to the range of summer temperatures if average conditions increased by 2°C . Under the previous climate there would be an average of 4 days per summer that get to 35°C or hotter and it would never get hotter than 38°C, whereas there are about 17 days over 35°C under the new climate that has warmed on average by 2°C and 3 days reach 38°C or more – conditions not experienced under the previous climate.

Rainfall

Fifty seven years of rainfall data were available from Kamieskroon, but showed no significant overall trend, although there was an increase in the number of days with rain and a decrease in rainfall variation over time.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. It is not yet certain which of the scenarios is most likely, although models more commonly predict drying along the west of South Africa, making the wet scenario is least likely. Also note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of smaller steadier rain events).

SANParks has an important role in educating the public about the importance of greener lifestyles and wise water and energy use.

Reducing waste and increasing opportunities for recycling are also critical.

Namaqua can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

Cross-reference: Refer to West Coast for a discussion of the implications of oceanic climate change for the marine environment. The cold, nutrient rich, Benguela current runs up the West Coast of South Africa, while the warm, nutrient poor, Agulhas current runs down the east coast.

A stronger warm Agulhas current would result in wind changes that increase the upwelling of nutrient rich cold water. In fact, the inshore sea surface temperature along the west coast has been observed to be getting colder due to this and related processes. These two currents have major impacts on the circulation of heat and nutrients in the oceans globally. They also affect atmospheric pressure systems that determine air movements, rainfall, wind speed and wind direction. Therefore any changes in temperature and chemical composition of the water in these currents can change the way in which they flow and the dynamics of associated wind and rainfall over the oceans and adjacent land. Current observations and generic predictions for the South African coast include a cooling west and south coast and a warming east coast. These changes in turn have profound impacts on the distribution and life cycle of species dependent on the oceans, and therefore also on people and animals that rely on these marine resources.

What will happen to flower season under climate change? How does predictability of season influence tourism?

The park was expanded specifically with climate change in mind and includes an altitudinal gradient, from sea level to 956 m above sea level.

It would be beneficial to set up a network of weather stations across the park at different altitudes to enable monitoring of differences in climate change at different altitudes. This information will in turn be useful for trying to estimate possible species level impacts of change.

Alien species

H

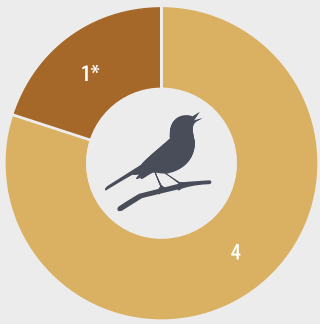
Only 23 alien species (18 plants and 5 animals) have been documented in Namaqua, the third least of any park.

Animals

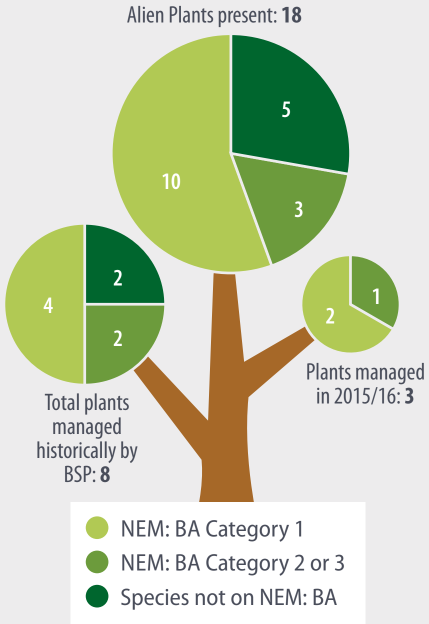
Sheep grazing is permitted in the Skilpad region to stimulate flower displays for tourism (see resource use section), while domestic cats and dogs are likely transient. There is currently an Anatolian dog-predator-livestock mitigation program in the park to assist in dealing with real and perceived threats of Damage Causing Animals.

House sparrow (*Passer domesticus*)

Alien Animals present: **5**



NEM: BA Category 2 or 3
Species not on NEM: BA
*House sparrow



A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

While alien species are not currently a major threat in the park, the NEM: BA legislation will require management plans for all 10 listed species by September 2016. These species include the weedier or spiny cocklebur (*Xanthium spinosum*) and Mexican poppies (*Argemone* sp.) as well as two species of prickly pear (*Opuntia* sp.). Only 4 of the NEM: BA species have been routinely worked on to date.

Plants

The potential transformer species like rooikrans (*Acacia cyclops)* are well under control and the other species have not been identified to pose a major current threat, although graminoid species like fountain grass (*Pennisetum* sp.) may become a problem in the future.

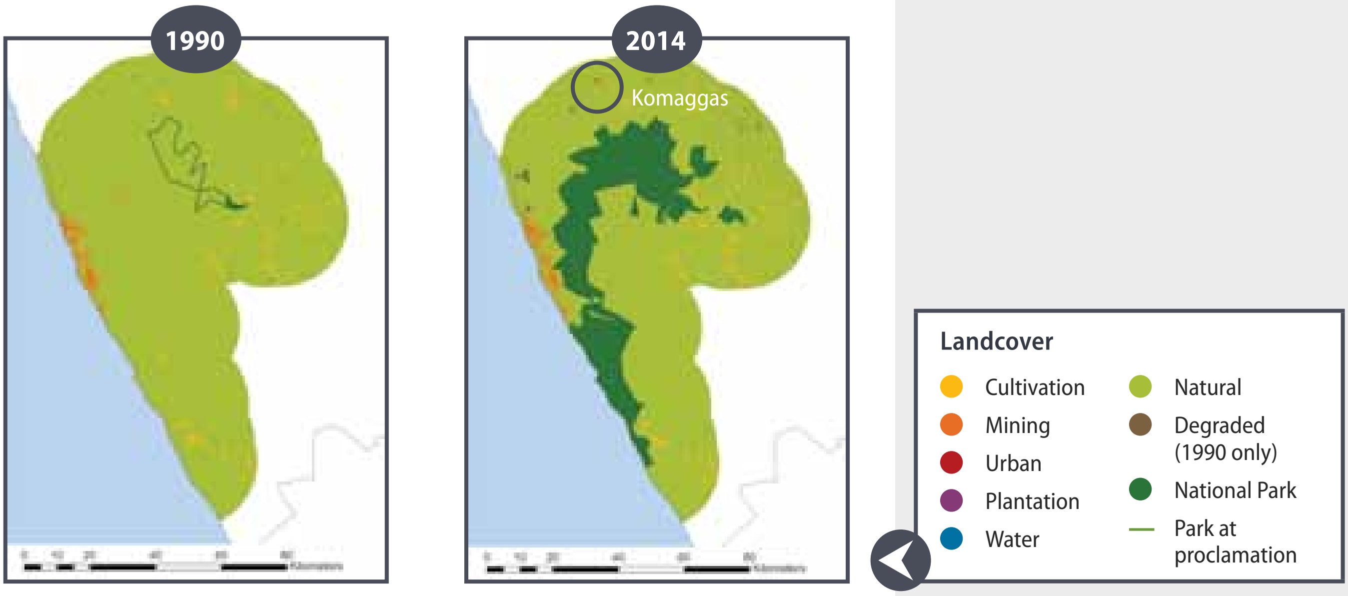
Mexican poppy (*Argemone ochroleuca*)

Land-use change

H

Namaqua National Park is another of SANParks expansion success stories. Since declaration in 2001, the park has expanded from the first area of just 1000 ha to almost 150 000 ha, now conserving 13 different habitat types. A large part of the Namaqua coast has historically been mined for diamonds with De Beers being the largest company involved. Over the past decade they have reduced their operations, selling and donating much of their land to SANParks, and selling the remainder of their rights to smaller companies. The land-cover layers reflect this withdrawal, showing a 7 km^2 (11%) decrease in the extent of mining in the 20 km radius from the current park boundary. The development of new technologies has however created a need for rare minerals which are used amongst other things for cellular phones, microchips and solar panels. The Namaqua region has been found to hold many of these minerals and new prospecting applications and mining right requests are increasingly being received by the park. The integrity of the Groen and Spoeg Rivers is likely to be threatened by the granting of such rights. The town of Komaggas also seems to have undergone expansion (23%, although the town is very small).

Mining (example at Kleinzee) is exceedingly destructive, and rehabilitation (being implemented here at Koiingnaas), is costly, labour intensive and requires special barricades to keep sand from blowing over plants that are trying to establish. Sand blown from mining areas poses a threat to natural vegetation growing in the vicinity of mines.



Land-use change between 1990 and 2014 in the 20 km radius around the current park boundary. The first map shows the area of land proclaimed in 2001 in dark green (the Skilpad wildflower reserve was the only protected area in existence at the time), while the 2014 land-use map shows the current park extent, including recent expansion.

Disease

M

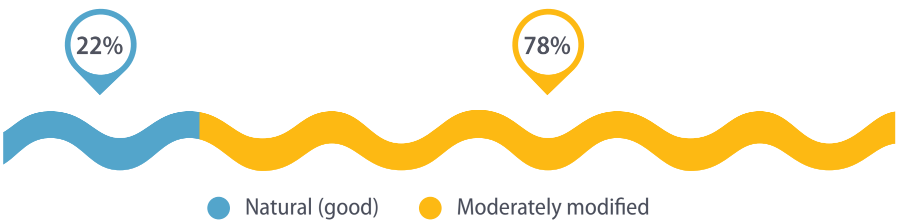
Disease is not currently a major threat in the park, although the long term impacts of intensified or heavy mining such as the addition of abiotic pollutants, including salt from desalination plants and acid from mining along the coast, are uncertain. African horse sickness and Botulism are the only notifiable diseases currently thought to be present in the park.

Freshwater

L

QUICK STATS

- Total river length in park: **144 km**
- River Ecosystem types (of 223 in SA): **6**
- River length in good condition: **22%**, all of which has also been designated a Freshwater Ecosystem Priority Area (FEPA). The remainder is moderately modified
- Freshwater Ecosystem Priority Area (FEPA): **22%** of river length (a further 20% would qualify if FEPA modified condition restored)



Condition of all rivers in Namaqua National Park (as per the National Freshwater Ecosystem Priority Assessment).

The juxtaposition of rivers and estuaries inside and outside of the park make an interesting case for investigating the impacts of conservation on estuaries versus the river systems that feed them. A once-off survey to determine the present ecological state of the Groen River estuary was done during February 2015. This survey showed an absence of benthic macroinvertebrates, mesozooplankton, fish and low bird counts (mainly short-billed waders). This supports the conclusion that the Groen Estuary was a stressed ecosystem in February 2015. A monitoring system that looks at seasonal fluctuations in the estuary is proposed.

Groen River estuary

The development of a wetland inventory is a high priority. The process for inventorying wetlands has already commenced in some of the other parks. Some information on wetlands is available through the Working for Wetlands project, but the NFEPA wetland ground-truthing has not yet been done in Namaqua.

Estuaries: There are two estuaries in the park, Groen and Spoeg River estuaries, but the rivers feeding the estuaries flow largely outside of the park. The Swartlintjies River runs through the park but its estuary lies outside of the park.

Quiver trees (*Aloe dichotoma*) are threatened by climate change and populations have been noted to be decreasing. Observations have been made of adult trees being poached. There is a need to investigate the relative roles of poaching and climate changes in population size fluctuations of Quiver trees.

Quiver tree

Resource use

M

Thirty-eight resources, representing mainly isolated incidents of illegal reptile and succulent plant collection for the pet and nursery trades, are known to be harvested from Namaqua. Other harvested resources include a few species that are poached for food, while abiotic resources such as water and sand are used by the park. The list of resources is likely to be complete, but in many instances is not very specific (e.g. genera as opposed to species have been identified as targets for illegal harvesting for the succulent ornamental trade). Trends in use are unknown, but as there is a low human population density in the area, the only real threat is from collectors coming in from outside areas to poach plants and reptiles.

Grazing for 200 sheep is permitted on 200 ha of degraded farmland in the Skilpad section of the park to promote the growth of flowers for the tourist season. The biodiversity value of the area is low given the former land-use and the grazing impact is minimal when offset against the tourism benefits.

Sheep are permitted in the Skilpad section of the park.

RICHTERSVELD
NATIONAL PARK

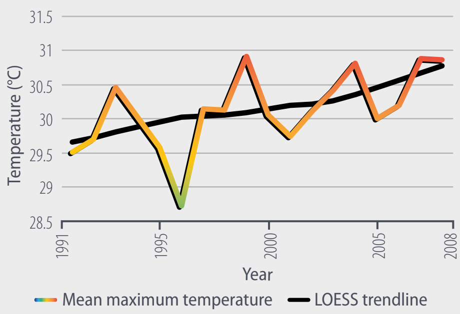
The Richtersveld National Park (~180 000 ha) is the only national park that is a fully contractual park with local communities, known as the Richtersveld Gemeenskap, and it is not state-owned land. Part of the contractual agreement is that 26 registered livestock farmers with a total of 6600 small stock units are allowed grazing in the park. Mining is economically important to many livelihoods and mining activities will remain a dominant land-use in the area. The Richtersveld has one of the richest succulent diversities in the world due to the unique geology formations and soil types that create small unique habitats with diverse humidity, sunlight and temperatures in this winter rainfall desert ecosystem. Many of the plants are especially adapted to these areas and increases in temperature and changes in environmental conditions could be detrimental to the requirements of these specialised plant and animal species. Increased temperatures and rainfall changes that are predicted for the north western part of South Africa will not only be a threat to the unique succulents and biodiversity in the area but also to living and working conditions in the Richtersveld.

Climate change

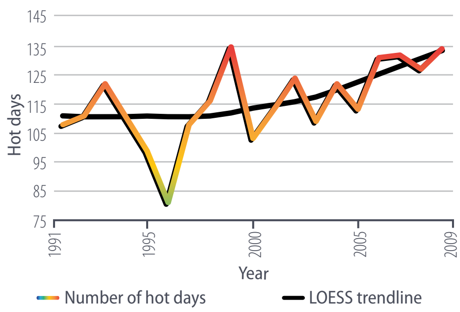
H

Temperature

Some of the most dramatic temperature changes observed across parks were observed in the Richtersveld area, with significant increases in average minimum and maximum temperatures of 1.1°C to 1.2°C in just 20 years at the Henkries weather station. The 1 degree of change that has already taken place has resulted in a sharp increase in the number of very hot days, especially in summer (see figures below). Predictions of future climate change include further increases in annual average temperature of between 1.4°C and 2.4°C by 2050, which will result in unbearably hot temperatures throughout significant portions of the year.



Annual average maximum temperature measured at Henkries, showing a significant increase.



The number of days in the year where the temperature has reached or exceeded 35°C at Henkries, showing a significant increase since 1990. Currently more than a third of days in the year have temperatures in excess of 35 degrees.

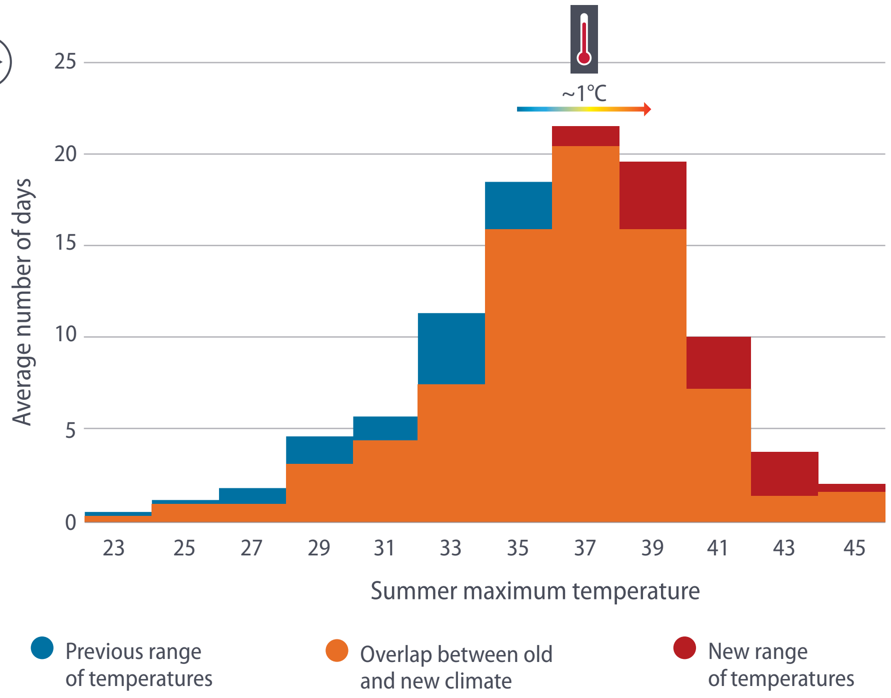
Predictions of future climate change include further increases in annual average temperature of between 1.4°C and 2.4°C by 2050.

A seldom considered impact of climate change is that on people who work outdoors: Under hotter conditions, people's work rate will be reduced and in some instances people may not be able to do much outdoor work at all. This has dramatic implications for the Richtersveld and other northern parks where summer temperatures are predicted to become unbearable.

Quiver trees (*Aloe dichtoma*) are dying out in areas with increased evapotranspiration (i.e. in places where rising temperatures cause increased water to evaporate off the earth's surface and from plants)

Re-determine optimal herbivore numbers (especially of domestic livestock) in the park under scenarios of increased temperature and reduced moisture availability.

Analysis of change in climate variables other than temperature and rainfall (e.g. fog index and wind) as well as an assessment of where additional weather stations are required or where micro-climate analysis might be important would assist in making recommendations for adapting to climate change.

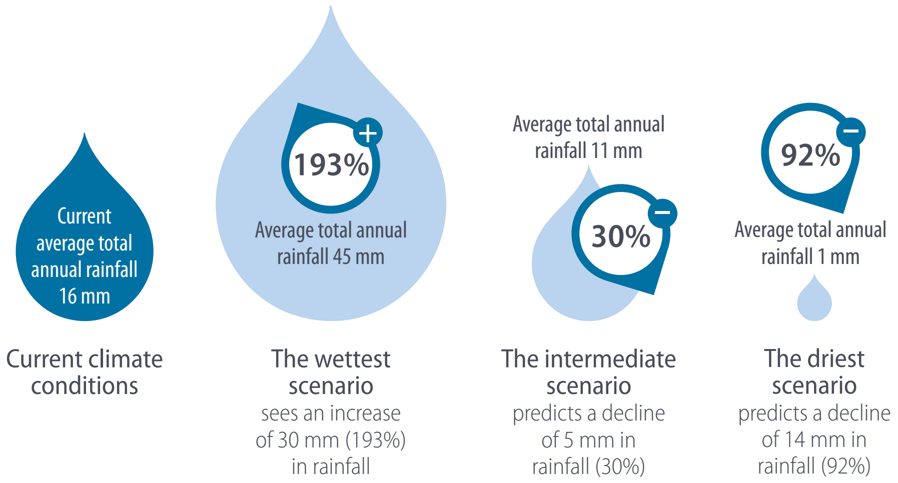


The average number of summer days reaching between 23°C and 45°C at Henkries in the 1990s compared to the late 2000s (2005–2009), showing how an average shift of 1°C is impacting on the number of hot days experienced. By the late 2000s, over 80% of summer gets to 35°C or hotter compared to just over 70% in the 1900s. In addition, 27% of summer days (almost one third) were over 40°C, compared to only one fifth in the 1990s. The temperature increases that are still predicted to occur will mean that even higher numbers of days will reach these thresholds with significant impacts on plants, animals and people that have to work outdoors.

Rainfall

Changes in rainfall were less obvious, but as in Namaqua, an increase in the number of days with rain was observed, although this was accompanied by a decrease in the amount of rain per rainfall event. This means that the already desert-like area is likely to become even drier under hotter conditions as smaller rain events will evaporate very quickly. Under the driest scenario, it is predicted that the area will almost cease to receive any rainfall at all.

Cross-reference: Refer to West Coast for a discussion of the implications of oceanic climate change for the marine environment. The Orange River mouth is expected to become an important refuge for estuarine species as rainfall is likely to increase in its catchment area, making it one of few stable estuaries as climate dries along the west coast.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. Although it is not yet clear which of the future scenarios is the most likely, most models favour the drier scenarios in this part of the country. However, the park should note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of lighter steadier rain events).

Despite no overall change, rain from smaller rainfall events will evaporate faster and may result in lower water availability for plants and animals. Although fog (which has not been considered) may play an important role in water availability, especially in the more coastal areas, the dramatic temperature increases observed in the region make it likely that aridification impacts will begin to be observed. This has significant implications for the impact of overgrazing.

Biome changes and impacts on vegetation types

If the more extreme predicted warming and drying changes do occur, then it is expected that the Richtersveld area would be more desert like and with much less of the Succulent Karoo characteristics than are currently present.

- SANParks has an important role in educating public about the importance of greener lifestyles, particularly in water scarce areas.
- Reducing waste and increasing opportunities for recycling are also critical.
- Richtersveld can save water and electricity in a number of ways including use of low flow toilets that make use of recycled water and tourist and staff awareness programmes.
- Appropriate signage for tourists can increase awareness and support for water and energy management changes.
- Tourists can also be encouraged to bring their own water supplies along to relieve pressure on the park.

Actions to make a difference

The halfmens (*Pachypodium namaquanum*) is a near threatened species and listed as a species of special concern. The species has been subjected to illegal collecting for both national and international markets. The tree is also threatened by mining activities in Namibia and intense grazing and trampling by domestic livestock. They have low levels of recruitment so that global environmental changes, especially high temperatures with high evaporation could be detrimental for the survival of this species in hostile environments.

The halfmens (*Pachypodium namaquanum*) is one of the iconic species in the park and listed as a near threatened species.

The most challenging rehabilitation issue is the availability of brush packing material for rehabilitation due to the absence of the indigenous woody species in the area. The suggested alternative is the provision of a mulching machine for production of brush packing material. The eradication of *Prosopis* species can be a good source for mulching. The spreading of seeds through this operation will be minimal and monitored under the supervision of the project manager.

An initial effort was made to map the network of individual rills and gullies for the entire park. Rehabilitation measures were suggested for achieving optimal rehabilitation results. The implementation will rely mainly on budget allocations.

Rehabilitation measures should be focused on areas with slight degradation as bigger hectares can be rehabilitated using soft option techniques with minimum resources. Rock gabions, silt fencing and mulch packing is the main management recommendations for erosion in the park.

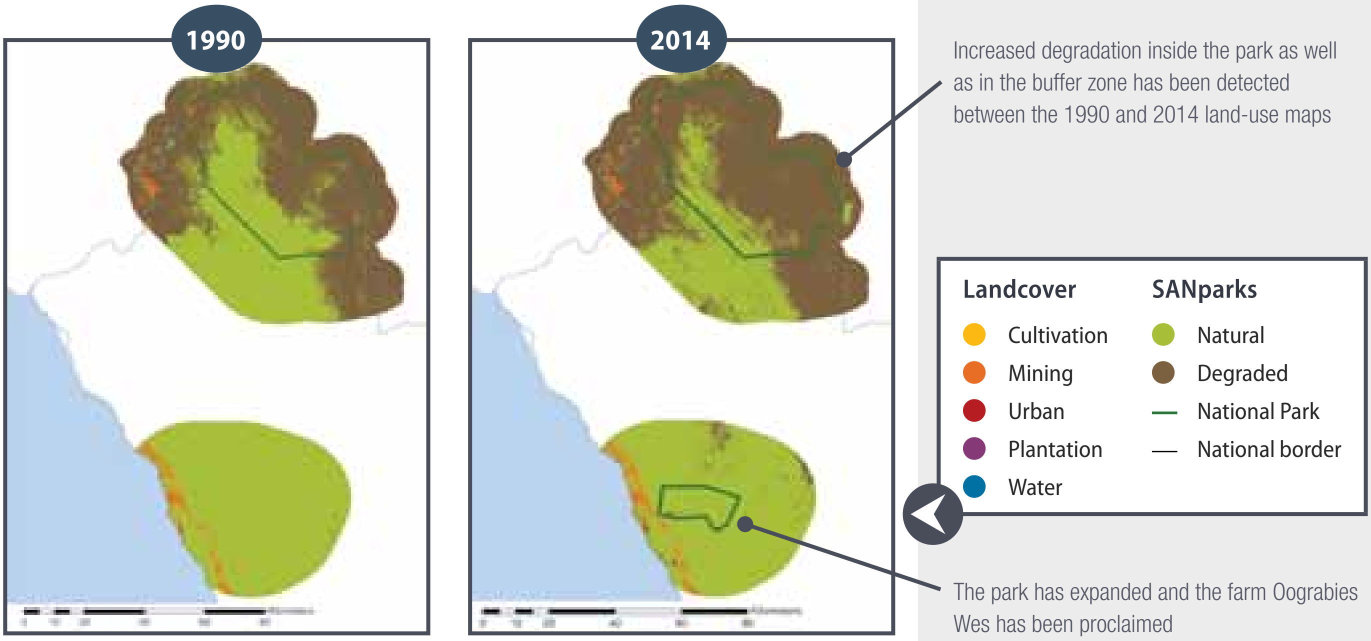
Landscape Function Analysis (LFA) which looks at soil stability, infiltration & nutrient cycling and vegetation monitoring (vegetation recovery i.e. succession) forms the basic monitoring criteria in degraded areas. Recently, ant diversity has been included as an indicator of degradation and rehabilitation. Baseline data need to be collected before and after rehabilitation measures. Monitoring will be undertaken by Scientific Services.

Land-use change

L

Since declaration in 1991, the park has expanded by 17 500 ha to the current 179 792 ha and has increased the conservation of habitat types from 13 to 21. The park is a contractual park where local surrounding communities have access to grazing inside the park. Land-cover layers for both 1990 and 2014 show that more of the park is degraded than represents natural vegetation. The buffer areas also show a similar situation of degraded areas around the park. This could however be somewhat misleading as the natural vegetation of the area is quite sparse and may have been classified as degraded when in actual fact this is the natural condition. Although it is often challenging to distinguish between natural and human induced erosion, the effects of domestic grazing and footpaths in the Richtersveld National Park are very pronounced.

SANParks Scientific Services have identified four plant communities that are threatened by erosion for monitoring and restoration purposes: Central Richtersveld Montane Shrubland, Northern Richtersveld Scorpionstailveld, Swartport Plain Desert and Noams Mountain Desert. These areas are characterised by networks of severe rill erosion, which in most instances have developed into severe gullies. Roads, animal foot paths and compacted soils from over grazing are the main drivers of erosion.



Land-cover layers for both 1990 and 2014 shows that more of the park and buffer areas are degraded than represents natural vegetation. This could however be somewhat misleading as the natural vegetation of the area is quite sparse. The park has expanded and now includes the farm Oograbies Wes.

Disease

M

Disease is not currently a major threat in the park, although an increase in domestic stock could introduce additional disease issues. Pollution of the Orange River could also impact on the health of game animals and the ecosystem. See also black fly example in the Augrabies Falls section.

Alien species

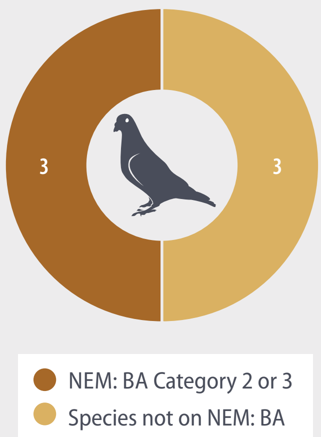
M

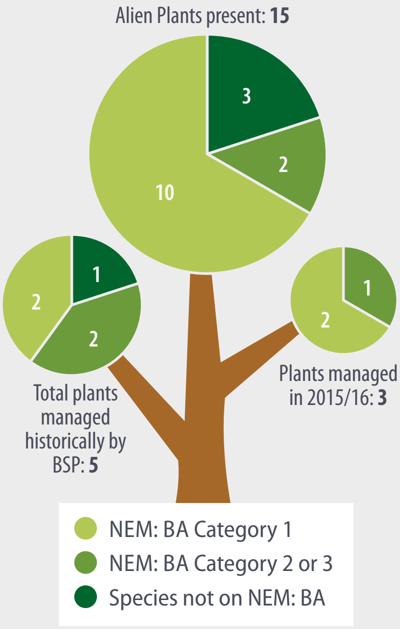
The Richtersveld has the least documented alien species of all the parks, only 21 (6 animals and 15 plants, 10 of which are listed in the NEMBA regulations under category 1b, thus requiring active control). *Prosopis* occurs with other plants along river, which is generally invaded by similar species composition between growth-management-flood cycles. In terms of alien animals, livestock grazing has a high impact and large extent, but this is better discussed as a resource use issue than one of alien species. Other alien animals include dogs, rock doves, cats and European starlings.

Animals

Rock doves (*Columba livia*), House sparrows (*Passer domesticus*) and the European starlings (*Sturnus vulgaris*) are invasive birds present in Richtersveld NP.

Alien Animals present: **6**





A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

Plants

Prosopis invasion along the Orange River.

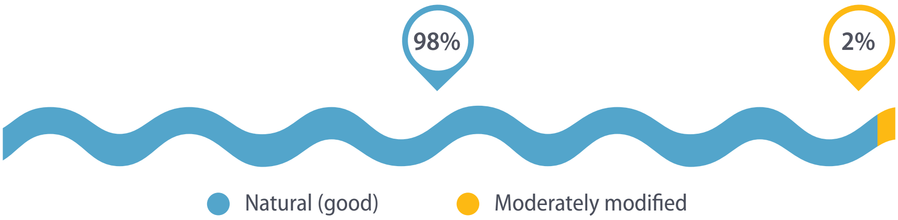
Freshwater

L

Orange River

QUICK STATS

- Total river length in park: **376 km**
- River Ecosystem types (of 223 in SA): **8**
- River length in good condition: **98%** (remainder moderately modified)
- Freshwater Ecosystem Priority Area (FEPA): **18%** of river length. **35%** of river length is a fish support area
- The development of a wetland inventory for is a high priority and the process for inventorying wetlands has already commenced in some of the other parks



Condition of all rivers in Richtersveld National Park (as per the National Freshwater Ecosystem Priority Assessment).

Resource use

Initially our survey revealed only 16 harvested/used resources (4 abiotic resources, including rocks used for erosion control, livestock grazing, five plants and six fish). The fish species most commonly caught along the Orange River include sharptooth catfish (*Clarias gariepinus*), Vaal-orange largemouth yellowfish (*Labeobarbus kimberleyensis*), Vaal-Orange smallmouth yellowfish (*Labeobarbus aeneus*), Orange River mudfish (*Labeo capensis*), and the alien Mozambique tilapia (*Oreochromis mossambicus*) and common carp (*Cyprinus carpio*). Further communication with the park has provided additional insight into the diversity of plants harvested and used by local communities adding more than 20 plant species harvested in the park (see photos on p 152). This is the only national park in which diamond mining takes place.

Wood for fire and some medicinal plants are collected by community members. It is estimated that a family uses about 15 kg of fire wood a day. This wood is collected around towns/ settlements but it is becoming more difficult to find wood close to communities. Species that are most sought after in winter are tree mesembs (*Stoeberia arborea* and *Stoeberia frutescens*) and spekboom (*Tetraena prismatocarpa*). In summer Cape ebony (*Euclea pseudebenus*) and white karee (*Searsia pendulina*) are used along the Orange River. Medicinal plants such as cancer bush (*Lessertia frutescens*), teebossie (*Leysera tenella*), knoppies-stinkkruid (*Oncosiphon suffruticosum*), bergsalie (*Salvia dentate*) and wild mint (*Mentha longifolia*) are used for colds, sore throat and to clense the body. Jacobregop (*Pelargonium crithmifolium*) is used for stomach related problems and the roots of the klapperbossie (*Nymania capensis*) and boesmansuring (*Anacampseros* species) are used with sugar or honey in brewing beer. The alien tabak plant (*Nicotiana glauca*) is used for curing breast and chest pains. Some plants are used for the construction of traditional homes such as the blinkblaar-wag-'n-bietjie (*Ziziphus mucronata*), branches for the frames of traditional huts and reed mats from the matjiesgoed (*Cyperus marginatus*), harde matjiesgoed (*Pseudoschoenus inanis*), steekbiesie (*Schoenoplectus scirpoides*), *Scirpoides dioeca* and *Juncus acutus* subsp. *leopoldii*. The gum of the rare Acacia doringboom (*Vachellia* [*Acacia*] *karroo*) is still sometimes mixed with water, mud and dung to make floors for houses. The young wood of the Karoo boerboon (*Schotia afra* var. *angustifolia*) is used in making hooked sticks and karwats while the wild olive or olienhout (*Olea europaea* subsp. *africana*) is sought after for making walking sticks. Propagation of several cuttings and seedlings for a nursery also occurs on a small scale in the park.

In general, the resource use pressure is low as the park is extremely isolated and the human population small. Due to the isolation of the park, it is easy for visitors to illegally collect succulent plants. Local communities live and graze their livestock within the park, which can have extensive negative impacts on species richness and composition. The most obvious effects of livestock grazing are seen at water points, along herding pathways and around stock posts and are interestingly not related to herd size. Trampling and herbivory alter the soil structure by loosening the soil surface to a fine texture that is then prone to gully erosion, while defecation and particularly urination result in high soil salinity that may alter soil chemistry and vegetation dynamics. The contractual management agreement specifies that a set stocking rate of 1 Small Stock Unit (SSU) per 25 ha is allowed for grazing in the park. The 2015 counts estimated that there are about 4100 sheep and goats grazing in the park.

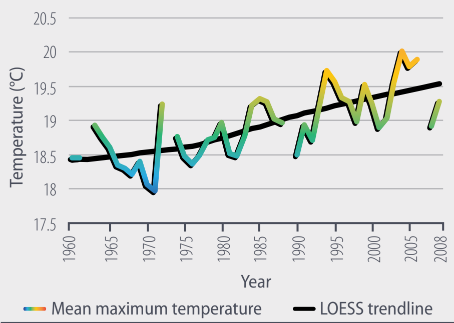
1.68% human population growth rate for the period 2001 – 2011.

Livestock grazing in Richtersveld.

Plants harvested for medicinal uses in Richtersveld National Park. – *Pieter van Wyk*

TABLE MOUNTAIN
NATIONAL PARK

Creative and adaptable management will be required to deal with each issue that arises as part of the bigger picture.



Annual average maximum temperature at Cape Point station since 1960, showing a significant increase.

The Table Mountain National Park (~24 500 ha) is a magnificent park bounded by South Africa's third largest city, while the 1000 km^2 marine protected area includes busy commercial fishing zones and is bounded by shipping lanes and traffic. As such the park has to be resilient to multiple invisible pressures and the dynamics of urban lifestyles. There are plans to consolidate the conserved area and thereby increase resilience and enable species movement and migration in and out of the park. However the densification of Cape Town reduces the possibility of corridors and makes the remaining fauna and flora particularly susceptible to the impacts of multiple global change drivers. Both poor and wealthy people in the city rely heavily on the park's rich biodiversity for various resources ranging from water to recreation and food. Some of the latter is harvested for large scale overseas markets, e.g. abalone, some for subsistence and medicinal use. Although some resources are legally harvested both marine and plant resources are under dire threat. Alien species are a permanent threat, with budget cuts and constraints on efficient and well-prioritized expenditure potentially leading to spread of aliens in areas that were formerly under control as well as colonization of new areas, while the city's residential gardens pose a perpetual risk for the introduction of new species. New legislation does however provide the promise of reducing the number and nature of alien species available for sale to the public. The impact of these change drivers, (over harvesting of resources and aliens) is compounded by increasing temperatures, which increase the risk and frequency of wildfires and pose a number of related threats to native species and management. The park is, however, an important climate change refuge given that predictions of future climate change are milder compared to other parts of the biome and country. The topographical temperature gradient provided by all the mountains and peaks may reduce the effect of rising temperatures.

Climate change

M

Temperature

Over the last 50 years, average minimum temperatures have increased by 1.05°C, while average maximum temperatures recorded at the Cape Point station have increased by 1.25°C since 1960. Though these increases appear small, they dramatically impact on the occurrence of warmer weather and related risks. Interestingly, these observed changes are similar to regions in the north of the country, where much greater warming is predicted.

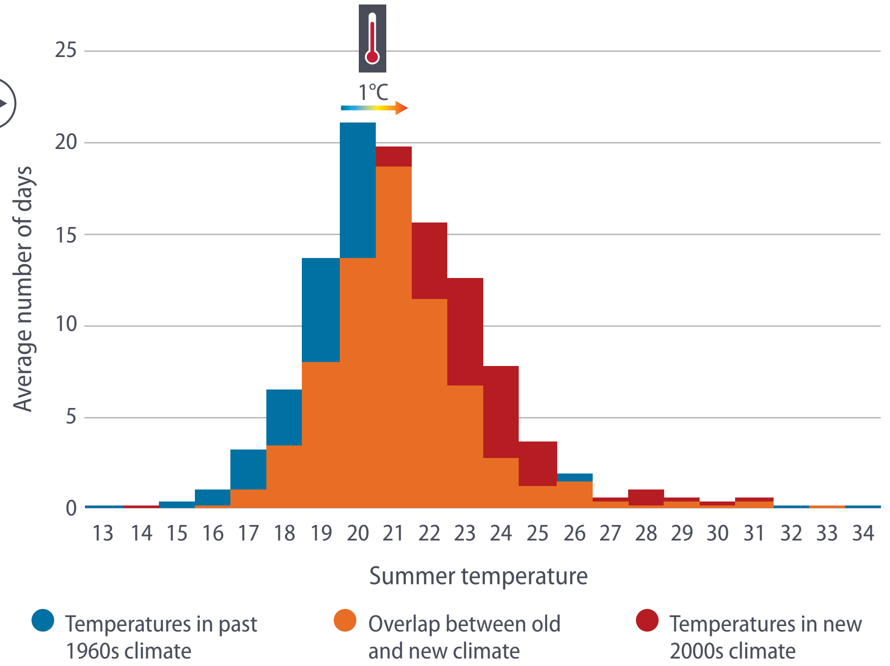
Further Increases in mean annual temperature of between 0.9°C (best case), 1.4°C and 1.8°C (worst case) are predicted by 2050.

An increasing number of high fire danger days is already being experienced as a result of increasing temperatures. An assessment of long-term vegetation change in Cape Point (as monitored by Jasper Slingsby and SAEON) shows that sites that experienced particularly severe periods of hot and dry days in the first summer following a fire have declined in species richness. Repeat occurrence of fires in extremely hot conditions like the March 2015 fires, followed by severe hot and dry summers could lead to a decline in species richness over time. In addition, drier hotter conditions and more frequent fires may also lead to fire-induced soil hydrophobicity (i.e. soil water repellence).

Soil hydrophobicity was monitored in the park after the 2014 prescribed burns and 2015 wildfires in Tokai by Ruth-Mary Fisher (SANParks). Soil hydrophobicity hampers the infiltration of water and may have negative impacts on plant growth.

Table Mountain was the second park to include specific climate change objectives in its management plan.

Experiments to determine potential mismatches in the timing of flowering of key Fynbos species and the presence of their pollinators as a result of increasing temperatures need to be investigated.

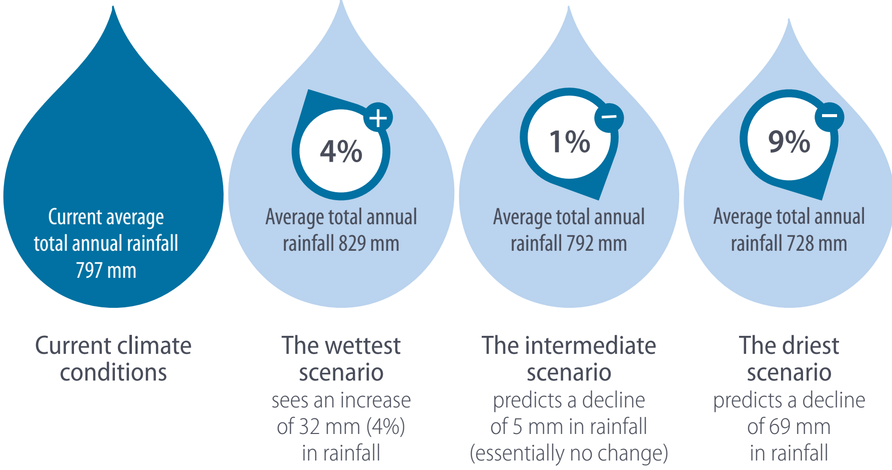


Average summer temperature in the 1960s at Cape Point, compared to the 2000s, showing how an average shift of just 1°C impacts on warm extremes. In the 1960s, an average of only 2 days would have been above 25°C and about one quarter of the days would have been above 22°C, whereas in the 2000s, an average of six days are above 25°C and half of the summer days get hotter than 22°C. This effect becomes even more dramatic in areas where temperatures are naturally hotter than in Cape Point (e.g. where average summer temperatures are 30°C and above, the occurrence of very hot day, 35°C+, increases sharply).

For Table Mountain, the biggest climate change impacts in the near future will be the effect that increased temperatures will have on the fire danger index, as well as the ability of fire fighters to control wild fires.

Rainfall

No major rainfall changes were detected in the historical rainfall record for the past 110 years, except for a slight increase in rainfall event size (more rain per rainfall event). This heavier rainfall has implications for flooding.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. None of the scenarios predict particularly dramatic rainfall changes for this region. However, it should be noted that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of smaller steadier rain events).

Possible biome changes

The predicted changes are not as severe as changes predicted for parks in other parts of the country and no major changes in the distribution of Fynbos biome extent are predicted in the region of the park by 2050. However, contraction of the biome as a whole is predicted, making it all the more important to put adequate conservation measures in place in the regions that are predicted to be slightly more stable over time. Additional concerns include the impact that higher levels of carbon dioxide currently present in the atmosphere (which 'fertilizes' plants) will have on alien species. CO_2 fertilization is expected to promote plants that use type C3 photosynthesis, which includes many of the alien grasses and all woody species. For example, Zoe Poulsen and Timm Hoffman (UCT) observed a 65% total forest expansion in Table Mountain National Park with higher rates in Orange Kloof and Blinkwater Ravine, largely due to fire suppression, but likely aided by elevated CO_2.

SANParks has an important role in educating public about the importance of greener lifestyles.	Reducing waste & increasing opportunities for recycling are also critical.
Table Mountain can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.	Appropriate signage for tourists can increase awareness & support for water & energy management changes.
Using mini-buses to transport tourists from the Cape Point gate to the Lighthouse could reduce the traffic volumes and carbon footprint.	The Cable Way has already implemented various such interventions, with notable savings.

Actions to make a difference

Land-use change

H

The idea behind the proclamation of the national park was to consolidate the protected land in the area under a single management agency. The park was declared in 1998 at 14 000 ha, with a target of expanding to roughly 30 000 ha. The park area currently stands at 25 000 ha, of which 20 700 is declared and 4 300 is being processed for declaration. The MPA is 1000 km^2. While much of the land is still owned by other organs of state, the additions and consolidation allow for a more continuous area to be conserved and for management actions and prioritization to be applied consistently across the peninsula.

Due to the close proximity to the City of Cape Town (CoCT) in the north and the ocean in the south, Table Mountain National Park has very hard boundaries and no traditional buffer zone. Working with the City of Cape Town, corridors have been identified as connection routes for both people and animals. Using the Green Belts between urban areas it may be possible to link the entire park via natural areas. The City of Cape Town has developed a BioNet of remaining natural areas (each scored in terms of biodiversity value) within the city on both public and private land. Table Mountain National Park is using the BioNet plans to create corridors for both wildlife and people to access the park.

Research has shown that Erica species are particularly susceptible to drought, while restios are able to use water directly from clouds.

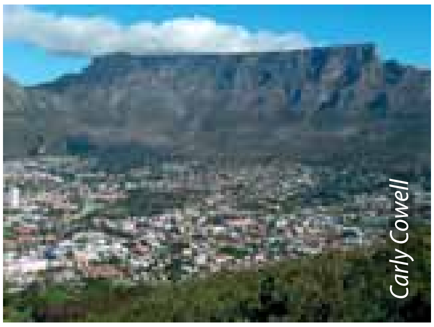
Scenario planning has been suggested as a tool for managers to plan for the full range of potential future conditions. Data collection and expert workshops working in conjunction with park management will be required to successfully model, predict and implement the adaptation and mitigation management options for the future scenarios.

Although much of the park is found in the higher lying areas of Cape Town, predicted sea-level rise as well as storm events could significantly impact on access to the park (e.g. much of the False Bay coastline is at risk).

Rutgers University (New Jersey, USA) saved 7 391 065 sheets of paper in the one semester (equivalent to about 620 trees) by simply changing the default print setting to double-sided. How much could your office save?

Expanding parks is one method to provide species with an opportunity to move and expand their ranges in response to climate change. However, Table Mountain National Park is surrounded by city and sea and many of the species in the park already occur on mountains at high altitudes which does not allow for much space to move to adapt to the changing climate.

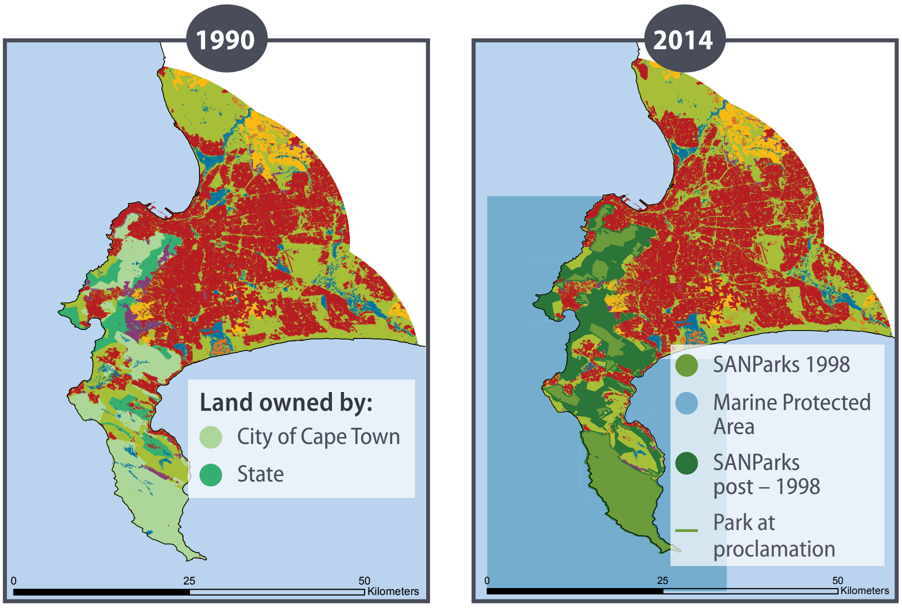
Dense growth of *Acacia* seedlings below eucalypts and pines that burnt in the 2015 fire.



Hard boundaries

Landcover

- Cultivation
- Mining
- Urban
- Plantation
- Water
- Natural
- Degraded



Land-use change on the Cape Peninsula between 1990 and 2014. Table Mountain National Park had not been declared in 1990, but the various owners of state owned-land on the peninsula are indicated in different shades of green on the 1990 map. The growth in the park since declaration in 1998 is shown on the 2014: the park boundary at 1998 is depicted in a light shade of green, while the areas added since 1998 are shown in dark green.

Bark strippers target large trees within the park boundaries and also in the green belts. Illegal bark harvesting has become so wide spread that even young trees that have been planted are stripped and die.

Baboons are protected species on the peninsula – a cooperative effort by citizens on the peninsula was one of the first where the public voiced their collective concern for the protection of a single species. This should be encouraged in other areas of the park and for other species.

Documentary to watch: Bongani Mnisi's lingcungcu 'sunbird restoration project' entitled Stepping stones through fragmented environments: www.caretakers.co.za/films.php.

Interestingly, while the park has expanded, little land-use change has taken place since 1990 in the first 5-10 km from the park boundary, while more extensive urban expansion (41 km^2) has taken place between 10 and 20 km from the park, particularly on the West Coast and the Cape Flats. Within the park itself, the plantations that covered a large portion of the Tokai area have been felled in a much shorter time period than anticipated following a large fire. This means that a large tract of land now requires rehabilitation and follow-up alien clearing (see aliens section).

Management beyond our boundaries: Innovative management will be required in future to encourage and extend conservation into the landscape beyond park boundaries. Ideas include encouraging water wise and indigenous gardens that provide range extensions and corridors for birds, insects and small mammals. Incentives such as free entry to the park or overnight accommodation could be awarded for pro-conservation behaviour such as planting of medicinal plants on pavements (see resource use), use of solar power, households' not requiring waste removal, wildlife in gardens, neighbourhood clean-ups, and indigenous planting.

Disease

M

The parks' significant human wildlife interface could pose increasing risks to both native species and people as the climate changes and opportunities for spreading novel diseases increase. Although disease is currently not a major issue, concern is increasing in light of observed bird, marine and baboon diseases and the threat posed by disease is predicted to increase as climate changes. Plant diseases, often spread via agriculture activities are also of increasing concern, with species like *Phytophthora* already causing some problems on the Agulhas plain, where a study is currently underway to better understand the distribution and strains of the fungus.

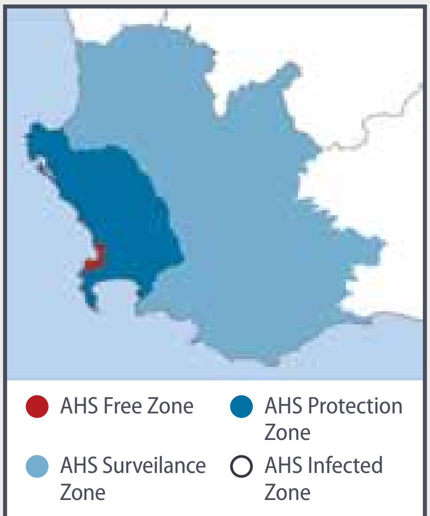
Root rot (*Armillaria* sp.)

Root rot (*Armillaria* sp.), a fungus that attacks large trees and fynbos has been detected in Kirstenbosch and is spreading out of the estate. This disease could cause untold problems not only for the forest species in Newlands and Orange Kloof, but also for fynbos across the park. The disease originated from the introduction of hardwood trees into the Cape for forestry and more recently in stock for the nursery industry. Its spread has been linked to warming climates in other parts of the world and may also be a problem in TMNP.

Although the park falls in the African Horse Sickness (AHS) Free Zone, recent outbreaks in the Protection Zone are cause for concern. AHS has significant implications for movement of all equine species, including zebras. Restrictions placed on equine movement could have detrimental impacts on conservation plans for mountain zebras, but there are also dramatic economic consequences for the Western Cape's flourishing equestrian industry. Due to current export restrictions the country's contribution to the annual global horse export market has a value of approximately R150 000 000, a figure which could be much higher if export of animals were easier. Aside from surveillance for AHS, the only notifiable disease thought to be present in the park is botulism.

Transfer of diseases between people and animals is also a potential concern, in a park with limited space, humans and wildlife are at times in close contact. It is therefore prudent to restrict unnecessary contact between people and sensitive environments.

Link to climate change

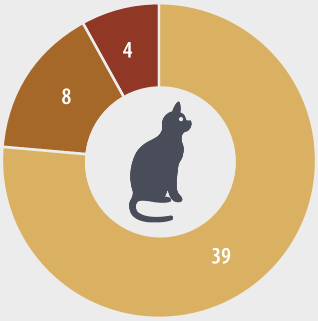


African horse sickness Control Zone

Climate change may influence the occurrence of African Horse Sickness within the control zone due to climatic conditions becoming more favourable for the disease vector (the *Culicoides* midge).

Alien species

Alien Animals present: **51***



- NEM: BA Category 1
- NEM: BA Category 2 or 3
- Species not on NEM: BA

*marine alien species have not been accounted for in this number as the list of species present still needs to be verified

More research is required on alien animals, especially invertebrates as very little is known about their impacts.

Example showing invasion by the Mediterranean mussel (*Mytilus galloprovincialis*) in the mid-zone at St. James Restricted Area.

The recommendation to remove the *Xenopus laevis x Xenopus gili* hybrids from water bodies in Cape Point is being implemented and management is ongoing to protect the genetic integrity of the endemic Cape platanna (*Xenopus gilli*).

Alien Animals

The urban edge is a particular problem for animals, especially cats, while the guttural toad, mallard ducks and the European wasp are also known to spread from urban areas. The impacts of alien animals, particularly invertebrates, are less well-studied than plants, but potentially include hybridization and competition with local species (e.g. guttural toads and Argentine ants), and impacts on people (e.g. the German wasp).

The Argentine Ant, German Wasp, Himalayan Thar and Harlequin lady bird are listed as Category 1 species on NEM: BA and are known to have detrimental impacts.

German wasp (*Vespula germanica*)

The rocky shore and deep ocean waters of Table Mountain National Park are also home to a number of alien species. Thirty-eight species have been listed for the biogeographic region in which the park is found (i.e. the transition zone between the cold west and warmer south coast zones), but the exact number of alien species present in the park still needs to be verified. The majority of introductions in South Africa are via shipping, the petroleum sector, mariculture and aquarium trade. There is however limited research on marine species and their impact on marine biodiversity within national parks. The three most prolific marine invasive species in South Africa are the European shore crab (*Carcinus maenas*), the Mediterranean mussel (*Mytilus galloprovincialis*) and the Pacific barnacle (*Balanus glandula*), all found in the TMNP MPA. Researchers from UCT (Brett Reimers, Charles Griffiths and Timm Hoffman) have documented an increase of these invasive mussels and barnacles in the park which displace indigenous species. The polychaete species *Ficopomatus enigmaticus* is listed on NEM: BA as a category 1b and is present in the zone in which the park is found.

Management of alien fauna to date has been limited to Tahrs, Fallow Deer and Sambar. While there are few formal clearing programmes currently running, where feasible animals are managed on an ad hoc basis. For example, SANParks is collaborating with the City of Cape Town EDRR (Early Detection Rapid Response) team to remove species such as German wasps, while NGOs, community groups, the city and SANParks collaborate on toad research and management.

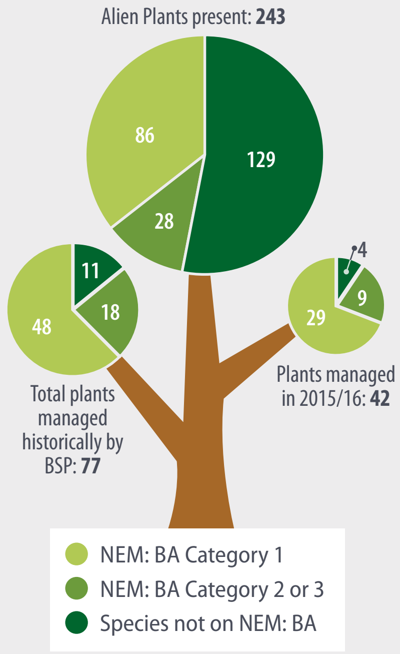
Alien Plants

The park has a long history of invasion resulting from the hundreds of years of human settlement and variety of past land-uses and as a result has the second most documented alien species of any park.

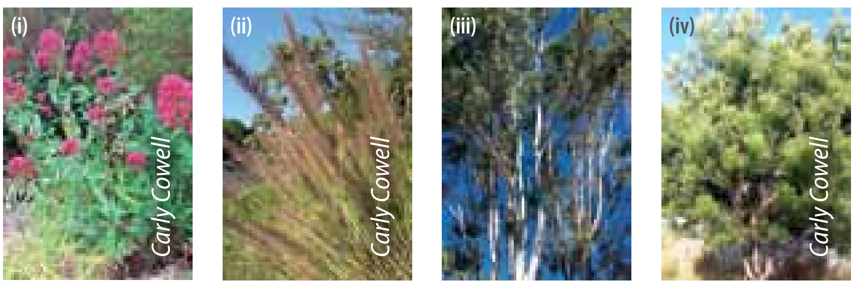
243 alien plants have been recorded in the park or on the peninsula, 86 of these are NEM: BA-listed as National species of concern (category 1), requiring management action. Significant planning will need to go into the implementation of this legislation. Many of these species, including *Acacias*, pines, eucalypts, hakeas and *Pennisetum* are known ecosystem transformers, altering the way in which natural ecosystems function, especially in terms of fire frequency and intensity, soil nutrients, water flow and community structure.

Initial invasive alien clearing between 2000 and 2015, covering over 90% of the park, focussed on non-heritage mostly woody plants, but high altitude areas (requiring rope access) are an on-going challenge.

Where is the Impact? Areas that are currently under greatest threat from alien vegetation include the urban-park edge, as well as historic and current plantation areas such at Tokai, Cecilia, and Newlands. The areas burnt in the fires of March 2015 also require urgent attention if the gains made by previous clearing are to be maintained (see infographic).



For some species targeted, well-planned focus could achieve eradication. The mapping exercise has identified (i) Red Valerian, (ii) Fountain grass, (iii) Eucalyptus and (iv) Hakea as prime targets for eradication from the park.

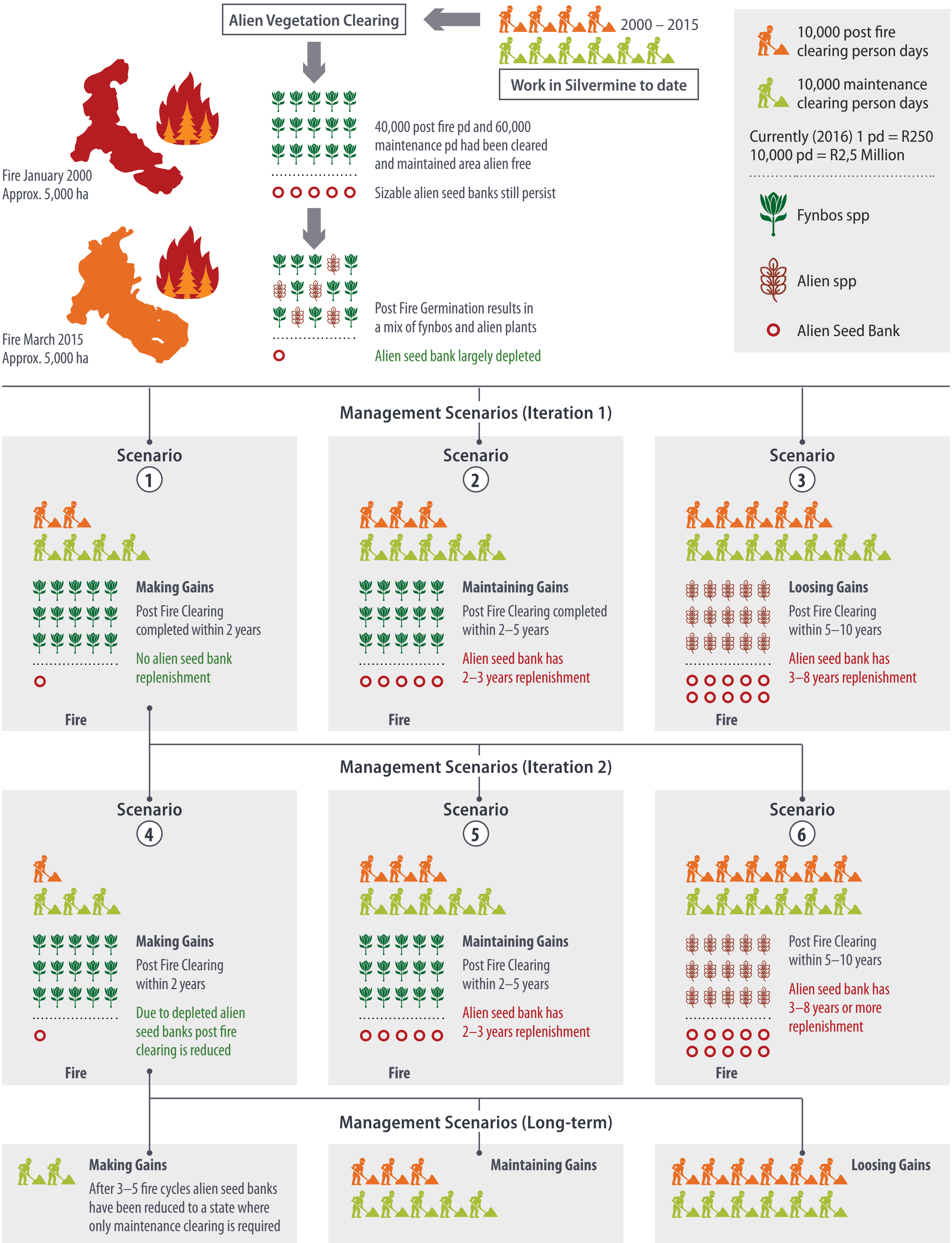


A comprehensive mapping project was undertaken and presence of alien species was mapped in 10 357 plots uniformly spaced across the park. The mapping was completed in February 2015, by which time 220 species had been detected. The outputs provide fine-scale information for prioritization and planning of future clearing.

GO indigenous

Nurseries are beginning to take heed of the NEM: BA regulations. Samgro Wholesalers for example collected all their *Pyracantha koidzumii* (Formosa firethorn, Category 1b) stock from all their retailers and burned it in April 2015 after being informed of its invasive properties and legislative requirements not to trade in the plant.

A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.



The financial, ecological and long-term impact of being able to respond quickly to changing clearing priorities such as following a fire.

Fire stimulates native species to release their seeds to colonise the areas opened up by the fire, but it also stimulates the seeds of alien species that have been released in previous seasons to germinate. The alien species' seed bank gets larger with every year that adult plants are present in an environment, which is not the case for the indigenous species which retain their seed on the adult plant until a fire.

- The former R35 million rand/year budget covered treatment of less than 10% of species present, several of which are not yet under control
- Budgets were cut by more than 40% in 2016 and indications are that budgets will continue to be cut over the next few years, making prioritization essential. This needs to take into account the implementation of NEM: BA, direct impacts on species of special concern and stakeholder requirements
- 114 species are listed on NEM: BA (86 category 1) and will require some form of management. There is a significant shortfall between this number of species and the number typically worked on annually (30 species). Only 14 NEM: BA listed species have been worked on in at least nine of the last 13 years (available collated data)
- External research suggests that if we really want to get on top of the problem, we should focus on even fewer species and clear them properly
- There is currently a high degree of inflexibility in the clearing programme which does not allow funds to be shifted quickly to priority areas (e.g. after a fire), although current and future budget cuts are necessitating revisions to planning
- Operational challenges and delays currently significantly reduce the impact that scheduled clearing operations are able to make, decreasing the value for money spent. For example, the first alien clearing teams for the 2015/16 financial year entered the field four months late and lost valuable time for clearing the regrowth of aliens after the 2015 fires as they could not work in the wet winter months. This could have severe long-term cost implications (see infographic)
- High altitude areas need to be cleared to ensure that gains made in lower-lying areas can be maintained and ensuring that this takes place remains an ongoing management challenge

Aliens burning in Silvermine; Protea seeds released from adult plants after a fire.

The current clearing programme has a large number of inefficiencies. Research into how the impact of the money being spent can be improved is required. In particular, focus on social aspects and the incorporation of monitoring the response of native communities to clearing will be important.

- Alternate models for funding alien clearing that (1) provide longer term employment and (2) retention of people who have undergone training and acquired skills in alien species identification and clearing methods and (3) have clear objectives relating to reduction in alien species cover coupled with monitoring of both alien regrowth and native species response are required to improve the performance of the current programme
- New land being consolidated into the park often has very dense infestations and long history of invasion. Clearing of such areas remains a challenge and novel budgeting methods are required (e.g. negotiating reduced prices for the land to cover alien clearing costs)
- The park boundary needs to be continually monitored for potential new invasions (EDRR). SANBI and the City of Cape Town are good partners in detecting new species and planning should be conducted jointly
- The detailed alien mapping exercise should be repeated at set intervals to assess the impact of revised management actions on containing alien species
- Case studies that demonstrate the positive impacts of alien clearing are essential for ensuring future funding, so care should be given to monitor the response of natural systems after alien clearing

Lower Tokai is one of the last remaining patches of Cape Flats Sand Fynbos that provides a real chance for saving this critically endangered vegetation type from being lost forever. To date, over 14 000 seedlings from threatened Fynbos species have been planted. Six species are already extinct in this area but three of them have been re-introduced and should they survive three generations at Tokai, their status will be upgraded!

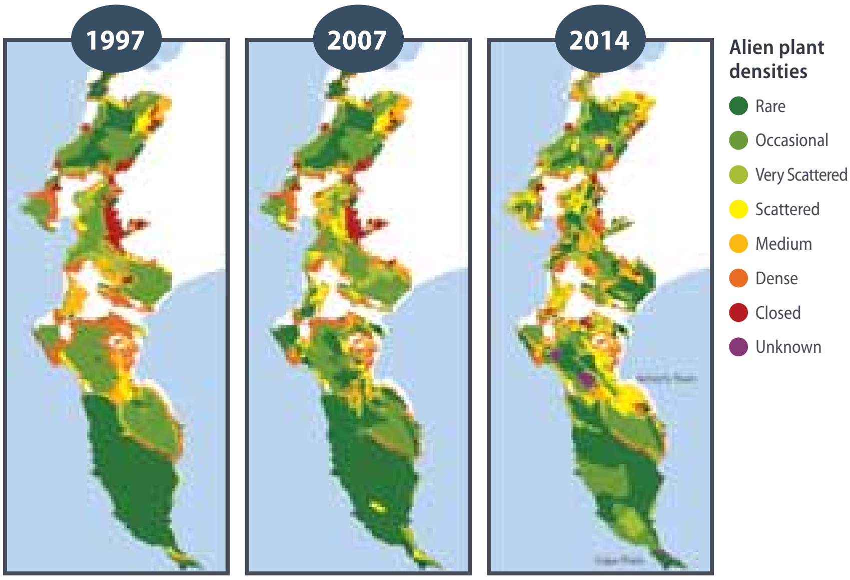
Research by Jasper Slingsby (and SAEON) has shown the impacts of historical invasion by wattles (and *Acacia cyclops* in particular) are still apparent in Cape Point almost 40 years on with plots that formerly had high wattle density having lower species richness. There are clear benefits to removing aliens!

Management of the urban park edge can be tricky, but it is possible! Here a prescribed burn is being conducted. Planned burns form an essential management tool in controlling alien species, keeping fuel loads manageable, reducing fire risk, and rejuvenating old veld to stimulate new Fynbos growth.

In desperate situations, taking Tokai as an example: where no budget was planned for and the situation is set to get out of control in the absence of clearing before alien species set seed, dramatic management actions like burning sections of aliens, where no Fynbos has germinated, again should be considered. This essentially removes the current plants (including the reduction in the seed bank as a result of their germinating) as well as all the seeds they would release over time, from the area.

Growth of alien seedlings in Tokai 2 months and 15 months after the 2015 fire. By June 2016, some of the trees were almost 2m tall and would be ready to release new seeds within 2 years of germinating.

Despite major challenges, the work done to date has prevented Table Mountain National Park from being overrun by alien species (we are estimated to be 50 years ahead of where we would have been without the clearing effort expended to date). In addition, significant progress has been made in some areas, e.g. Simonstown, where the alien species cover has steadily declined since 1997. Cape Point also has very little alien species and continual maintenance ensures seedbanks are depleted as they germinate. For example, Ruth-Mary Fisher and colleagues noted only 1 *Acacia longifolia* seedling across 10 monitoring plots one year after a fire in 2014, testimony to the seedbank depletion.



Impact of alien clearing implemented in Table Mountain National Park since 1997.

Freshwater

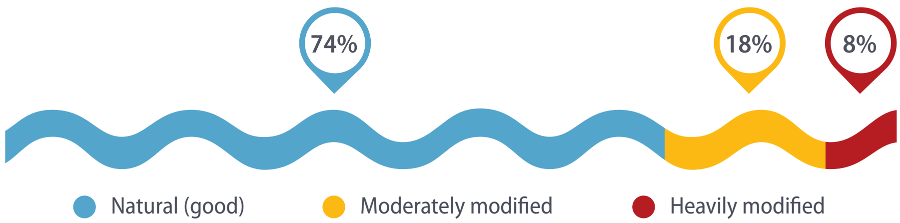
M

QUICK STATS

- Total river length in park: **31km**.
- River Ecosystem types (of 223 in SA): **4**.
- Freshwater Ecosystem Priority Areas: 43% of river length, while **21%** of river length is a fish support area.
- Current monitoring includes (1) seasonal measurement of water chemistry at two sites (300 and 400m above sea level) in each of 12 streams flowing off Table Mountain while (2) River health monitoring sites exist, though these are only visited on an irregular basis by the Department of Water Affairs and Sanitation and City of Cape Town.
- Systematic monitoring is a high priority. The Cape Research Centre (CRC) is in a process of assessing what has been done and what is required in terms of the Biodiversity Monitoring System Freshwater programme and the Park Management Plan. While the CRC can implement biodiversity monitoring, monitoring of water consumption will need to be undertaken by park management under the Responsible Tourism function.
- Detailed wetland data are available for the park through the City of Cape Town.

The components of water quality monitoring

Type of monitoring	What gets measured	Current or envisaged role players
Chemical and physical variables	Temperature, pH, electro-conductivity/salinity, dissolved oxygen and turbidity	Researchers, Cape Research Centre
Biological variables	Macro-invertebrates, fish and riparian vegetation	River health programme, Cape Research Centre
Pollution with faecal matter	*Escherichia coli* and *Enterococcus* bacteria	City of Cape Town
Consumption	Water levels, amount of water used per water use licence	DWS, SANParks Responsible Tourism



Condition of all rivers in Table Mountain National Park (as per the National Freshwater Ecosystem Priority Assessment).

- Assess the gaps in inventorying the wetlands within the area and follow up with the City of Cape Town to conduct fine scale mapping of wetlands
- Assess priorities for monitoring of rivers
- Undertake a water quality review to determine if there is adequate water quality monitoring for the river systems within the Park; and if not to identify the gaps and recommend a monitoring to address these gaps

Under the strategic planning framework (as per the park management plan) the main freshwater management objective is to maintain and improve, where appropriate, the present ecological state of freshwater ecosystems. In order to achieve this, greater understanding and the implementation of comprehensive monitoring of these freshwater ecosystems is required.

Prinskasteel River, Tokai

Because of the many agencies involved in management, in many instances water quality monitoring is not being undertaken as assumptions are made that other departments or organizations are undertaking the work.

- TMNP conserves the source areas of most rivers on the peninsula
- In a review by WWF and the CSIR, the mountainous regions of TMNP were identified as one of the strategic water source areas for the country (i.e. an area that supplies a disproportionate amount of the regional run-off)
- 4 Rivers have River Health Programme sites protected in the park
- Approximately ¾ of rivers in the park are in good ecological condition
- Freshwater aquatic fauna within TMNP particularly the invertebrates is extremely species rich and includes species that are critically endangered

Threats and concerns

- Management of rivers is conducted under the auspices of the Department of Water and Sanitation and therefore issue of water use licences and water abstraction do not require input from SANParks
- There is up to 100% abstraction of water from the Disa River at certain times of the year due to dams on top of Table Mountain
- No ecological reserves have been determined in terms of the National Water Act for rivers where water use licences apply
- There is interest in harvesting fog to supplement water supplies, which could impact on the availability of moisture for ecological processes, especially as the climate starts to change
- Site-level water quality data is generally available for major rivers, but lacking for smaller streams, which are often the last refuges for much freshwater biodiversity. Most of the water quality monitoring is being undertaken by the Department of Water and Sanitation and City of Cape Town. These data were previously kept in the National Rivers Database. There have been problems updating and accessing the database. However, the data for the Western Cape are available through the regional DWS offices in Bellville
- Many of the lower lying areas in Cape Town were covered by seasonal wetlands before urbanization of the Cape. Increased urbanization has increased peak runoff and exacerbated flooding in certain areas, a situation which is predicted to get worse with sea-level rise and an increase in extreme rainfall events under climate change

Resource use

H

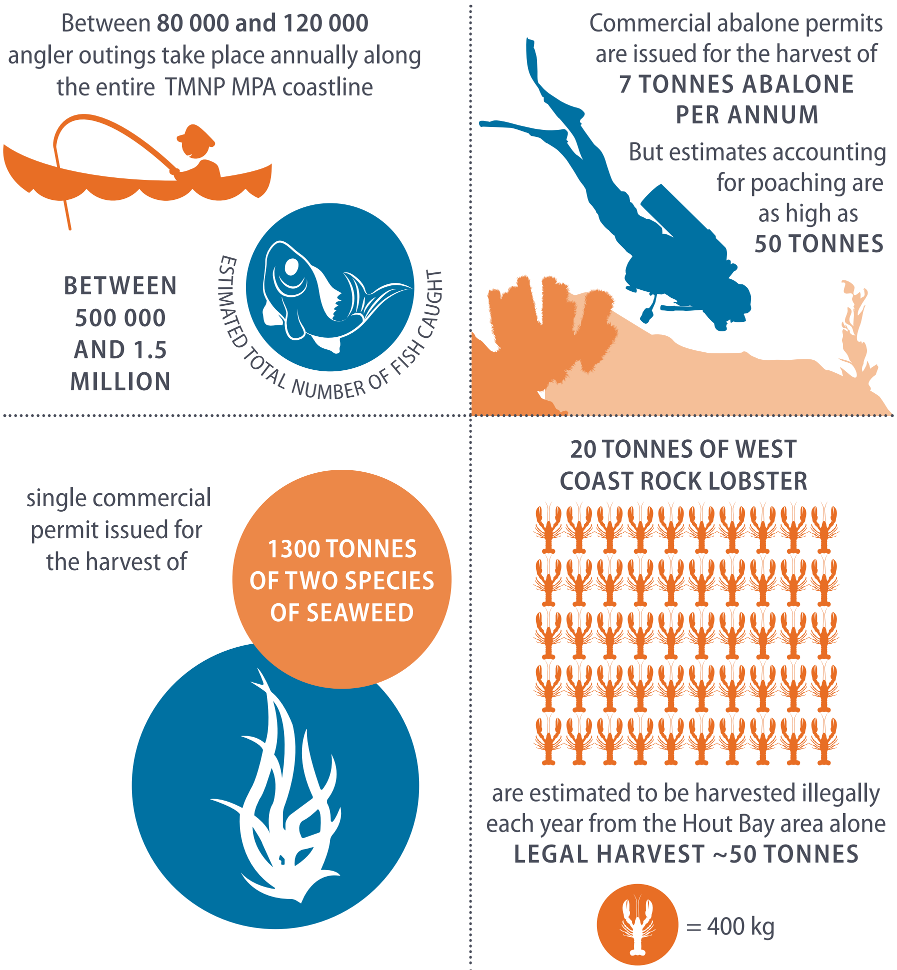
A considerable effort was spent in collating the list of harvested resources from Table Mountain National Park, with more park staff interviewed than for any other park. Interviewed rangers and law enforcement officers were tasked with describing and quantifying all resource use to the best of their knowledge. One hundred and sixty-six resources were documented in this way, which was considerably more than for any other park. Despite the extensive data collection exercise, work by others (see section below) suggests that the number of harvested resources could be substantially larger. The SANParks survey documented 65 marine species, approximately 23 terrestrial animals, including species harvested for food, medicinal purposes and species culled as part of management (e.g. tahrs, sambar, rabbits), over 60 plants, seaweeds, honey, mushrooms and abiotic resources. Harvested plants include sour figs, kooigoed (*Helichrysum* sp.), buchus, cut flowers and species harvested for firewood (mainly alien species). Estimates of harvested quantities are however uncertain. External research indicates that harvest pressure is likely to increase and that additional species may be harvested in the future as preferred options become scarce and resource substitution takes place. There is likely to be increasing pressure on the park for access to resources as well as unauthorised harvesting. Novel methods for managing this challenge will increasingly be required.

There are very few community resource use projects in the park, but harvest permits are obtainable for certain resources. For example, in the past there was an agreement with local farmers and WWF for 22 bee hives to produce honey from the park and 10-15 permits were issued monthly for harvest of buchu hybrids (used for medicinal purposes), which was encouraged to reduce the number of hybrids in the park. Neither of these permits are currently being issued (the hybrids have all been removed). The former medicinal plant nursery was not financially sustainable after external funding expired.

- Species are being used that we are not even aware of
- Resource substitution (harvest of the next best thing once the original resource becomes scarce), is common and places new, previously non-target, species at risk

Nurseries appear to be the solution to plant harvesting but are often not sustainable for various reasons including financial costs in outlay in comparison with returns and access to markets. In some areas, wild grown plants are perceived to be more effective as medicines, although this is not observed everywhere. The parent stock of the plant determines its properties so that plants grown from wild seed may produce high-quality products, but there is more to healing than measurable active chemicals.

In the marine environment, several commercial and small-scale fisheries permits are issued annually. The Department of Agriculture, Forestry and Fisheries are responsible for issuing these permits and allocating catch limits and restrictions, so SANParks does not have complete data on the catches. The estimates that are available are provided in the infographic below:



Roving creel surveys indicate a decline in angler fishing outings and a decline in the number of fish caught. This is however likely an artefact of sampling effort (less interviews conducted, across a smaller portion of the day) than a real trend. An investigation into how comparable estimates can be created needs to be undertaken. Additional metrics such as catch per unit effort can also be incorporated to provide an indication of change in fish stocks over time.

Input from communities on what they want and how to solve the challenge of limited stocks, is paramount. Alternate measures such as providing plant material for users to grow near their homes and perhaps partnering with Kirstenbosch to grow the plants initially, should be investigated.

Work by the Sustainable Livelihoods Foundation

(Leif Petersen and colleagues)

454 species / items are harvested from parks and reserves (within the City of Cape Town the largest area being within TMNP):

250 plants

198 marine & terrestrial animals

6 abiotic items e.g. stones & seawater

Based on survey extrapolations there are approximately **5100** practicing traditional healers in Cape Town, as well as some **10 000** trainees

The economic value of the collective medicinal trade in the Western Cape is estimated at **R 180 million/year**, with the contribution of CFR products estimated at **US $6.9 million/year**

Approximately **279 tonnes** of biological material are harvested annually from the City of Cape Town for use in traditional medicines

The significant scale of harvest is concerning. At Tygerberg Nature Reserve alone (almost 1/10th the size of TMNP at 300ha), **9936 bulbs of *Tulbaghia capensis* (wild garlic)** were confiscated during working hours from unauthorised medicinal harvesters over an 8 month period in 2010 (Law Enforcement Records from Penny Glanville, CoCT)

Reasons for harvest include treatment of ailments, but also witchcraft that supports illegal activities, for example:
So I don't get caught when I'm driving around without a License
If you do something wrong, the police chase you and you want to come out, then you must use uphuncuka

While the problem of unauthorised harvesting seems insurmountable, the sidewalk medicinal gardens create some hope. SANParks should co-investigate (with local communities) initiating similar projects in certain high use areas. Other alternatives include mapping of common species that have medicinal properties and then trialling harvesting projects and monitoring the impacts. Areas of compromise between conservation and harvest might exist in degraded areas, where some species are common and impact on non-target species could be minimized. CapeNature is investigating similar solutions and there are opportunities for collaboration.

A successful project has been initiated by the Sustainable Livelihoods foundation where conservation managers and bush doctors have collaborated to plant indigenous and medicinal species along road verges and public lands. Nearly 4000 plants have already been planted, the gardens are being used, they attract animals such as chameleons and create a great place for sharing knowledge and stories across boundaries that would otherwise have been difficult to cross. The project has created links between very different groups of people and enabled much better understanding of their diverse perspectives, while at the same time serving both biodiversity and people. For more information, visit: http://livelihoods.org.za/projects/herbanisation

Neville van Schalkwyk, bush doctor, at his sidewalk urban medicinal garden.

For resprouting species, cutting the tree down at the base after it has been ring-barked can save the plant as it will resprout again from the base. Examples of this kind of species include Boekenhout/ Cape beech (*Rapanea melanophloeos*), a species which is targeted in the park.

Bark stripping in Tokai for medicinal use. In this instance this is an alien species, but bark of many endangered indigenous trees is stripped in Newlands forest with potentially devastating consequences.

- Information on harvest quantities of medicinal plants and food items (including marine species) is urgently required to enable proactive and informed management
- The distribution of common species with either medicinal or food value should be mapped to determine potential for sustainable use as well as the impact of harvesting if implemented
- Long-term monitoring of certain endangered species needs to be set up (for example trees in Newlands forest)

- An up-to-date register of unauthorised harvesting incidents, including information on the species and quantities involved should be maintained
- Routine monitoring should be set up for the most widely used species such as *Helichrysum* sp., *Tulbaghia capensis*., *Agathosma* sp., *Cissampelos capensis, Lessertia fruescens, Aristea africana, Haemanths* sp. and *Chironia baccifera*
- Alternatives to wild harvest need to be discussed with communities and appropriate benefit sharing projects initiated

Top: *Aristea africana, Agathosma sanguineus* and *Agathosma serpyllacea* (research by Lisa Philander and colleagues indicates that these species are unsustainably harvested in the Western Cape). Bottom: *Haemanths, Chironia baccifera* and *Tulbaghia capensis.*

TANKWA-KAROO
NATIONAL PARK

The Tankwa-Karoo National Park was initially proclaimed in 1986 to protect an area of Succulent Karoo as one of 25 biodiversity hotspots throughout the world. The region has been used by nomadic San hunter gathers and livestock farmers for thousands of years and agriculturalists more recently. Old cultivated fields are found scattered all along the floodplains that drain into the Renoster River, with canals and dam walls constructed in order to assist with flood irrigation. Much of the land is degraded and is vulnerable to erosion. This may be exacerbated by it being an open access park with two public roads leading from Ceres to Calvinia and Middelpos (the R355 and P2250) cutting through the Tankwa-Karoo. The park covers an area of 146 715 hectares and is still in a stage of expansion, consolidation and development. The current broad plan and strategic framework need to be constantly updated and refined as new information on plant communities, species distribution, ecosystem patterns and processes such as riverine corridors, edaphic interfaces, upland-lowland gradients and macroclimatic gradients, become available.

Climate change

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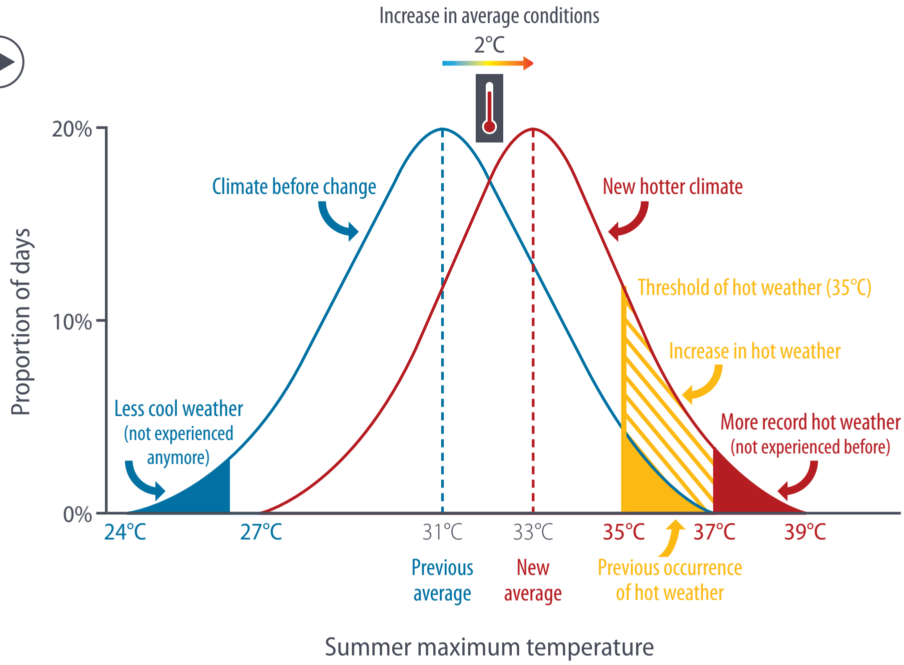
Temperature

Only 24 years of temperature data were available (from the Agterkop station), but no significant annual trends were identified from this short record. Increases in mean annual temperature of between 1.4°C (best case), 1.9°C and 2.5°C (worst case) are predicted for the area by 2050. While the predicted increases seem small, we have demonstrated the effect that a 2°C increase would have on the relative proportion of days above 35 degrees for a hypothetical park where average summer maximum temperatures are about 31 degrees (similar to the current averages for Tankwa-Karoo; see figure on p. 170). The effect of a 2.5°C would be even more dramatic, and under this scenario over a third of summer days in Tanka-Karoo would be likely to reach 35°C.

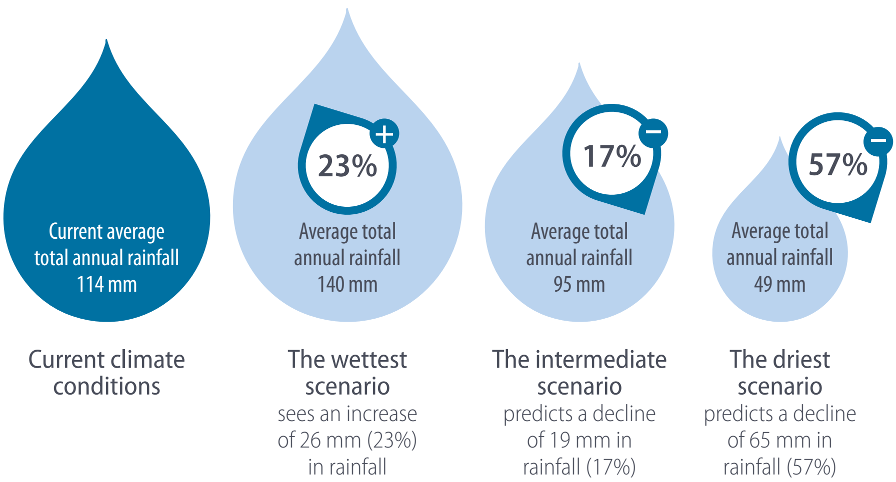
Increases in annual average temperature of between 1.4°C (best case), 1.9°C and 2.5°C (worst case) are predicted for the area by 2050.



This figure shows the number of summer days reaching between 24°C and 39°C for a hypothetical situation where the historical average maximum summer temperature was 31°C, compared to the range of summer temperatures if average conditions increased by 2°C. Under the previous climate there would be an average of 4 days per summer that get to 35°C or hotter and it would never get hotter than 38°C, whereas there are about 17 days over 35°C under the new climate that has warmed on average by 2°C and 3 days reach 38°C or more – conditions not experienced under the previous climate.

Rainfall

No change in overall rainfall could be detected in the historical rainfall record for the past 77 years at the Calvinia station, but the number of consecutive dry days appears to have increased. At the time of data collation there were no stations in the park; Calvinia is 80km away from the park and at a different altitude.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. The range future scenarios are quite variable and it is not yet clear which of these is most likely, although drying is more commonly predicted for the western parts of South Africa. Planning for a variety of different possible futures (scenario planning) is therefore recommended. These scenarios also do not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of smaller steadier rain events).

Possible biome changes

No major changes are predicted in the distribution of Succulent Karoo biome in this region as a result of climate change by 2050, although small areas are predicted to become more desert like under the driest scenario.

Observable changes based on historical repeat landscape photos, indicate that the Tankwa-Karoo Plains have experienced a slight increase in grass cover (*Stipagrostis* sp.), succulent shrubs such as *Augea capensis* as well as shrubs such *Lycium* sp., whereas there appears to be greater stability in the escarpment vegetation types.

Photos taken at the same location in 1992 and in 2013 showing an increase in vegetation (grass, succulent and shrub) cover in the Tankwa plains. The Cedeberg Mountains can be seen in the background.

Photos taken at the same location in 1992 and in 2013, showing more stable vegetation cover in the escarpment area of the park.

SANParks has an important role in educating public about the importance of greener lifestyles.

Reducing waste and increasing opportunities for recycling are also critical.

Tankwa-Karoo can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

The substantial expansion of the park includes a significant aridity and altitudinal gradient. This creates important corridors (pieces of land that species can use to move between habitats), forming part of a vital climate change adaptation strategy, that along with the maintenance of the partnership with the Greater Cedeberg Biodiversity Corridor allows for conservation of a key transition zone between the Fynbos and Succulent Karoo biomes.

Tankwa-Karoo was the first park to include climate change in its management plan.

For the western areas of the park, the climatic conditions could more closely resemble those associated with desert by 2050. In this instance, game numbers may have to be reduced or allowed access to only the western section during the winter season. Water points should not be opened in these areas as they may cause unnecessary degradation of the arid areas.

Sheep farming in the buffer area around the park, looking towards Middelpos.

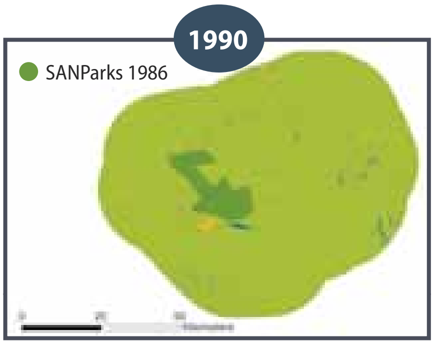
Land-use change

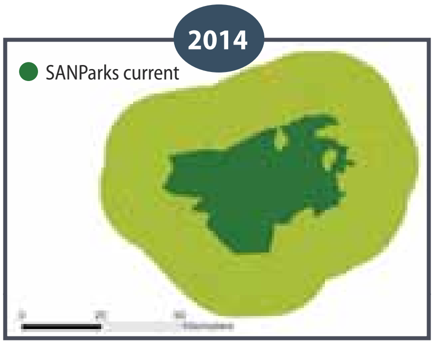
H

The main land-use in the area surrounding the park is livestock farming, and the vegetation is largely natural. No major changes in formal land-use are detectable in a 20 km radius of the current Tankwa-Karoo park boundary according to the land-cover images for 1990 and 2014. The park itself has however expanded by 120 000 ha since the proclamation of the original farm in 1986, to its current size of almost 150 000 ha. Since 2005 this expansion has incorporated many livestock farms near Paulshoek, Gannaga pass as well as Varschfontein. Only a very small portion of the land in the surrounding 'buffer area' is used for formal cultivation and the extent of this cultivation up to 20 km from the current park boundary has decreased since 1990 by 8 km^2 (16%).

Landcover

- Cultivation
- Mining
- Urban
- Plantation
- Water
- Natural
- National Park
- Park at proclamation





Expansion of the park since 1990 and surrounding land-use showing minimal change.

Disease

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Disease is not thought to be a major driver in the area and human and livestock densities in surrounding areas are low, with low risk of transmission. The status of plant diseases is however unknown. Botulism is the only notifiable disease thought to be present in the park.

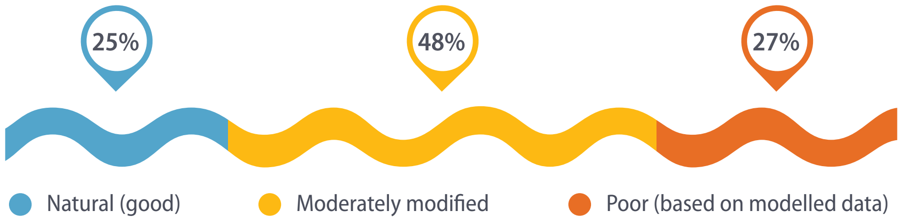
Freshwater

M

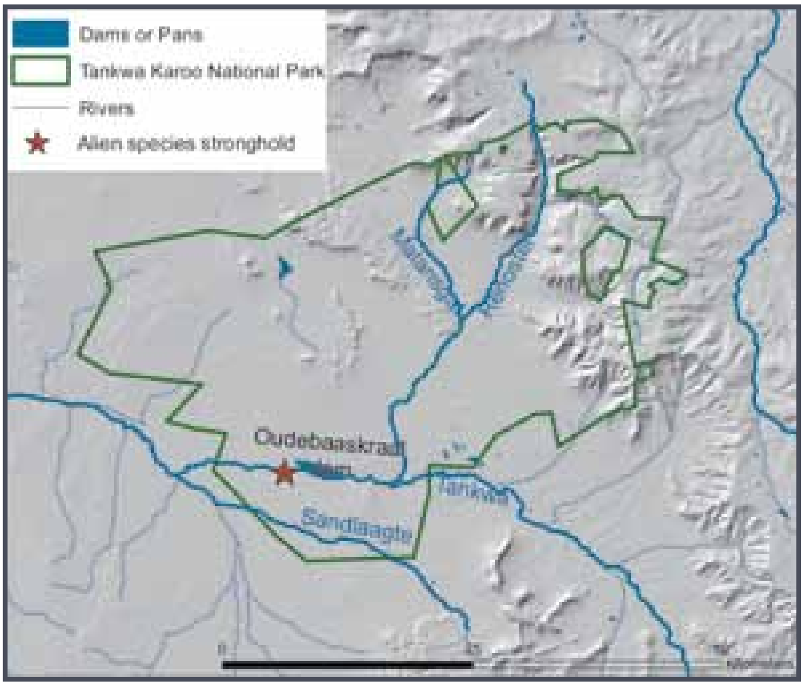
This wetland near Platfontein is an example of a groundwater-fed wetland that supplies permanent water, supporting life like this Cape River frog (*Amieta fuscigula*).

QUICK STATS

- Total river length in park: ~**145 km**
- No rivers flow permanently
- River Ecosystem types (of 223 in SA): **6**
- River length in good condition: **25%** (remainder moderately modified, 48%, or poor condition based on modelled data, 27%)
- Freshwater Ecosystem Priority Area (FEPA): **16%** of river length (a further 22% would qualify as FEPA if modified condition restored)
- Based on recent field surveys (2013 and 2014), Tankwa-Karoo contains several small spring-fed wetlands, a number of large seasonal pans and man-made dams.
- **33** alien species (**27** plants [**13** on NEM: BA 1b] and **6** animals have been recorded in the park
- The NFEPA wetland ground-truthing started in 2013. Park management assisted Scientific Services with locating most of the wetlands. The NFEPA maps showed areas mapped as Channelled Valley-Bottom towards the southeast of the park. The ground-truthing showed that the area had mostly terrestrial vegetation with no wetland plants found. Soil still needs to be tested to see whether it is a wetland or not. The ground-truthing will be completed by 2017

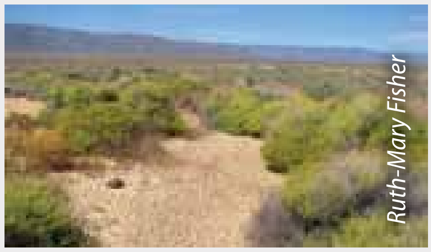


Condition of all rivers in Tankwa-Karoo National Park (as per the National Freshwater Ecosystem Priority Assessment).



The flow of the rivers through Tankwa-Karoo National Park, showing the position of the Oudebaaskraal Dam, where mesquite (Prosopis sp.) remains a problem.

- The Renoster River should be rehabilitated via neutralization of old agricultural structures that diverted water
- Future park expansion should seek to include the entire Renoster and Sandlaagte river catchments
- Mesquite (*Prosopis* sp.) should be ring-barked in combination with herbicide treatment in spring for maximum effectiveness
- Negotiations for park expansion to include properties upstream of the Oudebaskraal dam in the Tankwa River are currently underway. A fish survey of the Oudebaskraal dam in 2011 showed that the endangered Clanwilliam sandfish (*Labeo seeberi*) and Clanwilliam yellowfish (*Labeobarbus capensis*) were not found in the dam. It was recommended that the upstream reaches of the Tankwa River also be surveyed for possible populations there. If found, the inclusions of the new property will aid in the conservation of these species
- Sustainable access to groundwater is a fundamental consideration influencing future development of Tankwa-Karoo as a tourist destination
- The Sandlaagte River is important for its provision of natural flow and sediment pulses to the downstream free-flowing Doorn River



Area mapped as Channelled Valley-Bottom wetland by NFEPA. The ground-truthing revealed that the area had more terrestrial vegetation with no wetland plants. Soil testing still needs to be done to confirm whether it is a wetland or not.

- An inventory of wetlands needs to be finalised for Tankwa-Karoo to contribute to the revision of the FEPA maps
- Some of the parks' wetlands are springs (classified as Depressions) fed by groundwater sources. Further research on the groundwater/surface water interaction is needed to understand the persistence of these systems and to aid management.

Oudebaaskraal Dam poses a challenge to the hydrological connectivity and associated ecological processes of the Tankwa River as well as the downstream Doring River which is a flagship free-flowing river. However the dam also provide some tourism benefits.

- A detailed groundwater hydrocensus for the Tankwa area is currently being undertaken by Department of Water and Sanitation in collaboration with SANParks which should contribute to a more systemic understanding of water resources
- Malansgat and Sandlaagte Rivers are Freshwater Ecosystem Priority Areas
- The main alien animal problem was goats, but these have been effectively managed and it is likely that their impact will decrease
- The upper Tankwa and Renoster Rivers have been identified as genetic refuge areas for the Clanwilliam sandfish (*Labeo seeberi*) to be established via re-introductions. The dam will act as a barrier to genetic contamination of the upper parts of the river

Alien species

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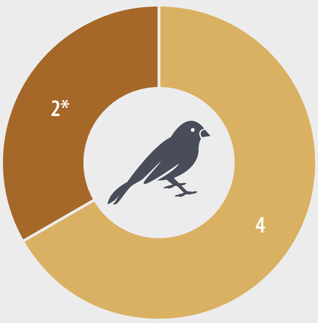
Alien Animals present: **6**

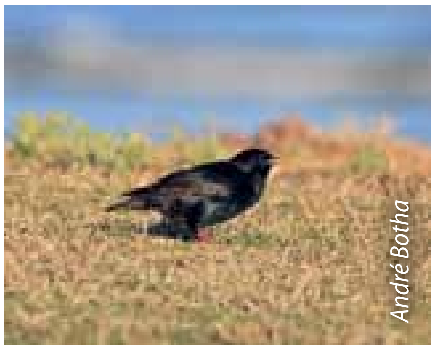


NEM: BA Category 2 or 3
Species not on NEM: BA
*house sparrow and European starling

Animals

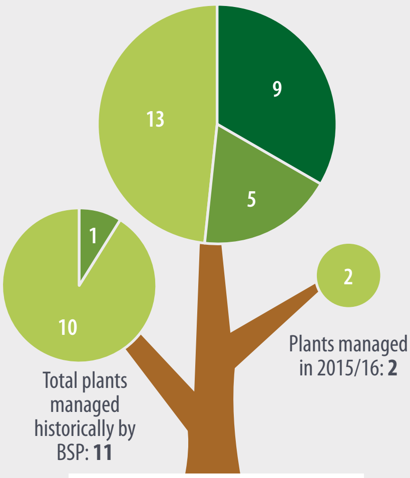
Alien animals present are the house sparrow (*Passer domesticus*), European starling (*Sturnus vulgaris*), the extralimital hadeda (*Bostrychia hagedash*) and guinea fowl (*Numida meleagris*), feral cats and goats. Where present around old farm buildings and staff housing, feral cats are a concern because they can hybridize with African wild cats. The population of feral goats appears to have declined and management actions are being taken to control the remaining animals.

House sparrow (*Passer domesticus*)



European starling (*Sturnus vulgaris*)

Alien Plants present: **27**

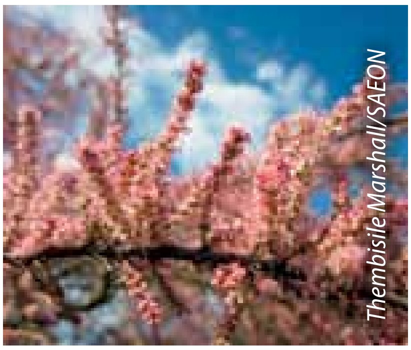


NEM: BA Category 1
NEM: BA Category 2 or 3
Species not on NEM: BA

A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

Plants

- While most alien species are under control, mesquite (*Prosopis* sp.) remains a problem along rivers. Initial clearing is still required in several areas. Coppicing is also a problem below the Oudebaaskraal dam, where herbicide treatments have not been successful
- Pink tamarisk (*Tamarix ramosissima*) is an emerging alien (120 ha currently invaded) and Mexican poppies (*Argemone* sp.) appear to be invading cleared areas. These species are NEM: BA listed and legally require control



Pink tamarisk

Mexican poppy

All known rooikrans (*Acacia cyclops*), American aloe or century plant (*Agave americana*) and creeping prickly pear plants (*Opuntia humifusa*) have been removed from the park. Monitoring to ensure that these species do not return after fire or disturbance or spread into the park from elsewhere will be required.

Resource use

No unauthorized use of natural resources was reported for Tankwa-Karoo in an initial survey. The park reported use of only abiotic resources and one alien species. Being relatively isolated, the plant and animal populations far from roads are relatively safe. However, field observations in Paulshoek noted several *Hoodia gordonii* plants had been harvested in the veld and next to the road. *Hoodia gordonii* is a sought after succulent species and has undergone a decline since 2001 as a result of harvesting for its appetite suppressant characteristics. Research on population recovery, post harvesting and degree of impact of the harvesting is required for this species. The park's largely open access nature with public roads running through it mean that sought after species are vulnerable to exploitation. In addition to resource harvesting, there are reports of illegal hunting of game species and anecdotal evidence of livestock grazing in the park. Engagement with neighbours and fencing options are being implemented to rectify this problem.

Groundwater is extensively used for both human consumption and game. Various boreholes are found within the park, some still in use and others not, as reported in the groundwater census undertaken by DWS and SANParks during 2013.

The use of boreholes, (i) an old borehole not in use, (ii) borehole for watering game and (iii) borehole for human consumption.

Freshwater in the landscape: Historically people settled where water was available. This wetland at Prambergfontein shows the ruins of an old homestead.

Fracking and other mining constitutes a threat throughout the Karoo and there is an increase in mining applications for a variety of resources.

SHALEGAS DEVELOPMENT (SGD)

The parks affected by SGD are Tankwa-Karoo, Karoo, Mountain Zebra, Camdeboo, Golden Gate and Mokala and possibly Addo Elephant.

In July 2016 during a stakeholder meeting Dr Bob Scholes from the CSIR presented key findings in a Research report on Shalegas Development (see http://seasgd.csir.co.za/scientific-assessment-chapters/). Some of the key threats identified are:

1. There is no water in the Karoo for fracking. The available water has been allocated for human consumption and agriculture. If fracking were to take place, water will need to be brought in, either from the sea or deep level groundwater that is not suitable for human consumption. Extracting this water may pollute and contaminate the scarce water sources that are available via leaking gas along the pipeline, spillage from the storage of fracking fluid and possible contamination of groundwater sources when fracking fluid is extracted from the boreholes to be used again.
2. Air pollution from SGD has a high risk to the health of workers, although the threat to the environment is lower.
3. While shalegas produces half the greenhouse gasses that coal mining does, it produces methane gas that is a much more harmful greenhouse gas that significantly contributes to climate change. Emissions from the gas processing plants are also a concern.
4. There are usually increased tremors with SGD, but the Karoo has a relatively low earthquake risk.
5. The main source of hazardous waste is the fracking fluid. The fracking fluid consists of water and several additives, some of which are toxic or hazardous and pose serious health risks. Several tens of millions of litres of fluid are stored temporarily in tanks on the surface at each wellpad.
6. The Karoo is rich in biodiversity and has high endemism. A major threat of fracking is that it would fragment the landscape. The mitigation would be to not allow fracking in sensitive areas and to define what activities can take place in specific areas.
7. The main air pollutants from SGD include nitrogen oxides (NOx), volatile organic compounds (Vocs), and particulate matter (PM). These can have negative impacts on human respiratory health issues (i.e. asthma, lung diseases and premature death).
8. SGD would impact on the sense of place, visual, aesthetic and scenic environment.
9. SGD might influence the Karoo's flagship Square Kilometre Array (SKA) and cause electromagnetic interference with the SKA.
10. SGD will impact on spatial planning and infrastructure: Town planning needs to change, municipal services need to be upgraded, and housing and road infrastructure would need to be provided.
11. SGD development will have large-scale economic and social impacts on the local communities. Job creation and infrastructure development might initially be promising, however after the initial 'boom' period jobs are unlikely to be secure in the longterm.

WEST COAST
NATIONAL PARK

West Coast Honorary Rangers

Nicola van Wilgen

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The West Coast National Park (~31 700 ha, plus ~15 600 ha of Marine Protected Area) provides protection for critical elements of marine, wetland and terrestrial biodiversity. The offshore islands provide breeding sites for a number of threatened bird species: Langebaan lagoon is a Ramsar wetland site of international importance due to the large number of migrant birds which spend the summer in the area and 32% (by area) of the South Africa's salt-marshes are found in the lagoon. The terrestrial area of the park makes an important contribution to Strandveld and Sand Fynbos conservation, vegetation types which are threatened by agriculture and housing developments.

Industrial developments in very close proximity to the park as well as other elements of global change pose serious threats to the long-term persistence of the habitats and areas currently conserved. The most pertinent threats include expansion of the Saldanha harbour and associated industry and traffic, increased mining applications directly on the park border and changes in fish stocks as a result of ocean circulation changes and overfishing.

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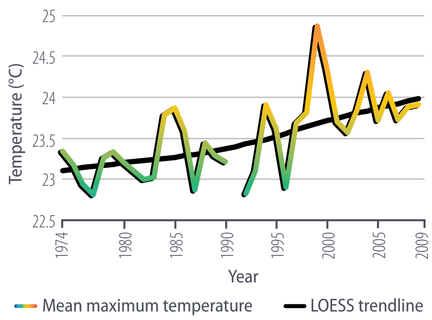
Terrestrial climate change

Terrestrial **H**

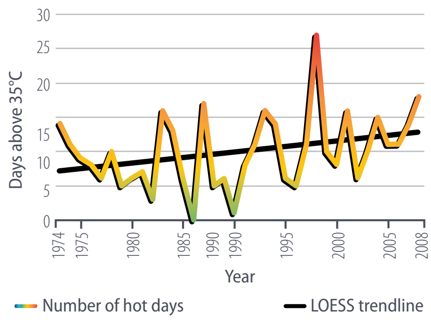
Temperature

Between 1973 and 2009 average minimum temperatures measured at the Langebaan station increased by 0.5°C, while average maximum temperatures increased by 1°C. As a result, there are an average of 6 more days in a year where temperatures get hotter than 35°C than there were in 1973. Further increases of between 0.9°C (best case), 1.4°C and 1.8°C (worst case) are predicted by 2050.

For West Coast, the biggest climate change impacts in the near future will be the effect that increased temperatures will have on the fire danger index. Hotter, drier conditions may lead to more frequent fires which will have negative impacts on species diversity as the Strandveld system is not adapted to frequent fires (the typical fire cycle is 50 years) like other parts of the Fynbos biome.

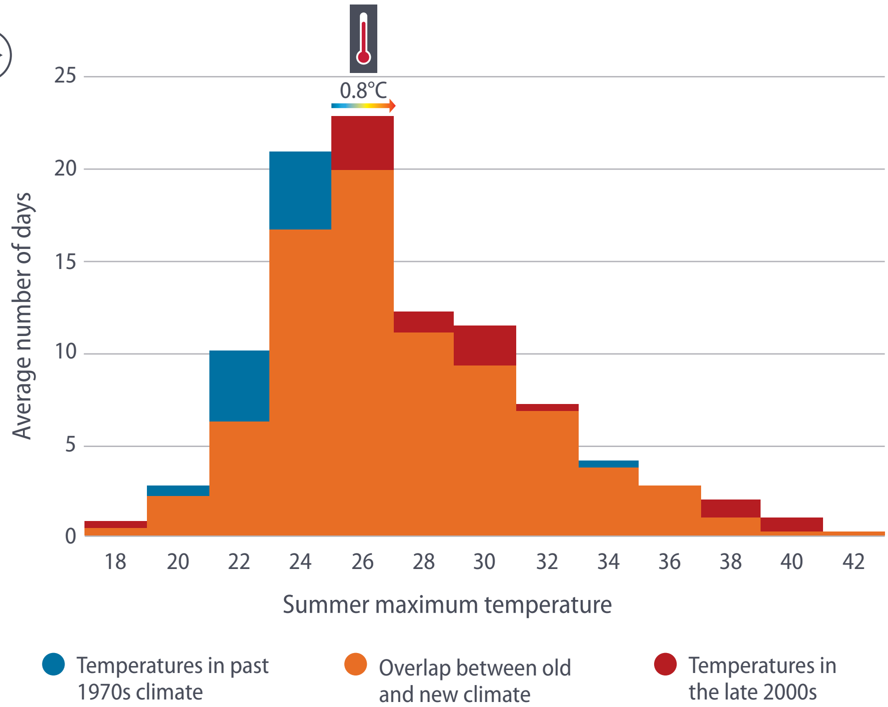


Annual average maximum temperature at Langebaan since 1973, showing a significant increase.



The number of days per year that reach 35 degrees or more at Langebaan, showing a significant increase. An increase in days above 35 degrees will result in more days with high fire risk and will exacerbate conditions for plants and animals during drought times.

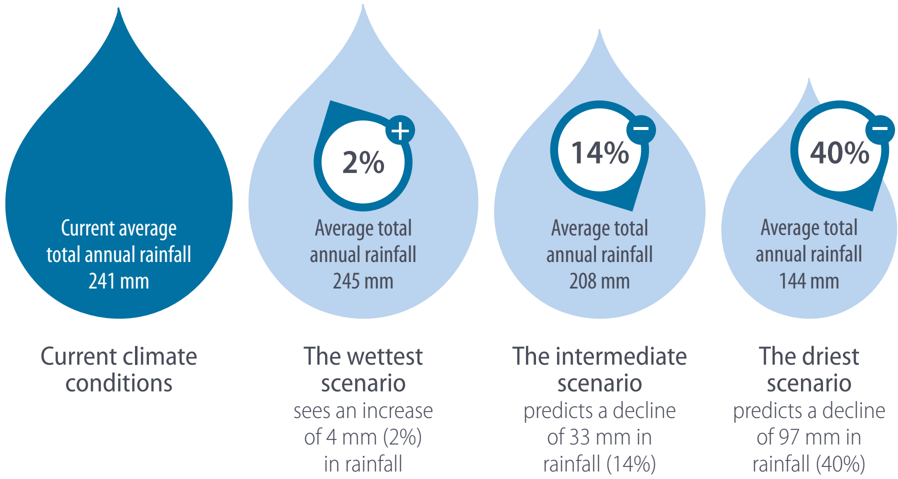
Further increases in mean annual temperature of between 0.9°C (best case), 1.4°C and 1.8°C (worst case) are predicted by 2050.



The average number of summer days reaching between 18°C and 42°C at Langebaan in the past (1974–2005), compared to the late 2000s (2005–2009), showing how an average shift of less than 1°C impacts on warm extremes. There are now an average of 10 more days in summer hotter than 25°C than there were in the 1970s. This effect becomes even more dramatic as the change in temperature gets bigger, especially in areas where temperatures are naturally hotter than the West Coast (e.g. where average summer temperatures are 30°C and above, the occurrence of very hot day, 35°C+, increases sharply).

Rainfall

No changes were detected in the historical rainfall record although only 37 years of data were available, which is too short a time to detect long-term rainfall changes.



This figure shows how climate change may impact on current rainfall totals, represented here by agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. None of the scenarios predict any major increase in rainfall and therefore some degree of drying along the West Coast can be expected. Also note that the above range of predictions does not include how predictable rainfall is likely to be. General climate change predictions are for more erratic rainfall (high in some years, low in others, or more infrequent but heavier rainfall downpours in place of smaller steadier rain events).

Possible biome changes

The predicted changes are not as severe as changes predicted for parks in other parts of the biome and no major changes in the distribution of Fynbos biome extent are predicted in the region of the park by 2050 under the intermediate scenario, although under the high risk scenario, climatic conditions throughout the park will resemble conditions associated with the Succulent Karoo. Contraction of the Fynbos biome as a whole is predicted, making it all the more important to put adequate conservation measures in place in the regions that are predicted to be slightly more stable over time. Additional concerns include the impact that higher levels of carbon dioxide currently present in the atmosphere (which 'fertilizes' plants) will have on alien species. CO_2 fertilization is expected to benefit plants that use type C3 photosynthesis, which includes many of the alien grasses and all woody species. As a result alien species may spread more rapidly to previously unoccupied sites.

SANParks has an important role in educating public about the importance of greener lifestyles.

Reducing waste and increasing opportunities for recycling are also critical.

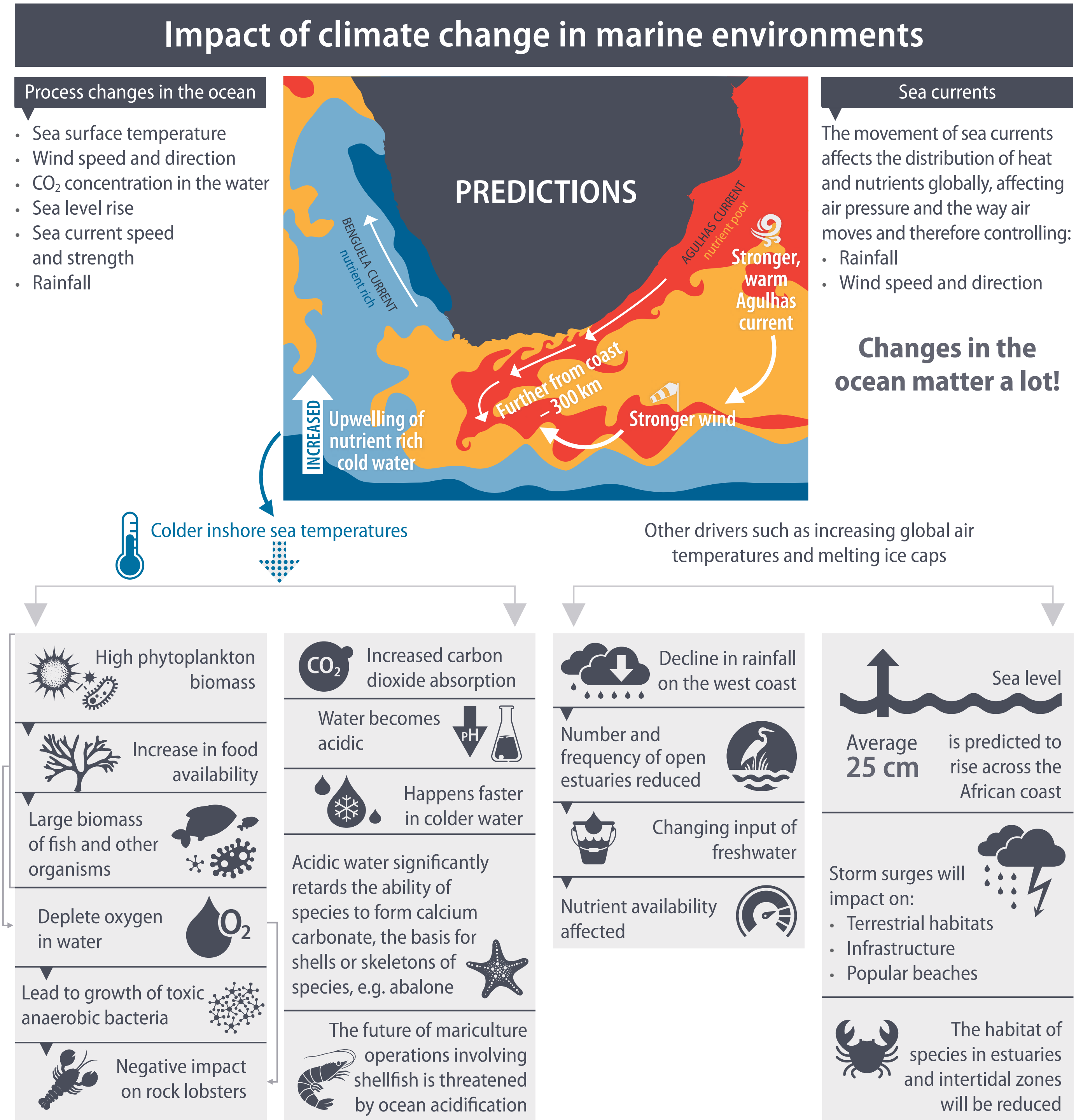
West Coast can save water and electricity in a number of ways including use of low flow toilets, rainwater harvest and tourist and staff awareness programmes.

Appropriate signage for tourists can increase awareness and support for water and energy management changes.

Actions to make a difference

Scenario planning has been suggested as a tool for managers to plan for the full range of potential future conditions. Data collection and expert workshops in conjunction with park management will be required to successfully model, predict and implement the management options for the future scenarios.

Impacts of climate change in the marine environment, including marine resource use



The nature and impacts of climate change in the ocean are complex and difficult to predict. The impacts are, however, expected to be profound. The cold, nutrient rich, Benguela current runs up the West Coast of South Africa, while the warm, nutrient-poor, Agulhas current runs down the east coast. A stronger warm Agulhas current would result in wind changes that increase the upwelling of nutrient-rich cold water. In fact, the inshore sea surface temperature along the West Coast has been observed to be getting colder due to this and related processes. These two currents have major impacts on the circulation of heat and nutrients in the oceans globally. They also affect atmospheric pressure systems that determine air movements, rainfall, wind speed and wind direction. Therefore any changes in temperature and chemical composition of the water in these currents can change the way in which they flow and the dynamics of associated wind and rainfall over the oceans and adjacent land. Current observations and generic predictions for the South African coast include a cooling west and south coast and a warming east coast. These changes in turn have profound impacts on the distribution and life cycle of species dependent on the oceans, and therefore also on people and animals that rely on these marine resources.

Potential impacts

The distribution of a marine species is determined largely by two things: its tolerance of the ocean temperature and its ability to move. Many species rely on ocean currents to transport spores (e.g. kelp) or larvae (barnacles), while others can simply swim.

Fish are particularly susceptible to temperature change as their body temperature changes with changing surrounding temperature, affecting the way they function physiologically, as well as the probability of egg and larval survival. Water temperature also controls reproductive cues in many species (e.g. seabream (*Lithognathus aureti*) do not spawn when temperatures are above 20°C). For some species, the new conditions may be too cold (e.g. snoek (*Thyrsites atun*) and sardines (*Sardinops sagax*)), while others (e.g. anchovies (*Engraulis capensis)*) may shift their distribution to the south coast as the cold current and upwelling move towards the Agulhas bank. Anchovy distributions have already shifted southwards several times in response to changing wind speeds and associated sea temperatures. In areas getting warmer, water has less ability to hold dissolved oxygen, which has further negative impacts on species with higher oxygen requirements and is expected to impact first on migratory species.

Shifting fish distributions have significant impacts on the bird species dependent on them. Recent shifts in sardine and anchovy stocks towards the south coast have had particularly dramatic impacts on west coast penguin populations. The survival of the important breeding colonies of several bird species on the west coast islands is a key concern as fish species move in response to changing sea temperatures, nutrients and ocean currents.

Although fish are likely to be the most tolerant of marine organisms to ocean acidification, eggs and larvae can be affected and some species may experience problems with skeletal formation that in turn affect behaviour. Rock lobsters will be particularly at risk, as will the mariculture industries that are based on shell-forming organisms such as abalone, mussels and oysters.

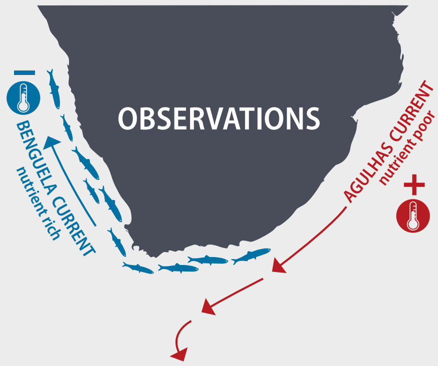
Species that rely on estuaries for breeding are expected to decline with declining rainfall. These include up to 85% of South Africa's line fish and commercial and sein-net catches.

Resource use

Marine **H** Terrestrial **L**

Marine resource use

Langebaan Lagoon is one of the oldest traditional small-scale fisheries in South Africa. Forty-two marine resources are currently known to be harvested from the marine protected area. The main user groups include local community (small-scale) commercial operators and recreational fishermen. Larger scale commercial operations, focussed on stocks such as sardines, snoek and anchovies are concentrated outside of the lagoon and MPA. Traditional fishing included the use of beach seine and later gill-nets to target harders (mullet). Fishing within the lagoon is however contentious. The lagoon was zoned in 1969 with the aim of protecting traditional fishing communities from increasing pressure resulting from recreational angling. However, the zonation currently works against these traditional communities, criminalizing fishing within the historical zones and increasing competition between recreational and subsistence fishing. Currently there are 10 users, including traditional fishers, with commercial fishing rights and an additional 7 users share 3 commercial permits, making a total of 13 vessels with gill-net



For some species, colder conditions on the west coast may become too cold (e.g. snoek and sardines), while others (e.g. anchovies) may shift their distribution to the south coast as the cold current and upwelling move towards the Agulhas bank. Anchovy distributions have already shifted southwards several times in response to changing wind speeds and associated sea temperatures.

Marine invertebrates and marine birds should be monitored to detect the impacts of harvesting and climate change. Several projects run by the CRC and external organizations currently exist and should be maintained and adapted to enable detection of any climate related influences.

Overfishing, climate change and ocean acidification are acting together to reduce populations of several species along the west coast, including rock lobsters, and anchovies (driven mainly by temperature changes) and species like penguins which rely on the fish stocks whose numbers and distributions are changing. There is a real possibility that the MPA will not be able to contribute to the conservation of these species in the future and other conservation measures need to be assessed.

The future of mariculture operations on the west coast are severely threatened by ocean acidification and toxic algal blooms, which could lead to shell forming species like abalone not being able to grow.

fishing rights. The zones in which their fishing is permitted however remain contentious. The annual catch of harders (caught within and outside of the zones prescribed on the current permits) is estimated at 50–60 tonnes and is thought to be sustainable. The by-catch associated with this fishery includes white steenbras (*Lithognathus lithognathus*), elf/shad (*Pomatomus saltatrix*), white stumpnose (*Rhabdosargus globiceps*), blacktail (*Diplodus sargus capensis*), strepie (*Sarpa salpa*), Cape gurnard (*Chelidonichthys capensis*), steentjie (*Spondyliosoma emarginatum*), geelbek (*Atractoscion aequidens*), maasbanker (*Trachurus capensis*). Aside from estimates of harder catches, information on harvest quantities of other species remains unknown. Roving creel surveys of the Langebaan Lagoon MPA coastline counted between 72 000 – 90 000 angler outings each year (during working hours) and estimated annual catches of between 1 and 3 million line fish, while the Anchor State of the Bay reports estimate that recreational fishers catch in excess of 90 tonnes of white stumpnose per year.

Many invertebrate species are used as bait by anglers; these include prawns, bloodworms and mussels. Roving creel surveys showed that the most commonly used invertebrates are prawns. Research by the Cape Research Centre indicated that two prawn species are highly harvested. Based on the ranger patrol records approximately 10 888 and 4 192 *Callichirus kraussi* and *Upogebia Africana* were harvested in 2015. This could be an under-estimate. The harvesting is seasonal higher in summer and spring and low in autumn and winter. This is associated with angling activities for the white stumpnose (*Rhabdosargus globiceps*). The impact of bait harvesting on food availability for wading birds requires further investigation.

Concerns have been raised by local fishermen regarding an increase in the number of seals in the lagoon, which could affect gillnet catches and seabird survival. As a response, SANParks has requested that DEA include the islands of West Coast National Park in their national monitoring programme.

Mariculture in the Langebaan lagoon

Both social and ecological research is required to determine the opportunities for sustainable resource use that could provide benefits from the park to local communities.

Terrestrial resource use

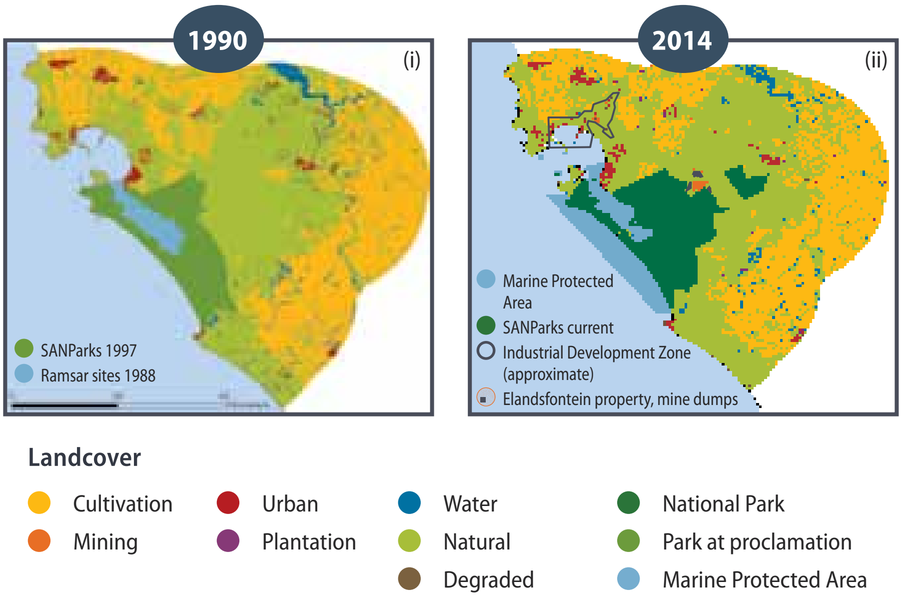
While most resource use in the park takes place in the marine environment, some terrestrial resources such as the culling of ostriches, and wood fuel from alien plant clearing are also used. Up to 150 ostriches are culled annually and the venison is sold to cover some of the costs. Several unauthorised activities also take place, including bee keeping for honey production, livestock grazing and poaching of reptiles, mainly tortoises, snakes and lizards for the wildlife trade. Information on harvest quantities are not currently available and trends are unknown.

Illegal beehive in the park.

Land-use change

H

Since proclamation in 1985, the park has undergone substantial expansion from 200 ha to 12 000 ha by 1990 to almost 32 000 ha at present. The MPA has also expanded by 11 000 ha to a total of just over 15 000 ha currently. The park now conserves 6 terrestrial and 5 marine habitat types (up from 3 and 4 respectively in 1990). Very little land-use change is detectable from aerial images (1990 compared to 2014) in the 20 km buffer area around the current park boundary. A small increase in urbanized or settled land is observable (totalling 6 km^2). However, there are a number of concerning new industrial developments which are likely to have far-reaching impacts for conservation. Firstly, a phosphate mine is currently starting operations directly on the border of the park at Elandsfontein, while major industrial expansions are planned in the marine and terrestrial environments as part of the Saldanha Bay Industrial Development Zone.



(i) The park in 1990, showing land-use in the 20 km around the current park boundary and (ii) land-use as of 2014, showing the area where mining operations are commencing in 2016 at Elandsfontein, as well as the Saldanha Bay Industrial Development Zone.

The best phosphate deposits are not in the area currently being mined, but actually occur in the park and the mine has put in a formal application to expand their operations into the park.

While bee keeping appears to be an obvious interest among community members, providing fair and sustainable opportunities may be challenging. Alien bees must not be introduced because they may carry diseases that ravish the native populations. This has potentially dire consequences for crops that require pollination. Maintaining natural pollinator populations is a high conservation priority that serves agriculture and food security.

A large number of unauthorised bee hives have been observed in the park, particularly during aerial park observations. In addition to the hives, access roads have been carved to allow for accessible placement of the hives deep within the park, for example at Grootfontein.

The new and exciting Foodie Route includes the Geelbek restaurant (situated in the park) where delicious local and sustainably produced cuisine is on offer.

The Elandsfontein mine needs to dewater the mining pit by pumping water out of the aquifer via boreholes. Removal of water from the aquifer might impact on water supply to Langebaan Lagoon. The mine plans to return most of the water to the aquifer through artificial recharge. There are some unknowns regarding the efficiency of the dewatering and artificial recharge, but these are relatively easy to adapt and optimize. A volume of water will return to the open pit which will need treatment before it can be used/released into the environment. Dewatering impacts on the Langebaan Road Aquifer and for users to the north of the site are not known. Monitoring boreholes have been set up to evaluate this.

Preparations for the phosphate mining (2015).

The Saldanha Industrial Development Zone (IDZ) envisions creating a number of jobs and economic and income-generating opportunities. However, dredging during the construction phase of the following planned developments may pose significant environmental risks. The development includes:

- Construction of a new rig repair quay (set to serve modern oil rigs) of 380 m in length and 21 m deep.
- Extension of the Mossgas quay from 38 m to 500 m, with a depth of 8.5 m. This quay will accommodate floating docks, where new service vessels can be built to support the offshore oil and gas industry.
- An offshore supply-base to supply oil rigs.

There will be implications for water quality, pollution, the spread of alien species, opportunities for illegal resource exploitation, sustainable and safe tourism in the bay, endangered species breeding on the islands and the aesthetic appeal of the area.

The necessary infrastructure developments to support the IDZ (such as powerlines, powerplants and roads) may also pose threats to the environment.

Freshwater

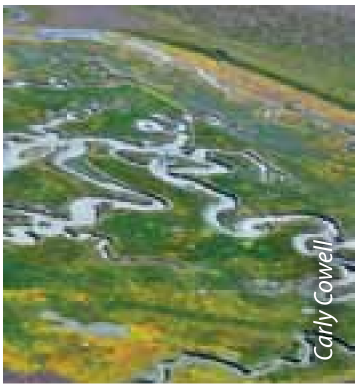
M

No rivers flow through the historical (pre-2011) part of the park, so the water quality of rivers was not assessed as part of the global change assessment. A small section of the Salt River, which joins with the Berg River that has its mouth at Velddrif, runs through the Umoyo property which has been donated to SANParks as an offset for the Umoyo wind farm.

The development of a wetland inventory is a high priority. While some wetlands outside of the park were assessed as part of the Freshwater Assessment for the Elandsfontein mine, no inventory or assessments of the wetlands in the park has been done, but plans are in place to start this process in the latter part of 2016.

Salt marshes are highly productive environments that provide the local ecosystem with nutrients that sustain a large number of invertebrate species. The salt marshes in the Langebaan lagoon are a particularly unique feature in that they represent the only salt marshes in the country not associated with an estuary, while also making up one third of the total salt marsh area in South Africa. A small amount of fresh water is thought to enter the lagoon and marshes through discharge from the underground aquifer, raising concerns about the proposed mining activities.

Groundwater monitoring at one of the waterholes in West Coast.



Langebaan saltmarshes.

Alien species

Terrestrial **H** Marine **H**

This is the only park where more alien animal species have been documented than alien plants. Twenty-one of the 36 documented aliens were animals and the remaining 15 were plants.

Animals

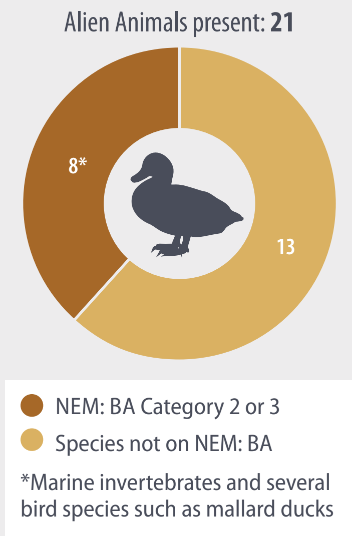
There are several groups of alien animals, including marine species, extralimital mammals (mainly confined to Postberg), terrestrial snails, several fairly cosmopolitan bird species like the house sparrow, and the rabbits on the islands, which have over many years adapted to a life along the ocean's edge and are in themselves a unique feature of the park. Some of these groups are more damaging to the environment and plans for their removal are currently being implemented. There are also several research projects assessing the impacts of the marine invaders. Eight alien animals are NEM: BA listed, including 4 birds and 4 marine invertebrates (no category 1).

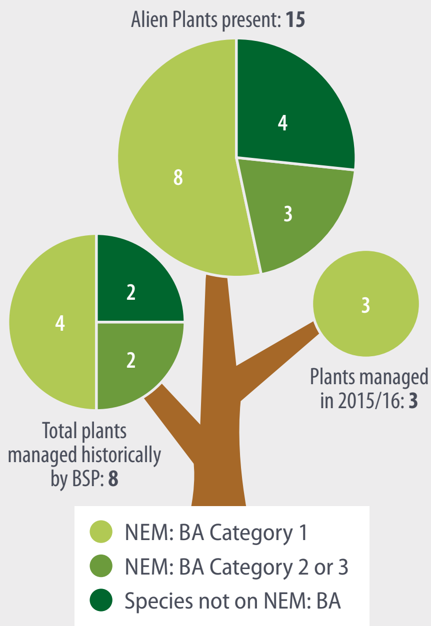
Saldanha bay (and Langebaan lagoon) was historically a restocking station for whaling ships. Prior to the establishment of farms around the bay, ships brought animals and left them on the islands for collection at a later stage. These animals included rabbits, sheep and goats. The Postberg peninsula was used as a winter grazing ground by stock farmers from the summer rainfall plateau areas. Over time this practice of moving entire herds was stopped and the area was converted into a game reserve. Private land owners bought in their 'favourite' game species, many of which were not indigenous to the west coast. The last few extra-limital species still remain in Postberg and plans are underway to remove them. Local indigenous species will be introduced to maintain the high levels of disturbance to the old fields where the well-known seasonal floral displays are seen.

Springbok are one of the extralimital species present in Postberg.

Plants

Several potentially high impact species have been documented in the park (e.g. *Acacias*, Eucalypts, pines, poplars and *Opuntias*) with *Acacia* species being the most widespread. Eleven of the plants in the park are NEM: BA listed (8 category 1b). Clearing of the *Acacias* has been successful in old parts of park, but the new areas are still quite heavily invaded, while maintenance is essential to ensuring the cleared areas remain so.





A SANParks Alien Plant Management Strategy is being developed in response to NEM: BA regulations to guide requirements and priorities within each park. While budgets and implementation remain challenging, the prioritization should increase the impact of money being spent.

While alien species are not currently a major threat in the older part of the park, the NEM: BA legislation will require management plans for all 8 category 1 species by September 2016. These species include the *Acacias*, pines, Eucalypts and prickly pear (*Opuntia monacantha*). Only 4 of the NEM: BA category 1 species have been routinely cleared to date.

West Coast is one of few parks in the Cape where the majority of the park is in a maintenance phase.

Local stakeholders should be engaged in monitoring the presence and removal of aliens.

The areas cleared of aliens should be monitored to determine the response of the natural communities and to identify the presence of any new or recurrent alien populations early.

Umoyo wind-farm offset donated to the park. Clearing requirements for the new park section will be more intensive due to dense rooikrans (*Acacia cyclops*).

Disease

L

Disease is not currently a major driver in the park, but the increased traffic at the Saldanha harbour (see above section) has the potential to introduce novel diseases and also to pollute the area that could impact on the health of plants and animals. Future concerns include bird diseases (for a botulism case study refer to Garden Route), marine animal diseases and the threat posed by mariculture. Species being farmed through mariculture are stocked at high densities, which facilitates the spread of disease, but can also lead to algal growth and nitrification, further impacting on the health of other marine organisms. No local studies have yet been done on the geochemical impacts that the proposed phosphate mine may have. Leaching of phosphates and other minerals through the aquifer could impact on the nationally important reed beds and salt marshes as well as the health of other plants, animals and ecosystem function in the park. The monitoring data collected by Anchor Environmental Consulting for their annual report on the State of the Bay will be very important.

The status of plant diseases is unknown, although plant health is expected to be negatively affected by the addition of phosphorus as Fynbos species are generally intolerant of this nutrient.

Appendix 1: Methods

Please note that although data collection and analysis have continued for some drivers, the underlying data were collected and core assessment conducted between 2009 and 2014.

Climate change

To assess how temperature and rainfall have changed in each of the parks, we sourced data from the South African Weather Service for all their stations within and close to national parks up until 2009. For some parks, this meant that we did not have all the data required to assess trends. Follow-up was done with individual parks to identify additional weather station information and where possible, these data have been archived or the location of the station recorded in a database for future work, but in many instances the additional data have not been analysed. The main reason for this is that several decades of daily data are needed for meaningful trend analysis and in many cases only recent data or long-term data recorded per month are available. Having daily data is important for calculating trends in many of the things we might be interested in from a climate change perspective, for example, change in the intensity of heavy rainfall (flood) events or the number of days above certain temperature thresholds. It is also much easier to pick up errors in daily data.

Three possible scenarios of what the climate might be like by 2050 were generated for all parks. The current conditions were based on agro-hydrology data averaged across all grid cells (1.8x1.8km) of which all or part occur in the park, thus representing current averages at a landscape level. The future scenarios were derived from modelling work done by Stephen Holness and Peter Bradshaw in collaboration with a team from SANBI and the CSIR and have been published by the DEA as part of the Long Term Adaptation Scenario Flagship Research Programme. To interpret the results of this modelling exercise, it is important to understand the basic approach that the team used to model the future scenarios. Because modelling of the future results in some uncertainty, 15 different models were used and the team selected the most extreme (hot, dry or wet) model results to display the potential range of future conditions as well as the most likely intermediate. The 'low risk' (warm wet) scenario combined results from the models that predicted each area to be the wettest under a changing climate with results from models which predicted the least warming, therefore predicting warmer, wetter conditions across the country. On the other hand, the 'high risk' (hot dry) scenario combined the hottest and driest model outcomes, predicting drier, very hot conditions everywhere. The combination of these extremes will not occur together naturally across the country, but have been used to explore the most extreme conditions which an area or biome might face. The intermediate scenario used results from a single model and represents rainfall and temperature changes that are likely to occur together. The predictions under the intermediate scenario are most likely, while those of the wettest or low risk scenario are less likely.

The possible impacts of the changing climate on the distribution of South Africa's biomes were also modelled. The current conditions in each biome were modelled to assess how the distribution of conditions associated with each biomes is likely to change under each of the three future climate scenarios. Although complete switches between biomes are unlikely to take place in this short period of time, the parts of the country where biomes are predicted to change indicate the areas where biomes are most at risk as a result of climate change by 2050. Importantly, because a biome (e.g. the Succulent Karoo) encompasses a fairly broad range of climatic conditions, a specific site could experience fairly large changes in rainfall and temperature and still remain within the conditions currently associated with that biome. For example, an area which is currently in the coolest and wettest portion of the biome, may end up with a climate similar to the hottest and driest areas of that same current biome. We do not know how biomes, and the ecosystems and species that make them up, are likely to respond to these novel climatic conditions in practice, but sites that stay within the envelope of conditions associated with Succulent Karoo are likely to retain a suite of Succulent Karoo species and still resemble what we know as Succulent Karoo, even though local extinctions are possible for particular species. What will happen in places where conditions move outside of what was experienced before remains to be seen.

The projected changes have been assessed in light of trends that we detected in weather station data, along with information from other published sources (where this is available) to make some suggestions at a park level of what the future might look like or the potential risks associated with the predicted changes. In all instances, parks have been advised to introduce climate change adaptation and mitigation measures that will both help park management and the park ecosystems adjust to the change and also set an example to the general public of green sustainable living.

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Land-use change

Land-use change in the 20kms surrounding parks was assessed using land-cover maps generated by the Department of Environmental Affairs for 1990 and 2014. For both 1990 and 2014, the land-use in this "buffer" area was mapped within one of four major types of converted land, namely Cultivation, Mining, Plantation or Urban land (including rural settlements), while the remaining natural land was classified as either Natural or Degraded, and all types of waterbody were mapped together. For each park, we calculated the change in each of the classes of land cover between 1990 and 2014. There were several parks where a large switch took place between natural and degraded land. While this could be explained for a couple of parks, it appears that there was probably a change in the way that natural land was classified, with areas that naturally have sparse vegetation (like the Karoo), being classified as natural in 1990, but degraded in 2014. We have therefore mapped all 'natural' and 'degraded' areas as natural unless there was a defendable explanation for a switch in these categories (which was seen within and outside of parks). We only report on changes in the four classes of converted land. Further details of how the GIS calculations were done are available on request.

Habitat change within parks was assessed on an *ad hoc* basis where information was available. An analysis across the parks proved unsuccessful due to high variation in the type of data available and a very limited number (if any) of repeat vegetation surveys. New technologies are however increasingly providing new ways of assessing habitat change and future analyses may be able to rely on time series analysis of measures such as NDVI (Normalized Difference Vegetation Index) and EVI (Enhanced Vegetation Index) from satellite imagery and repeat photography.

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Disease

All potential disease threats for SANParks were listed and categorized using published data and expert opinion. Information on the distribution, risk factors and records of outbreaks were gathered for the 15 diseases (see table below) deemed important (most likely to be linked to global environmental change) or regulated by the Animal Diseases Act (No. 35 of 1984 and Amendment No. 18 of 1991), that is, controlled diseases (see the summary of diseases controlled by this Act in the second table below). The 15 diseases include: anthrax, African swine fever, African horse sickness, avian influenza, bovine tuberculosis, botulism, bovine brucellosis, Crimean Congo hemorrhagic fever, corridor disease, canine distemper, foot and mouth diseases, heart water, malignant catarrhal fever, rabies & rift valley fever. Summary statistics regarding the distribution of and trends in diseases were calculated from available data.

The 15 diseases considered in the assessment and reasons for their selection

Disease	Interface disease	Affects International trade	Impacts Livelihoods and rural development	Zoonotic	Wildlife reservoir	Impacts wildlife health	Comments
Anthrax	Yes	No	No	Yes	No	Yes	Zoonoses often associated with wildlife mortalities and bioterrorism possibilities
African Swine Fever	Yes	Yes	No	Yes	Yes	No	Interface disease. Reservoired in wild pigs. Endemic in the Kruger, Mapungubwe and Marakele
African Horse Sickness	Yes	Yes	No	No	Yes	No	Interface disease. Zebra considered maintenace host. Endemic in Kruger.
Avian Influenza (HPAI)	Yes	Yes	Yes	Yes	Potentially	Potentially	Potential Zoonosis; human population infected with H1N1. Confirmation in farmed ostiches in the Western and Northern Cape resulted in trade embargos
Bovine Tuberculosis	Yes	No	No	Yes	Yes	Yes	Interface disease. Potential for transboundary spread to Mozambique and Zimbabwe. Maintained in buffalo in Kruger. Potential impact on wildlife.
Botulism	No	No	No	Yes	No	Yes	Potential impact on wildlife. Large scale mortalities in wild birds and occassionally mammals.
Bovine Brucellosis	Yes	No	No	Yes	Potentially	Potentially	Interface disease with potential spread to domestic stock and man. Buffalo seen as potential reservoir.
Crimean Congo Hemorrhagic Fever	No	No	No	Yes	Potentially	Yes	Zoonosis. Possible role of wildlife as virus reservoir.
Corridor Disease	Yes	No	No	No	Yes	No	Interface disease that is fatal in cattle, and is associated with buffalo in Kruger.
Canine Distemper	Yes	No	No	Yes	No	Yes	Interface disease that is maintained in domestic dogs with potential impact on wild carnivores, most notable outbreak in Serengeti that killed one third of the lion population. Wild dogs particulary vulnerable.
Foot and Mouth Disease	Yes	Yes	Yes	No	Yes	No	Trade-sensitive interface disease that is maintained in buffalo in southern Africa.
Heartwater	No	No	No	No	Potentially	Yes	Potential impact on wildlife, especially when non-endemic adapted species are moved to heartwater areas
Malignant Catarrhal Fever	Yes	No	No	No	Yes	No	Wildebeest associated MCF is an interface disease potentially fatal in cattle.
Rabies	Yes	No	No	Yes	Yes	Yes	Interface disease and important zoonosis, with the potential to impact wild carnivores.
Rift Valley Fever	No	Yes	No	Yes	Potentially	Yes (ranched wildlife)	Zoonotic disease with a recent increase in incidence in South Africa. Role of wild reservoir suspected.

Inclusion of only these diseases however restricted the analysis mainly to diseases of ungulates (probably because livestock and buffalo are tested most frequently), although some of these diseases are also known to spill over into their predators. In addition, most of the disease information was present for savanna parks and specifically for Kruger; likely because the most comprehensive, long-standing surveillance programme is present in these parks, as are most of the large mammals that are susceptible to these diseases. In addition, the climate of the savanna region is better suited to several of the diseases and more data is available in areas where commercial farming is prevalent. Surveillance and outbreak data were incomplete, making it difficult to determine trends. The data were generally also found to be biased: although surveillance of disease is carried out, the focus is on controlled diseases with data collection being intensified during outbreaks. Obtaining better data is however costly and is challenged by the fact that most diseases can only be diagnosed from samples collected from post mortem of affected animals. Active surveillance is mostly prohibited by costs unless linked to a specifically funded project. Disease information in the report therefore represents whatever information was available on any of these diseases for each of the parks, with some suggestions for improving data collection in certain parks, as well as a synopsis of risk factors for the park.

References

Coetzer, J.A.W. & Tustin, R.C. (eds). 2004. Infectious Diseases of Livestock. Oxford University Press, Cape Town.

Dyason, E. 2010. Summary of foot-and-mouth disease outbreaks reported in and around the Kruger National Park, South Africa, between 1970 and 2009. Journal of the South African Veterinary Association 81: 201-206.

Department of Agriculture Epidemiology Database http://www.nda.agric.za/vetweb/epidemiology/Disease%20 Database/OIEData/OIE_query_Criteria.asp

World Animal Health Information Database (WAHID) 2005 to 2012 data http://web.oie.int/wahis/public.php

Handistatus database for OIE data from 1996 to 2004 http://web.oie.int/hs2/report.asp?lang=en

A large research program to understand drivers for the pansteatitis outbreak in the Olifants Gorge in Kruger has been ongoing since 2008 when the first cases were detected.

Controlled and notifiable animal diseases in South Africa (Animal Diseases Act 35 of 1984)

Stars appear next to those diseases that were included in the assessment

Group	Disease	Included in assessment
Bacteria	Anthrax	*
	Bacterial Kidney Disease (in fish)	
	Contagious Equine Metritis (CEM)	
	Glanders	
	Johne's Disease	
	Psittacosis	
	Salmonella enteriditis	
	Salmonella gallinarum	
	Tuberculosis	*
	Strangles	
	Swine Erysipelas	
	Brucellosis (contagious abortion)	*
Mite	Sheep Scab	
Prion	Bovine Spongiform encephalopathy (BSE)	
	Scrapie	
Protozoa	Corridor Disease (Theileriosis)	*
	Dourine	
	East Coast Fever	
	Nagana	
Virus	African Horse Sickness (AHS)	*
	African Swine Fever (ASF)	*
	Aujeszky's Disease	
	Bovine Contagious Pleuropneumonia (CBPP)	
	Classical Swine fever (CSF)	
	Contagious haemopoetic Necrosis (in fish)	
	Contagious Pancreatic Necrosis (in fish)	
	Equine Infectious Anaemia	
	Equine Influenza (EI)	
	Equine Viral Arteritis (EVA)	
	Foot and Mouth Disease (FMD)	*
	Haemorrhagic septicaemia (in fish)	
	Newcastle Disease	
	Notifiable Avian Influenza	*
	Porcine reproductive and respiratory syndrome (PRRS)	
	Rabies	*
	Rinderpest	
	Swine Vesicular disease	
	Bovine Malignant Catarrhal Fever (snotsiekte)	*
	Bluetongue	
	Lumpy Skin Disease	
	Rift Valley Fever	*

Alien species

Original alien species lists (prior to 2011) were produced per park by reviewing Working for Water Information System (WIMS) data, BSP (Biodiversity Social Projects, then ISCU – Invasive Species Control Unit) databases, cybertracker records, scientific publications and reference books, herbarium records as well as consultation with SANParks staff. These lists were cross-checked in 2016 and compared to lists that appear in park management and lower-level plans and, where necessary, species were added to the lists. Species were only removed from the list where reliable information was available that a recorded species had been misidentified. Species that were deemed to have been eradicated were noted, but kept on the list. If these species are still absent at the next list revision, they will be removed.

In 2014 (with updates in 2016), regulations that detail how particular alien species should be managed were published under the National Environmental Management: Biodiversity Act (NEM: BA). The status of all species occurring in parks was cross-checked with this legislation and the number of species that require management plans and permits under NEM: BA were recorded per park. These lists were also compared to the work that is being done by BSP to manage aliens, to see how many of the species that require management under the legislation are currently being treated. Data on the species being managed per park were available for most parks from 2002 or 2003. Only records of work done on species that are known to occur in each park were considered (in some instances the BSP data listed work on species that are not known from a particular park; these species were deemed to be misidentifications by project management).

References

National Environmental Management Act - Biodiversity (No 10 of 2004) G-26436

National Environmental Management: Biodiversity Act (10/2004): Alien and Invasive Species Regulations, 2014 (GG 37885 - GN 598)

Spear, D., M. A. Mcgeoch, L. C. Foxcroft, and H. Bezuidenhout. 2011. Alien species in South Africa's national parks. Koedoe 53:Art. #1032, 4 pages.

Freshwater change

The assessment of freshwater status made use of results from a series of national freshwater assessments, from which park-relevant data were derived. As such, the accuracy at park level is sometimes not as nuanced as it could be. However, the results provide sound statistics for comparing freshwater condition between parks and also provide a baseline for future studies and a measure against which ground-truthing can be undertaken. The available national wetland data were deemed to have very inconsistent accuracy between parks and we have therefore not reported on wetland condition. SANParks, in collaboration with several key partners has however been making good progress in developing methods for ground-truthing wetlands and the process of mapping and documenting wetland condition has commenced in several parks. Where results are available from this work, we report on these.

Where available, additional information on water quality, impacts on freshwater systems (including groundwater), monitoring activity, research results and concerns were recorded at a park level in consultation with local SANParks researchers.

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THE IMPORTANCE OF FRESH WATER
STRATEGIC WATER SOURCE AREAS (SWSA)

SWSA are regarded as natural

"WATER FACTORIES"

supporting growth and development needs that are often far away

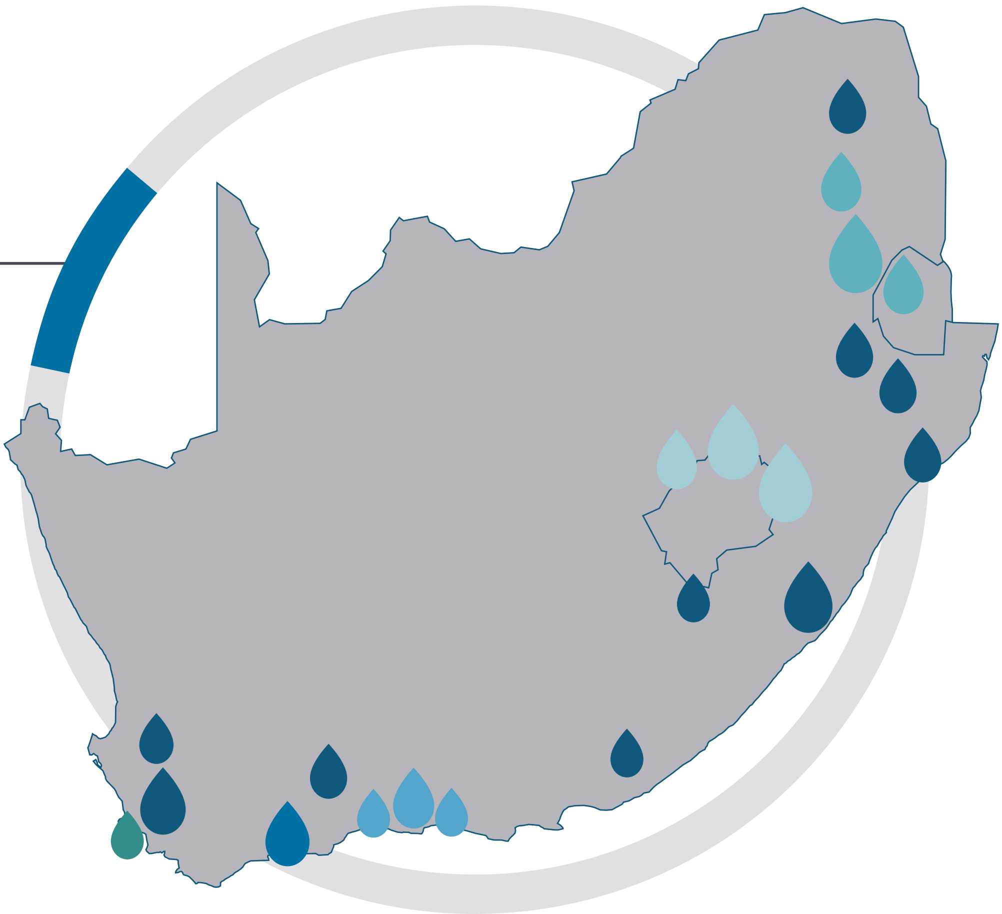
they are small areas that supply water to the rest of the country

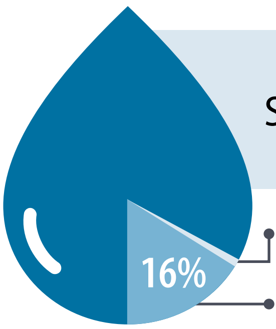
SOUTH AFRICA FACTS

SA is one of the driest countries (per capita) with **98%** of it's surface water already developed.

SA is experiencing a growing water **QUALITY** problem

8% of SA's land area provides **50%** of our water supply





Of these Strategic Water Source Areas:

- 1% within SANParks
- Within Protected Areas

The SANParks contributions are:

- Bontebok
- Garden Route (61.8%)
- Golden Gate Highlands
- Kruger
- Table Mountain

An important future priority for protected area expansion includes expanding into these areas

Resource use

Data pertaining to the number and extent of harvested resources were collected by means of a questionnaire that was sent to all national parks for completion by section rangers and park management. Questionnaire completion was assisted by scientists and emphasis was placed on all resource use – authorized and unauthorized – as we sought to describe all resources that are currently of interest to people or might be threatened by harvest. Summary statistics on the number of resources used in each park, the quantities used (or knowledge of quantities used), purposes for which resources were used, estimated number of beneficiaries and the level of authorization of use were compiled. The annual reports that head office compiles to send to the minister of Environmental Affairs on agreements that SANParks has entered into for the authorized use of resources were also reviewed. Data from our surveys were then updated with any additional information from these reports (available from 2010–2016). Additional data were also obtained directly from project managers (P&C officers and scientists) in parks where staff indicated that additional information was available for particular resource use projects. Where possible the full lists of harvested resources per park was compared to existing estimates of resource use from the literature to assess the likelihood that lists of harvested species were complete for each park. The conservation status of all harvested species was researched as one measure of assessing the likely sustainability of harvest. No social impact assessments were carried out during this project.

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van Wilgen, N.J., Dopolo, M., Symonds, A., Vermeulen, W., Bester, E., Smith, K., McGeoch, M.A., 2013. An inventory of natural resources harvested from national parks in South Africa. Koedoe 55, Art.#1096, 1095 pages. http://dx.doi.org/1010.4102/koedoe.v1055i1091.1096.

Timber harvesting in the Garden Route

Additional sources

Additional information on the project methods and results can be found in the following reports and publications:

Internal unpublished reports:

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Hofmeyr, M., Govender, D., van Wilgen, N.J., de Klerk-Lorist, L., Zimmerman, D., Bengis, L., Solano Fernández, S., Buss, P., Michael, A., Lane, E., Burroughs, R. & McGeoch, M.A. 2012. SANParks Global Environmental Change Assessment: Disease Summary Report. Scientific Report number 08 / 2012, South African National Parks, Skukuza.

Roux D, Russell I, Nel J, Van Niekerk L, Oosthuizen A, Holness S, Barendse J, Bradshaw P, Sink K, Biggs H, Dopolo M, Petersen R, Cruywagen K and Fisher R. 2013. SANParks Global Environmental Change Assessment: Aquatic Ecosystems. Scientific Report number 01 / 2013, South African National Parks, Skukuza.

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van Wilgen, N.J., Holness, S., Goodall, V., Bradshaw, P. & McGeoch, M.A. 2012. SANParks Global Environmental Change Assessment: Climate Change Summary Report. Scientific Report number 07 / 2012, South African National Parks, Cape Town.

van Wilgen, N.J. McGeoch, M.A, Dopolo, M. & Vermeulen, W. SANParks Global Environmental Change Assessment: Resource Use Summary Report. Scientific Report number 10 / 2012, South African National Parks, Cape Town.

Publications:

Foxcroft, L.C., N.J. van Wilgen, J.A. Baard, and N.S. Cole. 2017. Biological invasions in South African National Parks. Bothalia 47: a2158.https://doi.org/10.4102/abc. v47i2.2158.

Foxcroft, L. C., D. Spear, N. J. van Wilgen, and M. A. McGeoch. In preparation. Assessing multiple potential pathways and impacts of alien plant invaders in South African protected areas.

Roux, D. J., and J.L. Nel. 2013. Freshwater conservation planning in South Africa: Milestones to date and catalysts for implementation. Water SA **39:**151–164.

Spear, D., L.F. Foxcroft, H. Bezuidenhout, and M.A. McGeoch. 2013. Human population density explains alien species richness in protected areas. Biological Conservation **159:**137–147.

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van Wilgen, N. J., M. Dopolo, A. Symonds, W. Vermeulen, E. Bester, K. Smith, and M. A. McGeoch. 2013. An inventory of natural resources harvested from national parks in South Africa. Koedoe **55:** Art.#1096, 5 pages. http://dx.doi.org/10.4102/koedoe.v55i1.1096.

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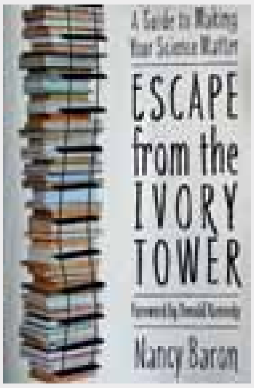
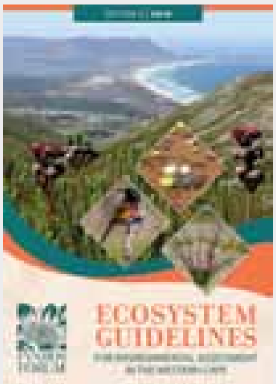
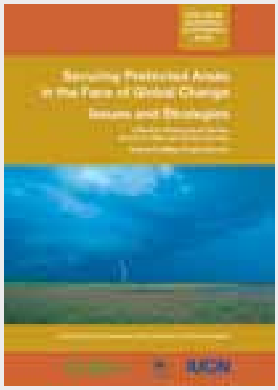
van Wilgen, N. J., and M. A. McGeoch. 2015. Balancing effective conservation with sustainable resource use in protected areas: precluded by knowledge gaps. Environmental Conservation **42:**246–255.

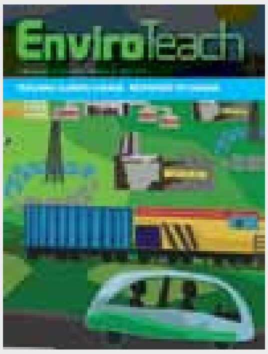
Further reading

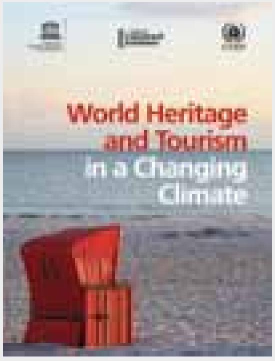
A selection from the significant works available on mitigating and adapting to change in the protected areas context

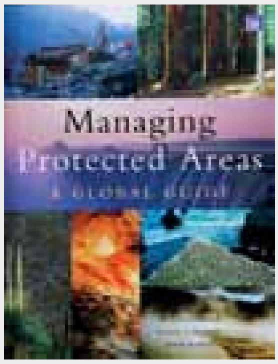


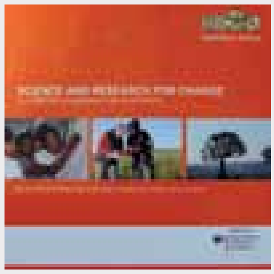


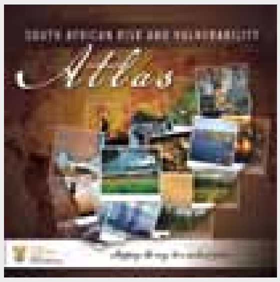


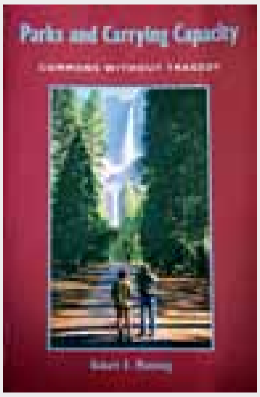


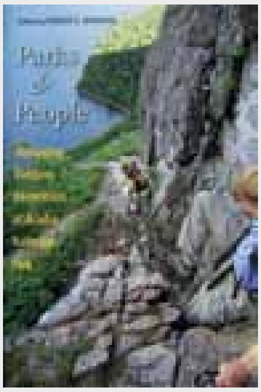


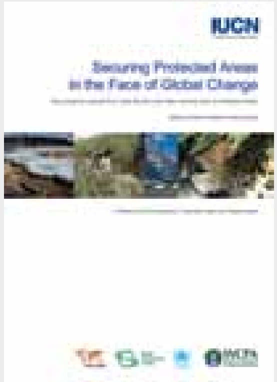


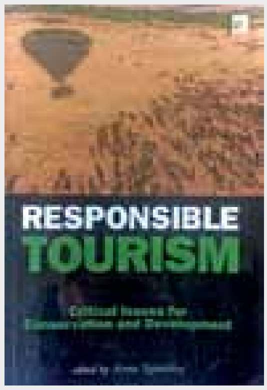


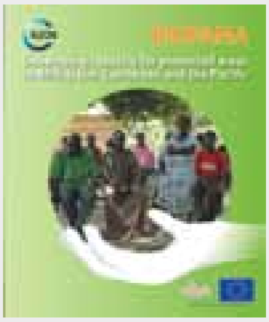


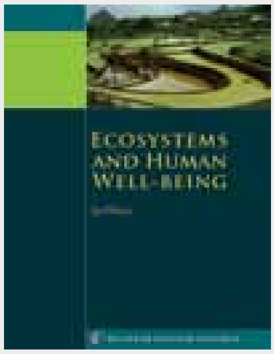


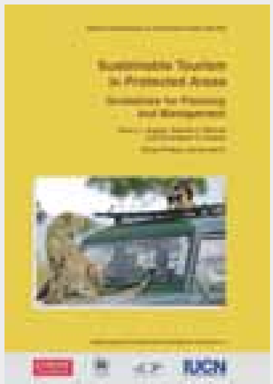


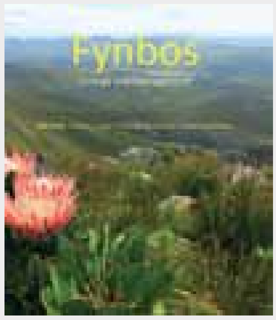


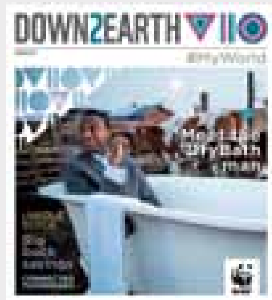


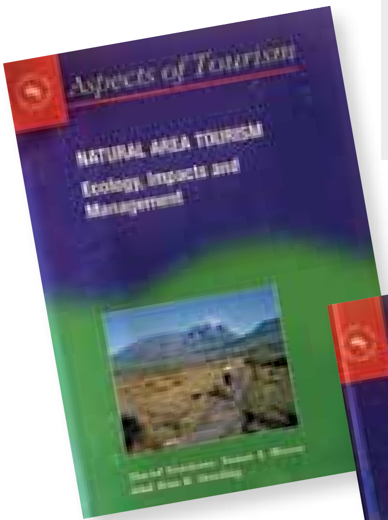


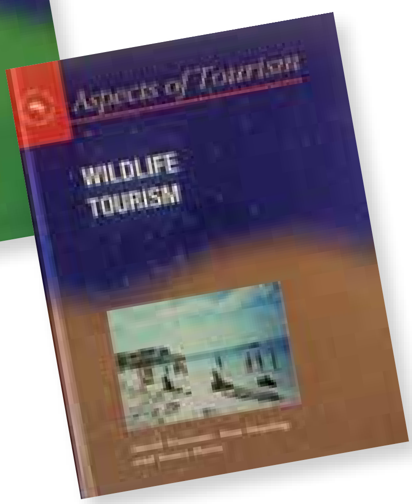




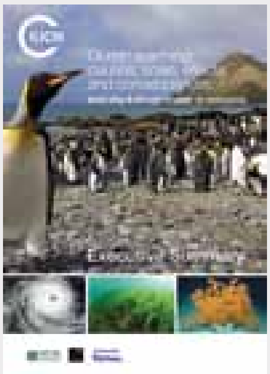




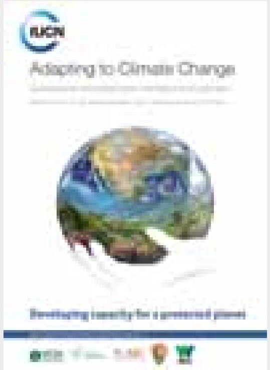




> “We have a single mission:
> to protect and hand on the planet
> to the next generation.”
>
> – Francois Hollande, former French president


IUCN
Executive Summary


IUCN
Marine Protected Areas and climate change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Developing capacity for a protected planet


IUCN
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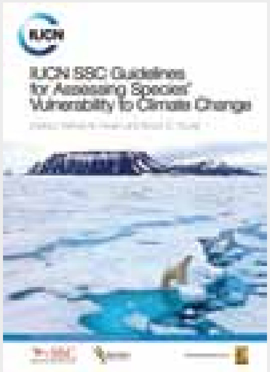
Solutions africaines dans un monde qui change rapidement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IUCN SSC Guidelines for Assessing Species' Vulnerability to Climate Change


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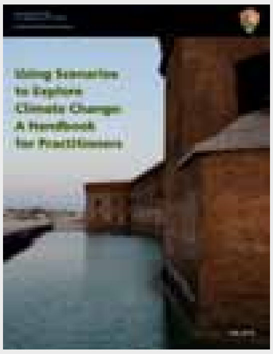
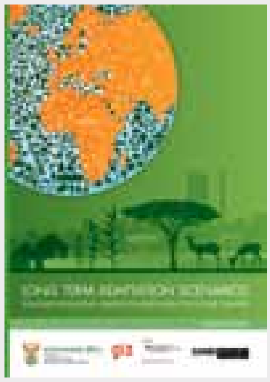
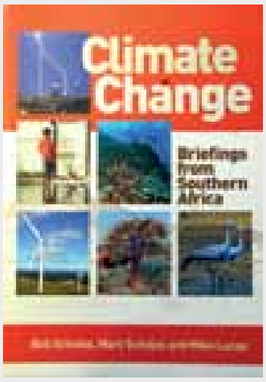
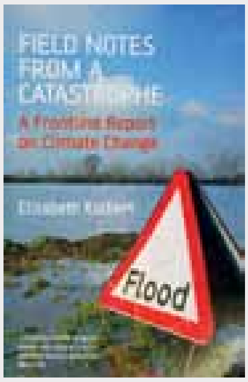
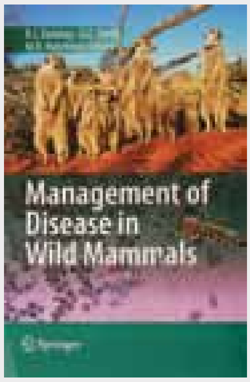

Using Scenarios to Explore Climate Change: A Handbook for Practitioners


LONG TERM ADAPTATION SCENARIOS

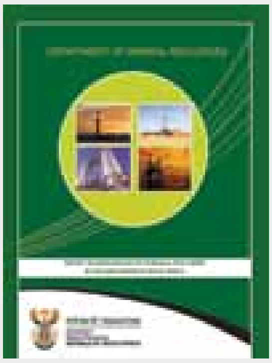

CLIMATE TRENDS AND SCENARIOS FOR SOUTH AFRICA


Climate Change
Briefings from Southern Africa

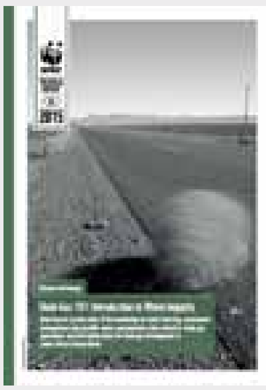

FIELD NOTES FROM A CATASTROPHE
A Frontline Report on Climate Change
Elizabeth Kolbert
Flood

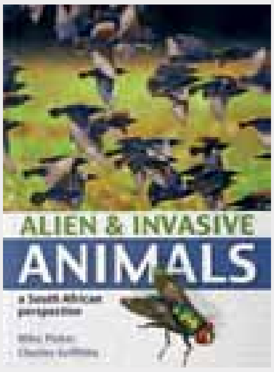

Management of Disease in Wild Mammals
Springer

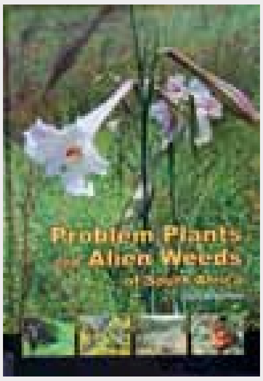

IUCN
Linking Landscapes

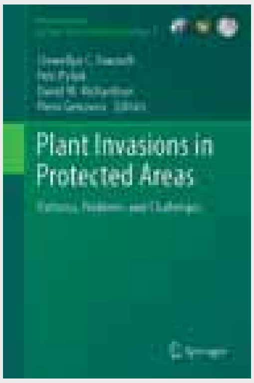



The Looming Threat of Bulk Marine Sediment Mining

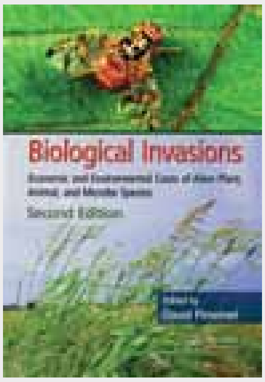


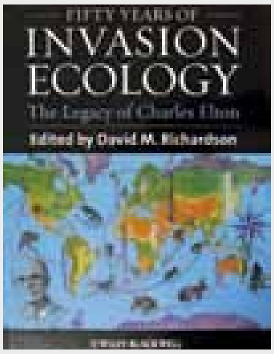

ALIEN & INVASIVE
ANIMALS
a South African perspective

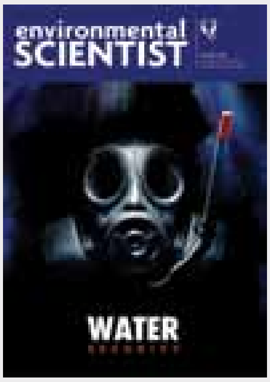

Problem Plants and Alien Weeds of South Africa

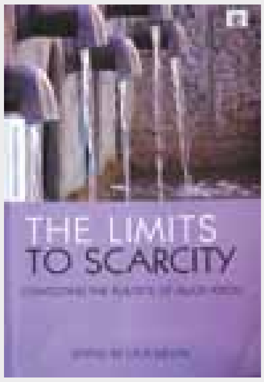

Plant Invasions in Protected Areas


Invasive Species, Climate Change and Ecosystem-Based Adaptation: Addressing Multiple Drivers of Global Change

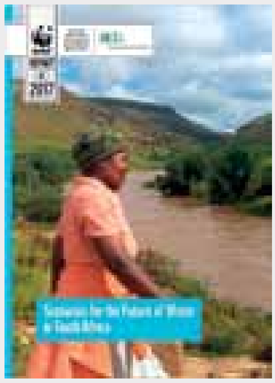

Biological Invasions
Second Edition


FIFTY YEARS OF
INVASION ECOLOGY
The Legacy of Charles Elton
Edited by David M. Richardson


environmental
SCIENTIST
WATER


THE LIMITS TO SCARCITY


WATERWHEEL
DROUGHT
WATER
WATER
WATER




Beyond the Source

“Climate change is no longer
some far-off problem;
it is happening here,
it is happening now.”

– Barack Obama, former US president


REDUCE • REUSE • RECYCLE • REPLENISH • RESTORE