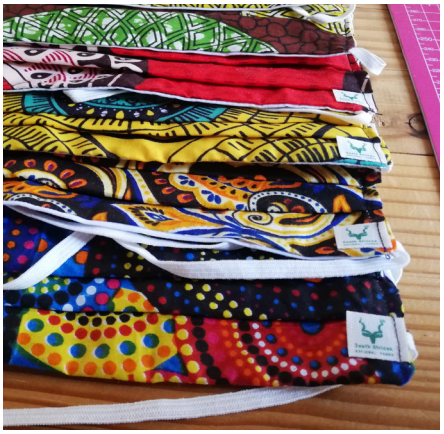


CREATING

KNOWLEDGE

WITH

SOCIETY

South African
NATIONAL PARKS

RESEARCH

20/21

South African
NATIONAL PARKS

THE EDITORIAL TEAM: Corli Coetsee, Nerina Kruger, Nicola van Wilgen-Bredenkamp, Danny Govender & Stefanie Freitag-Ronaldson
SECTION EDITORS: Graham Durrheim, Izak Smit, Louise Swemmer, Nkabeng Mzileni, Tercia Strydom
ARTWORK AND LAYOUT: Corli Coetsee

COVER PHOTO: Reef in Table Mountain National Park MPA, Mark van Coller

Contact SANParks: +27(0)13 735 4000

Cape Research Centre
Tokai: +27(0)21 713 7500

Garden Route and Frontier Research Unit
Knysna: +27(0)44 302 5600
Rondevlei: +27(0)44 343 1302
George Campus (NMU): +27(0)44 871 0058

Savanna Research Node
Phalaborwa (SAEON): +27(0)13 735 3534
Skukuza: +27(0)13 735 4235

Arid Research Node
Kimberley: +27(0)53 832 5488

Foreword

Thabo Kgomommu (Acting ME: Conservation Services)
& Mahlomola Ernest Daemane (Acting Senior GM: Research & Development)

The annual research report is reflective of the diversity of the estate that SANParks manages (terrestrial, freshwater, marine), the diversity of biomes contained in those parks, as well as the social, economic and the ecological interconnections. During the 2020-21 financial year, the impacts of the COVID-19 pandemic and the pandemic-induced regulations had a significant effects across the globe, including on protected areas. However, this historic shut-down of human movement provided a unique opportunity to improve our understanding of how humans and wildlife interact. While the National Lockdown in South Africa had a negative impact on our tourism operations, our conservation operations were allowed to continue as part of essential services.

SANParks undertook a study on the impact of COVID-19 pandemic and associated lockdown levels to reflect on the lessons learnt, including opportunities for positive change under the "new normal". Although the full extent of the impacts of COVID-19 on SANParks and individuals are not known, no retrenchments or loss of salaries were effected. Moreover, SANParks still managed to join forces to provide food parcels to neighbouring communities across different regions; Honorary Rangers continued to provide much needed support though donations and a compensation programme aimed to offset the direct damages incurred to livestock owners as a result of large predators escaping from the Kruger National Park was achieved.

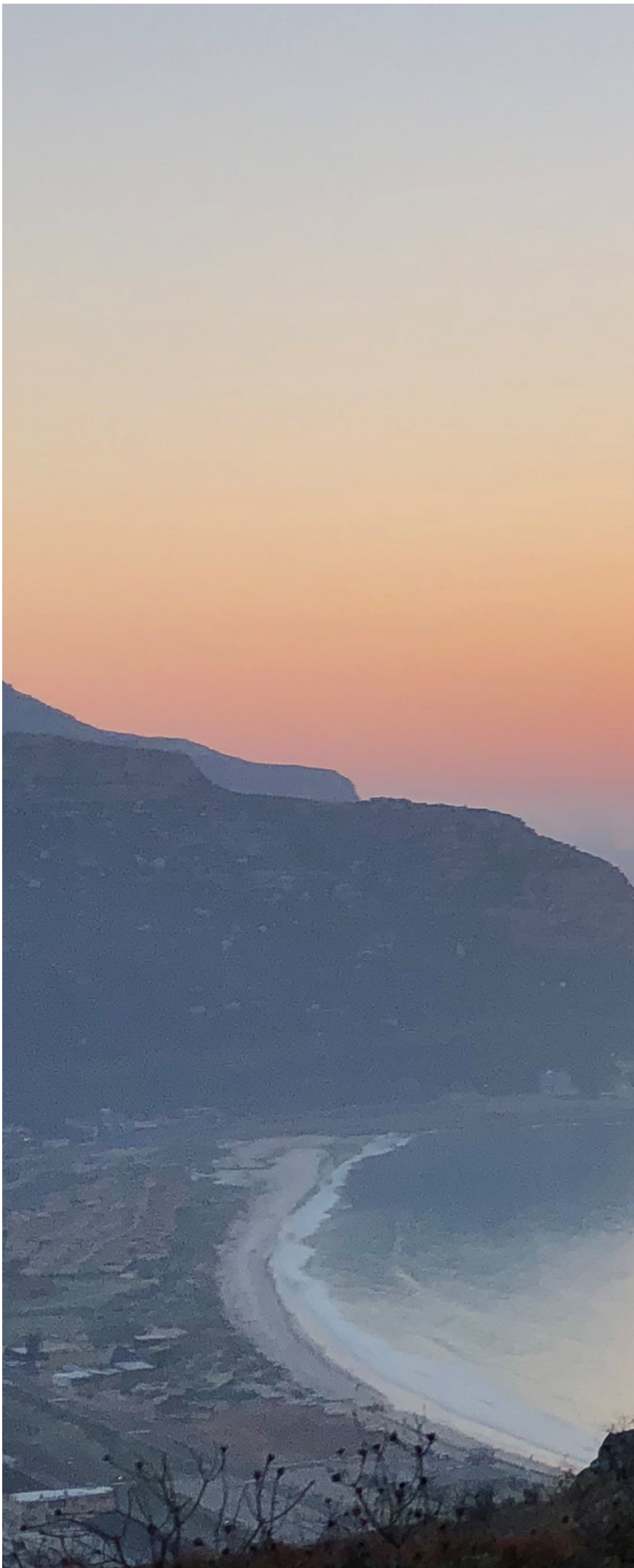
Even under these unprecedented circumstances, adaptive learning, innovation and research kept the research team going. SANParks was interested to find out if poaching of high value species like rhino would actually reduce in response to robust enforcement of lockdown rules. In the Garden Route Scientific Services staff were permitted to continue with a long-term monitoring project assessing patterns in estuarine recreational and subsistence line-fishing throughout the different lockdown levels. Fossil vertebrate tracksites were also discovered in the Garden Route by the African Centre of Coastal Palaeoscience at Nelson Mandela University, resulting in numerous publications. SANParks scientists continue to have influence on a range of scales, from the local level (e.g. discovering new species in parks; monitoring veld condition and species in parks; gaining new insights into alien species management) and the global level (e.g. international award for climate change research; contributions into 2020 Living Planet Report).

Though 2020/21 was a massively disrupted year, more papers were published by SANParks authors than in the previous two years.

Due to financial constraints and restrictions on travelling and attending live conferences, our scientists were in no way silenced by the pandemic. Our Scientists made use of the online platforms to share and influence. Many became involved in webinars both at local and international platforms, and also hosted and converted seminar series into a successful online webinar series as well as for a range of external forums. Scientific Services also launched a new website, a platform for scientists to share some of their stories through popular blog posts. The review of several park management plans were also disrupted by the pandemic, however a study was conducted to reflect on the entire Park Management Plan process and followed by a series of consultative virtual workshops.

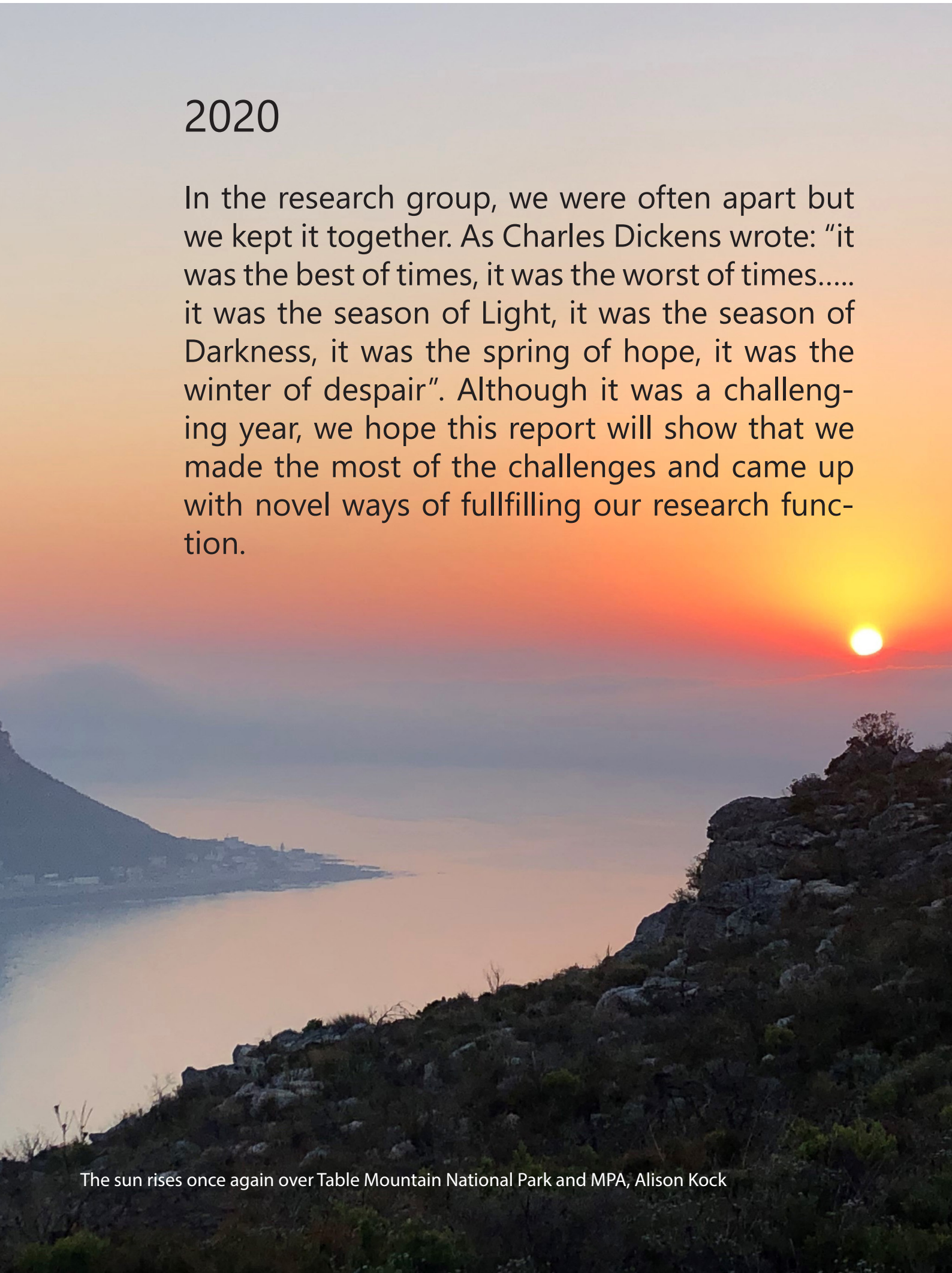
Besides all disruptions brought about by the pandemic, the year 2020 still brought out the best from the Conservation Services team. Noticeable number of colleagues across the nodes used the lockdown period positively and managed to further their studies (i.e. MSc and PhDs). SANParks also said goodbye to a few colleagues; Prof Abel Ramoelo joined University of Pretoria and Dr Mohlamatsane Mokhatla joined Sol Plaatjie University; a long serving colleague in Skukuza Herbarium retired (Guin Zambatis); and some of our promising junior scientists' whose contracts expired (Zoe Nhleko and Nelisiwe Mpapane).

As we leave 2020 behind, we salute those conservationists who fell along the way due to the COVID-19 pandemic. In the words of Charles Dickens, "it was the best of times, it was the worst of times….. it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair".



2020

In the research group, we were often apart but we kept it together. As Charles Dickens wrote: “it was the best of times, it was the worst of times….. it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair”. Although it was a challenging year, we hope this report will show that we made the most of the challenges and came up with novel ways of fullfilling our research function.



The sun rises once again over Table Mountain National Park and MPA, Alison Kock

Content

Governance

Creating and sharing knowledge

112 Out and About

Saying a fond goodbye and a warm hello

Achievements and celebrations

Closure 122

Author Biographies 124

Appendices

The COVID-19 pandemic is a global crisis that has, and continues to impact our lives in multiple ways. In an effort to slow transmission and assist health care systems, governments restrict human movement through travel bans and stay at home directives. In South Africa, the severity of restrictions implemented at any time varies according to infection rates, with restrictions easing as infection rates drop and *vice versa*. The ecological and social impacts of the pandemic and more importantly, the pandemic-induced regulations are being studied within SANParks.

An empty jetty at Thesen's Island, Knysna, during the initial "hard" lockdown. This jetty is usually very popular with fishermen.

A YEAR MARKED BY COVID-19

Reflections on lessons learned from COVID-19 create an opportunity for positive change

Research feature

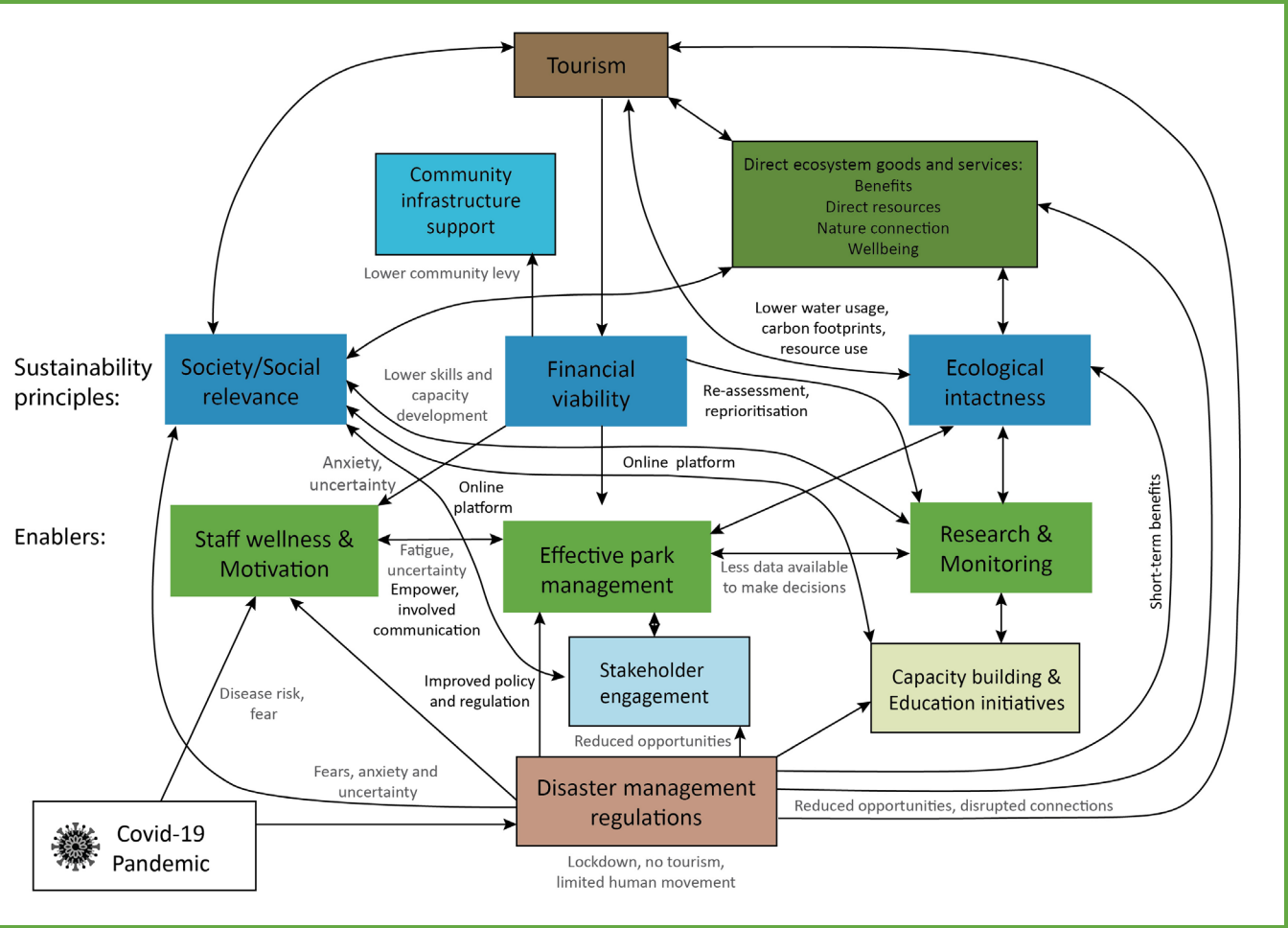
Text by Izak Smit, Kyle Smith, Mohlamatsane Mokhatla, Louise Swemmer, Dirk Roux, Stefanie Freitag-Ronaldson, Luthando Dziba & Howard Hendricks
Photo by Mightyman Mashele

The COVID-19 pandemic forced SANParks into crisis mode for most of 2020, including having to navigate operational changes in compliance with national regulations and a lack of income. In some ways, SANParks has weathered this storm so far but ongoing longer and lag effects are expected; e.g., some estimate that tourism in SANParks may take five years to recover to pre-COVID levels. During this unprecedented time, Scientific Services realised that COVID-19 is a "large infrequent disturbance" and capitalised on using it as a learning opportunity. Several COVID-19 related studies were initiated, the results from three of these are presented here.

The three studies provide a tapestry of variable impacts, vulnerabilities, challenges and opportunities identified from the level of the individual to the level of the organization. The first study, in conjunction with the Human Capital Development Division, explored the wellbeing of individual staff members during lockdown. A total of 446 colleagues from across a wide-range of functions participated in an online survey. The second study explored, through an in-depth survey, how SANParks' scientists navigated the hard lockdown. The final study, published as part of a Special Issue on the conservation and ecological effects of COVID-19 in the international journal Biological Conservation, focused on how COVID-19 impacted SANParks ecologically, socially and financially. This paper consulted various external (e.g., Department of Forestry, Fisheries and Environment) and internal sources (12 park managers, 10 section rangers, tourism department, socio-economic transformation and the office of the Chief Financial Officer).

> COVID-19 and the associated lockdown levels reverberated across the ecological, financial and social dimensions of SANParks – although many negative impacts were experienced, it also created learning opportunities and experimenting with doing things differently.

Various lessons emerged from the three studies. These lessons are not specific to COVID-19, but more generally how SANParks and society are affected by, and respond to large infrequent disturbances. Firstly, it was recognized that any disturbance (e.g., pandemic, economic crises, social instability, natural disasters) will reverberate through the entire SANParks system. If you "shake" one box in the "SANParks ecosystem" (Fig. 1), then you shake all other boxes. Similarly, due to these interconnections, if any component is neglected or deteriorates (e.g., tourism infrastructure, staff motivation), then the entire system is vulnerable and at risk. Secondly, it became clear that SANParks must think of ways to build resilience into the organizational social-ecological system. For example, in the same way that ecological diversity enhances ecosystem resilience, diversity of funding streams would enhance organisational resilience and policy that promotes diverse workplace arrangements would enhance employee resilience.



COVID-19 and lockdown regulations highlighted the interconnectedness of people and nature and the dependences, cascades and feedbacks between the ecological, social and financial dimensions of protected area management.

Two very positive lessons emerged from SANParks' COVID experience. Firstly, a crisis can act as a catalyst for initiatives that may benefit conservation outcomes but would otherwise be hard to get off the ground and operationalize (e.g., building of relationships through distribution of food parcels to vulnerable communities bordering national parks, creating local economic opportunities through employing local sewing groups in communities adjoining Kruger to make masks, and distributing these masks to traditional health practitioners). Secondly, massive organizational (and more broadly, societal) change is possible – old ways can be changed, giving hope for tackling broader global challenges like climate change.

The lessons learned above also have implications for how the organization can adapt to be more resilient in the future. This includes increasing the financial resilience of the organization, and making SANParks less vulnerable to perturbations to tourism (this may include not only disease outbreaks, but also events such as economic crises and water shortages due to droughts). SANParks must invest in all components of the SANParks ecosystem (e.g., staff morale and wellness, supporting infrastructure, biodiversity and natural capital, social relevance and community support, and people-nature connections) as these will make SANParks more resilient to future shocks, whatever forms these may take. It was also clear from the staff surveys that some staff experienced higher productivity working from home than from the office (39.2%), whilst others experienced a decline in productivity (19.5%). As such, SANParks should explore enabling policies that support employees to flourish and grow in their organizational commitments in diverse ways. Considerable financial, time and carbon savings were experienced due to online meetings, and this practice should be continued where appropriate to

Traditional Healer Practitioner with personal protective equipment donated by SANParks (supported by the Honorary Rangers).

compliment purposeful face-to-face engagements. For this SANParks will have to continue to invest in ICT systems. The study exploring how scientists experienced the hard lockdown, highlighted that many experienced great reward spending time without distraction to undertake deep, engaging and significant work. SANParks should explore ways in which enabling conditions and purposeful opportunities (e.g., focused retreats, short sabbaticals, sister organization exchanges) can be encouraged, possibly even as performance rewards, for staff in various functions within the organization. This will add to staff wellness, and create opportunities for staff to escape the trap of routine operations, crisis management and enhance and rejuvenate innovation, motivation and productivity.

The lessons learned and ways in which SANParks adapted during the COVID-19 pandemic should inform practical and strategic decisions within SANParks for positive ecological (e.g., greener operations), financial (e.g., multiple income streams) and social (e.g., staff wellness, diversified benefit sharing initiatives and enhancing people-nature connections) outcomes, towards sustainability.

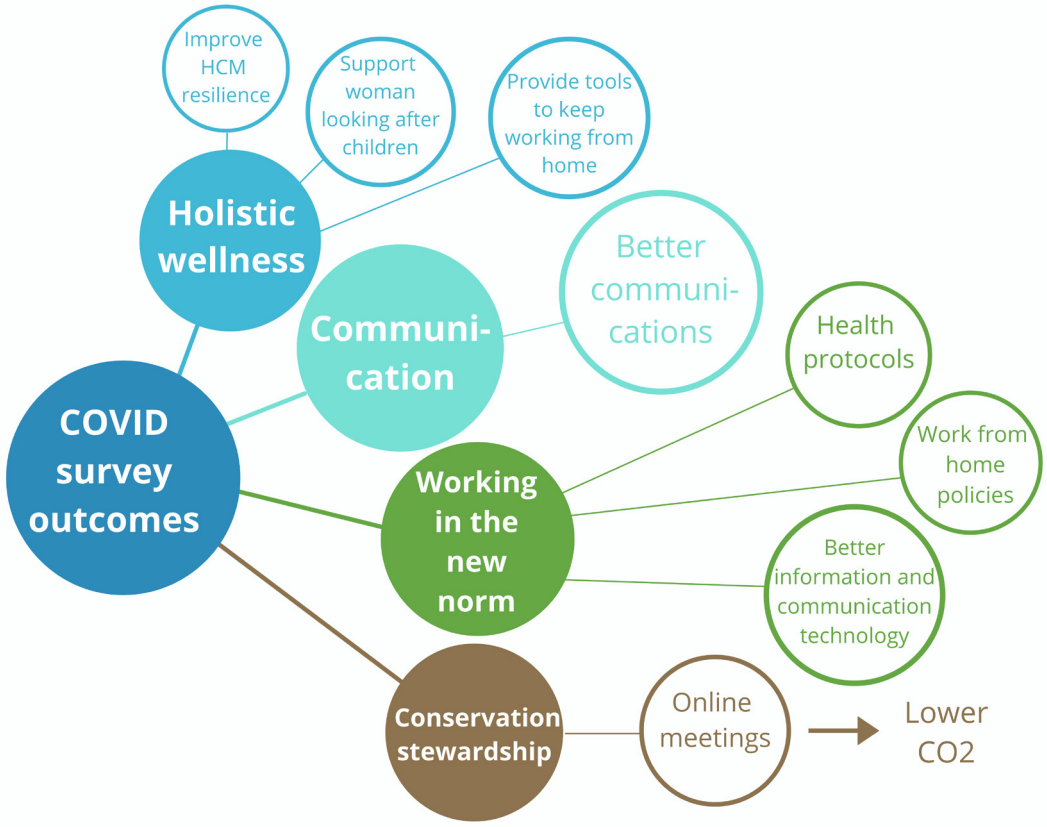
Mokhatla M, Freitag-Ronaldson S & Hendricks H. 2021. The impact of COVID-19 on the general wellbeing of SANParks employees: reaffirming the "human" in Human Resources Management. SANParks Scientific Services Internal Report 03/ 2021.

Smit IPJ & Freitag-Ronaldson S. 2021. SANParks Scientific Services reflections on COVID-19 and associated lockdown: Feedback from an internal survey. SANParks Scientific Services Internal Report 02/2021.

Smith MKS, Smit IPJ, Swemmer LK, Mokhatla MM, Freitag S, Roux D & Dziba L. 2021. Sustainability of Protected Areas: Vulnerabilities and opportunities as revealed by COVID-19 in a National Park Management agency. Biological Conservation, 255: article 108985. (* Equal contributions)

SANParks staff wellness and experiential assessment during hard lockdown

Text by Mohlamatsane Mokhatla & Stefanie Freitag-Ronaldson



Well, weren't we all tired of travelling, meetings and generally stressed out before March 2020? COVID-19 knocked us just as we were preparing for the close of our financial year with hopes of a better 2020/21, and little did we know how much our lives would change. The year 2020 presented us with a lot of challenges, foremost being the need to pause and enjoy the moment, no matter how insignificant we thought it might be. COVID-19 disrupted all aspects of our lives; how we work, live and play. To determine the impacts of these disruptions on our lives, we administered a survey to almost 2000 SANParks employees on their wellbeing during the initial hard national lockdown between March 2020 and June 2020. During this period only 33.9% of staff continued to work at their normal workstations. Although the impacts varied, 90% of respondents were concerned about the impact of COVID-19 on their well-being and their families' wellbeing, and 97% were concerned about the sustainability of SANParks. Most employees were in lockdown with families, with only 13.9 % going through lockdown alone, but all suggesting that working under lockdown was challenging. Despite these challenges, 53% of employees felt comfortable completing their tasks under these conditions and most experienced increased work efficiency and received adequate communication from their managers.

Despite the challenges, employees suggested that COVID-19 has taught some lessons for the organisation to consider as we navigate the next few years (see diagram), including holistic wellness, adequate resources and preparedness to work in the 'new norm', environmental stewardship and better communication. Although the full extent of the impacts of COVID-19 on SANParks and individuals are not known, respondents expressed a feeling of gratitude towards SANParks' dealing with the situation while ensuring salaries throughout this time and hope around the ability of SANParks to bounce back from this setback.

MORE THAN JUST A MASK engaging with traditional healers during COVID-19

Text by Louise Swemmer

"We are so happy to get the masks, sanitiser and messages from KNP. It means that you remember us"

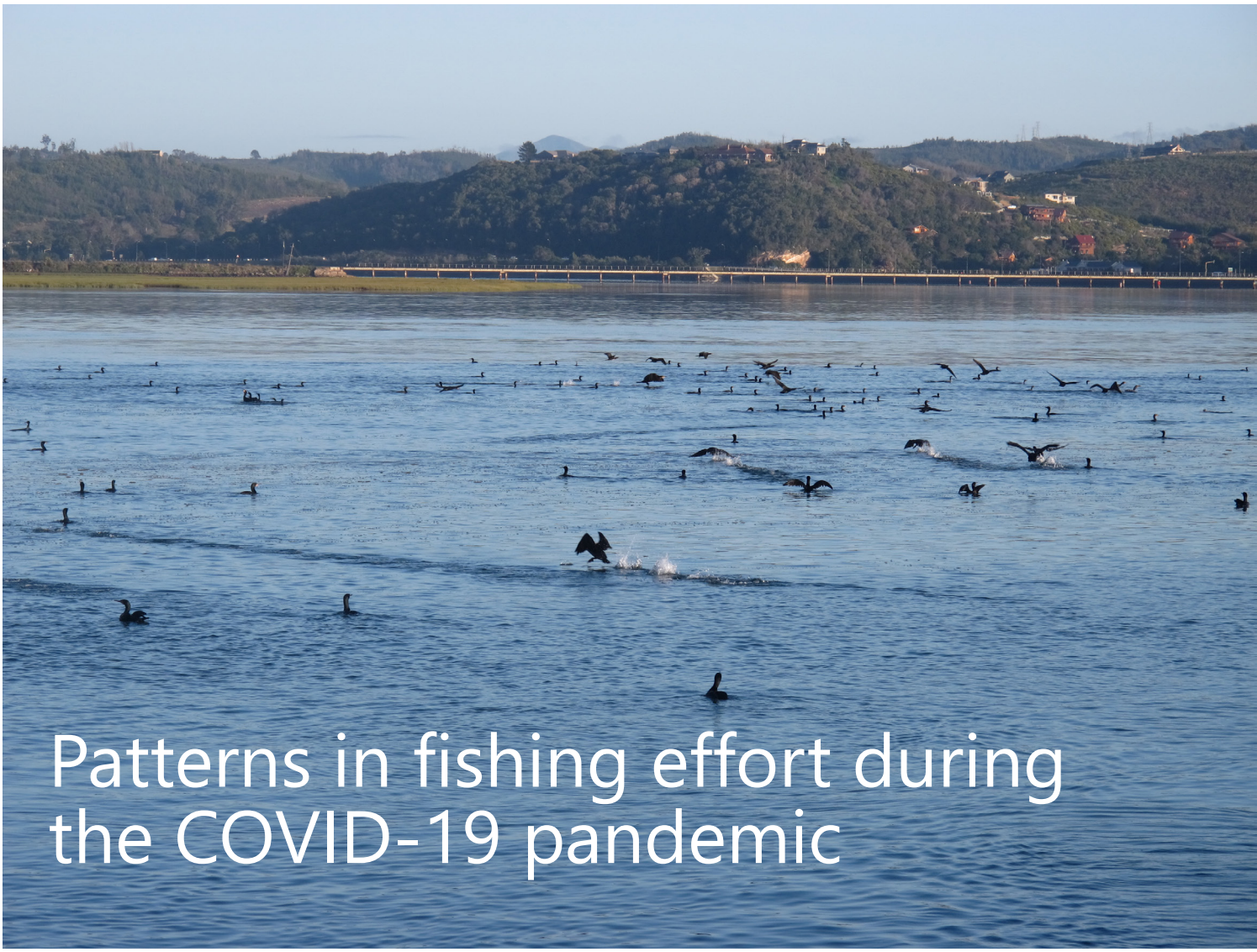
The COVID-19 virus has been a shock to the system, especially for health workers across the world who have been working tirelessly to save lives. However, it's not just health workers in more conventional settings that had to assist with responding to COVID-19; the thousands of Traditional Health Practitioners (THPs) living next to the Kruger National Park (KNP) are often the first stop when local community members need health care.

Traditional medicine has been around for a long time, with many people in developing countries depending on it for primary health care. In South Africa, about 40 million users consult THPs annually for physical and psychological illnesses and needs. THPs help to keep people healthy, are valued members of their communities, are holders of significant indigenous knowledge and play important roles in society as community stabilisers. The COVID-19 virus has placed THPs at risk due to exposure to high viral loads as they are widely consulted by members of their communities when falling ill. Furthermore, many THPs are elderly and as such vulnerable should they contract the virus.

Generous donations of over R 400,000 from the Honorary Rangers enabled SANParks to provide COVID-related support to approximately 3000 THPs adjacent to the KNP. Locally-made cloth face masks and hand sanitiser, as well as awareness material in the form of printed information brochures were provided. Furthermore, bulk-sms messages were sent to the healers via their cell phones during the peak of the pandemic. All material was translated into Tshivenda, Xitsonga, Sepedi and Siswati, the most commonly spoken languages in the area. The local sewing groups that made the masks benefited at a time when household incomes were negatively affected by the lack of tourism.

Although the coronavirus pandemic sparked a new type of engagement, SANParks has a long history of working with THPs mostly through the pepperbark (*Warburgia salutaris*) project. Healers are provided with saplings of this endangered medicinal tree that they then grow at home and use in their own practices. The social networks developed as part of the pepperbark programme enabled the effective implementation of the COVID-support programme, and the relationship between the KNP and the traditional healers has grown with both people and conservation benefits.

Covid 19 provided some innovative inspiration to do things differently, with SANParks supporting approximately 3000 traditional health practitioners living adjacent to the Kruger National Park, with protective equipment to help fight the virus.



Patterns in fishing effort during the COVID-19 pandemic

Text by Kyle Smith & Mohlamatsane Mokhatla
Photo by Kyle Smith

A flock of cape cormorants enjoy the quiet waters of Knysna Estuary during the stricter lockdown levels.

The COVID-19 pandemic is a global crisis that has, and continues to impact our lives in multiple ways. In an effort to slow transmission and assist health care systems, governments restricted human movement through travel bans and stay at home directives. Known as lockdown regulations, the severity of restrictions implemented varied according to infection rates, with restrictions easing as infection rates dropped. The ecological impact of the pandemic and the pandemic-induced lockdown is still being investigated. In the Garden Route Scientific Services staff was permitted to continue with a long-term monitoring project assessing patterns in estuarine recreational and subsistence line-fishing throughout the different lockdown levels.

On Swartvlei Estuary, significantly higher fishing pressure occurred during level 4 and in particular level 3 than pre-lockdown (Fig. 1). However, no significant difference was observed between pre-lockdown and lockdown level 5. Although level 5 was a hard lockdown, 3 fishermen were recorded fishing during this period. High variability pre-lockdown combined with these three observations resulted in no statistically significant difference, even though there was a trend of lower fishing effort during level 5. In reality, however, both our monitoring and the law enforcement records indicate that no other fishing effort occurred during level 5 which resulted in really low fishing effort for level 5. On Knysna Estuary trends were similar with a significant difference in fishing effort between pre-lockdown, lockdown level 5 and 3, with an increase in fishing pressure occurring during level 3 (Fig. 1). No monitoring

The COVID-19 pandemic had a significant impact on estuarine fisheries with an expected decrease in effort during the initial level 5 hard lockdown (~March 2020), increasing to very high levels of fishing effort occurring during level 3 (from June 2020)

occurred on Knysna Estuary during level 4 lockdown.

The increase in pressure during levels 4 and 3 were due to several factors which included the allocation of subsistence exemption permits by the government (these fishermen could access the estuaries during level 4), the coastline being closed to the public and hence pushing coastal fishing pressure onto the estuaries, recreational fishermen accessing the waterways (from level 3) which included students and employees not back at work who were fishing as means to "relax" and to "pass the time", and lastly, as salaries were cut or jobs lost, additional subsistence or supplementary type fishermen (fishing for sustenance or to supplement diet) entered the fishery. It is predicted that fishing effort will stabilise and potentially decrease over the next few months. However, the ratio of recreational vs. subsistence fishing may change as reliance on natural resources to supplement food security potentially increases.

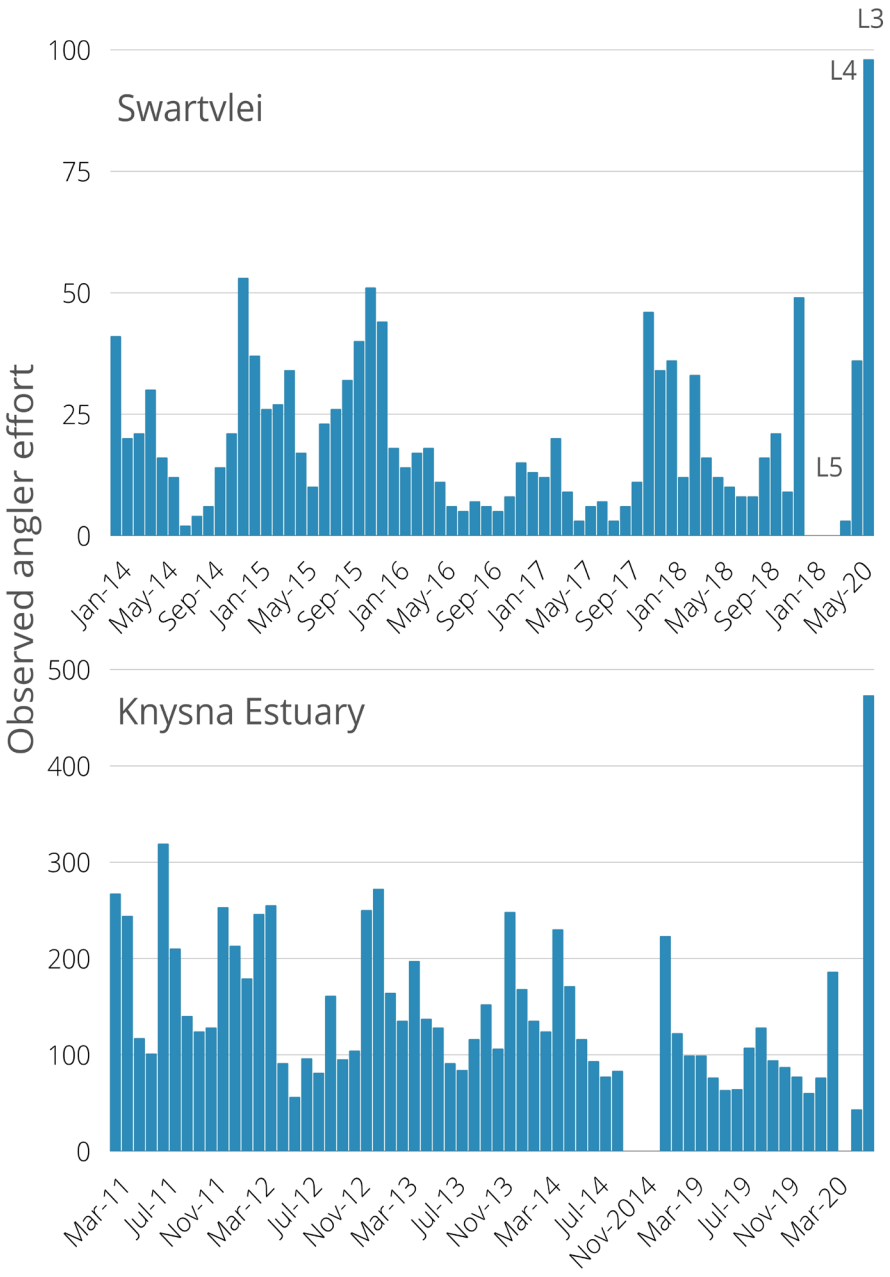


Figure 1. Observed monthly fishing effort on Swartvlei and Knysna Estuary. After low fishing effort during level 5, fishing effort increased drastically during level 3. No data indicate that no surveys took place.

Conducting field work during COVID-19: working towards assessing veld condition remotely

Text by Abel Ramoelo, Hugo Bezuidenhout & Nkabeng Mzileni
Photos by Nkabeng Mzileni & Roxanne Erusan

Combining field methods with remote sensing products may assist in remotely assessing veld condition in future

The COVID-19 pandemic significantly affected the approach and feasibility of conducting field work. In this novel "environment" innovative approaches and collaborations have become standard to continue with field work. Vegetation monitoring in national parks aims to determine potential changes in key habitats and plant communities as a result of drivers such as climate and herbivory and the consequences for the park. We used remote sensing with associated ground truthing in Mokala National Park as a case study. One of the most commonly used vegetation indices is normalized difference vegetation index (NDVI). NDVI uses remotely-derived reflectances on the near-infrared and red spectrum. NDVI values range from -1 to 1, where 1 is green dense vegetation , 0 represents no vegetation and -1 is snow or bare soil. Using time-series NDVI, various vegetation condition change or trend indicators were developed. The vegetation condition index (VCI) is a commonly used indicator for determining change associated with drought and overgrazing (Fig. 1). VCI indicates how the current NDVI is above (values above 50%) or below normal (values below 50%) conditions. The above normal values are associated with improvement in vegetation condition and the cover as compared to normal conditions, and vice versa for below-normal conditions.

In tandem with the NDVI calculation, we also conducted Veld Condition Assessment (VCA) on the ground to link the physical vegetation and remote sensing indexes. Habitat suitability is dependent on plant species composition, vegetation structure and the distribution of the plant communities, which is assessed by VCA and plot surveys. Certain grass species are unpalatable and not preferred by grazers, while some wildlife simply prefer specific types of grasses. By combining these two methods, we can reduce the frequency of site visits because we can better understand and interpret the VCI based on the NDVI. In this respect both qualitative and quantitative aspects of the veld condition are addressed.

Dr Hugo Bezuidenhout records surveys while Roxanne Erusan walks the transect and Lufuno Munyai and Correra Links identify species.

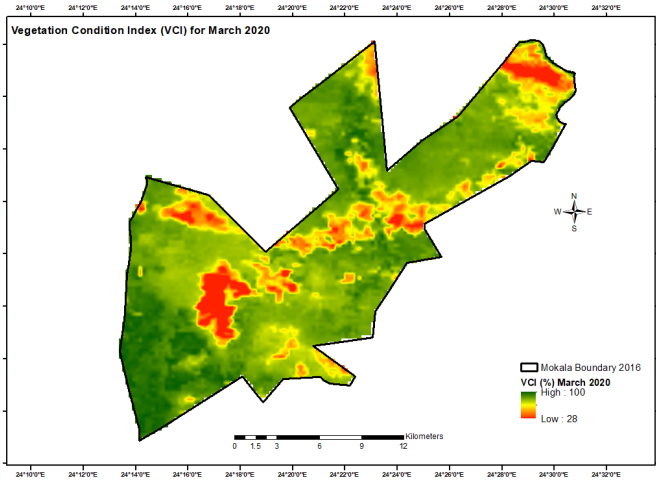


Figure 1. Vegetation condition index (VCI) map for March 2020, relative to March 2001 – 2020. Below normal conditions are indicated by values less than 50% (more red), and values above 50% (more green) indicate above normal condition.

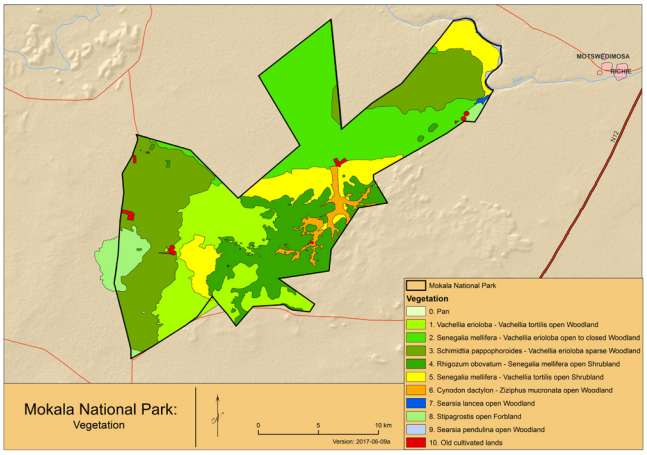


Figure 2. Plant communities of Mokala National Park (Adapted from Bezuidenhout et al. 2015).

Preparing for veld condition assessments in Mokala National Park; such fieldbased methods will be correlated with remote sensing products to enable researchers to monitor veld condition remotely when they cannot work in the field.

COVID-19 created a brief pause in rhino poaching in Kruger

Text by Sam Ferreira
Photo by Cathy Greaver

Various lockdown regulations associated with the COVID-19 pandemic are shrinking economies, leaving poorer people more vulnerable. In addition, the loss of livelihoods has forced food insecurity upon thousands of citizens that in some instances culminates in increased snaring for bush-meat and poaching of game. At the time of strict lockdown (levels 5 and 4), the associated regulations disrupted international flights, restricted local movement, and hindered access to national parks. SANParks was interested to find out if poaching of high value species like rhino would actually reduce in response to robust enforcement of lockdown rules.

Year-on-year trends in weekly poaching incidents from 2017 to 2019 helped predict the expected weekly carcass count in 2020. Trends predicted that rangers would find 68 carcasses in April and May. However, during the "hard" lockdown of April and May, rangers found only 14 carcasses ascribed to poaching (patrol effort stayed the same as essential services were not disrupted by lockdown). However, since the ease of lockdown restrictions in June 2020, poaching has returned at an unprecedented rate. In fact, from June to December 2020 rangers found 165 poached carcasses, 20 more than the 145 found in the same months of 2019.

South Africa's risk-adjusted lockdown response to the COVID-19 pandemic created a poaching pause experiment with a key lesson. SANParks should seek ways to recreate the short-term disruptive effect that adequate law enforcement of rules imposed by South Africa's hard lockdown had on the illegal supply chain of rhino horns. If this could be successfully done, the result would be at least 80% reduction in poaching risks to rhinos with a recovery of white and black rhinos in Kruger to pre-poaching population levels in 20 to 30 years. The time is now to pause poaching permanently.

While the humans were away...

Text by Jessica Hayes & Kyle Smith
Photos by Nicola van Wilgen-Bredenkamp

While humans were locked in their houses as a result of COVID-19 regulations, animals came out to play.

During the early months of the COVID-19 lockdown when much of the global population were under some form of movement restriction, media reports started circulating of wildlife behaving differently and being seen in areas they would usually avoid - from kudu and penguins in urban areas to wild dogs roaming through the Skukuza staff village in the Kruger Park.

This historic shut-down of human movement provided a unique opportunity to improve our understanding of how humans and wildlife interact. However at the same time COVID-19 regulations disrupted research programs and limited the ability of scientists to undertake field work and observations. Citizen science projects were also interrupted but projects designed with an online reach were possible. In this regard, we wanted to hear from the public what they had seen or experienced, and what broad environmental observations they may have made during this extraordinary time spent locked in their homes.

A short online survey provided twenty-seven responses; most were based in the Garden Route. Three of the twenty-seven were essential service workers and could move around during the lockdown.

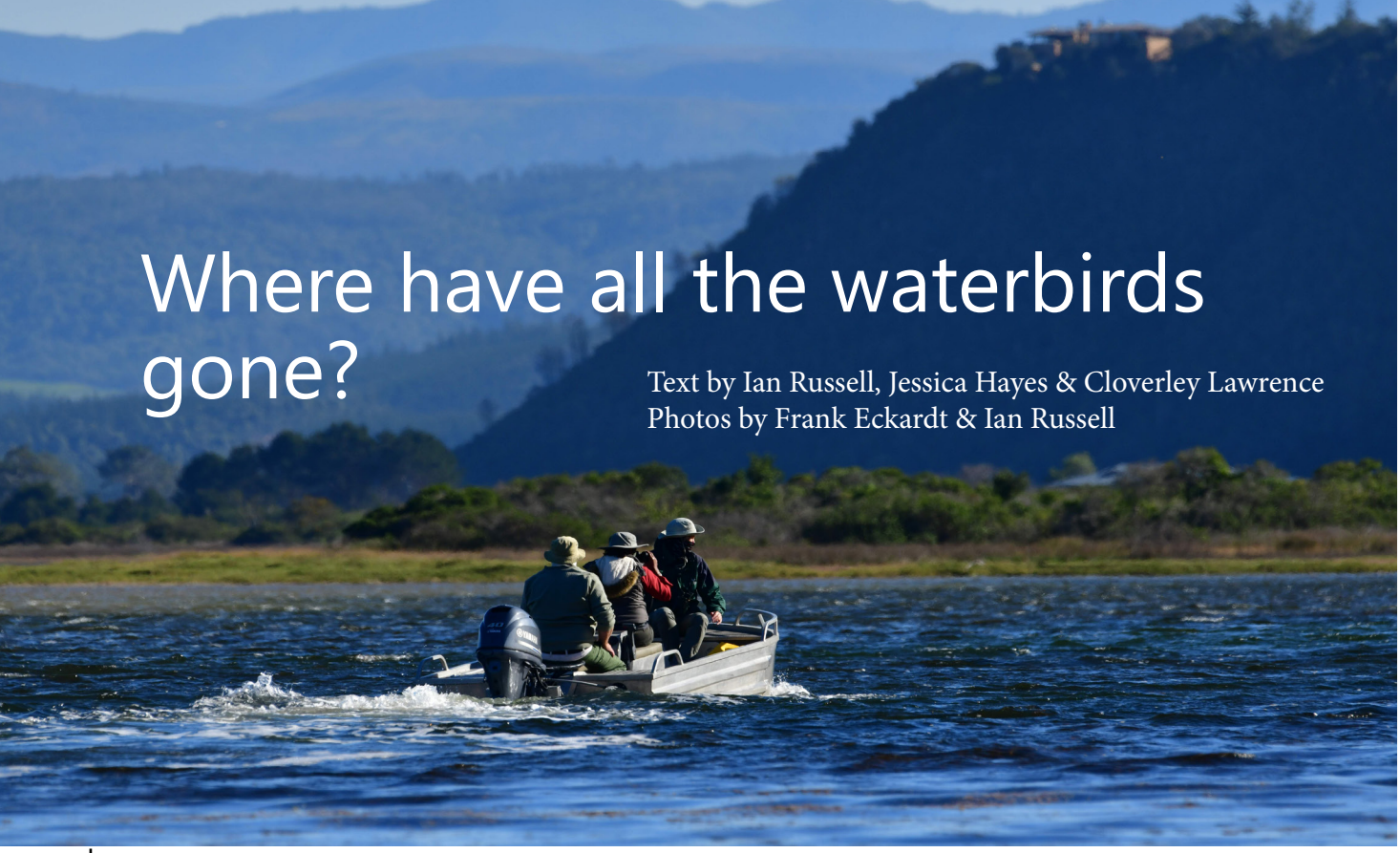
Forty one percent of the respondents mentioned the enjoyment they had found in their gardens; from observing daily butterfly activity to observing nighttime insect life for the first time. Many (40%) also reported sighting wildlife or signs of activity they had not seen before. Bushbuck roamed freely both day and night in some suburbs, while bush pig and porcupines ventured further from their greenbelts to mine surrounding gardens at night in search of bulbs and tasty plants.

People noticed a change in primate behavior in that baboons

Many animals seemed more at home in urban spaces when people were "lockdown'ed" in their houses. Raptors and owls were frequently spotted during the initial stricter lockdown levels, happily visiting suburban gardens during the daytime.

and monkeys seemed more peaceful, yet the incidences of food raids were higher than usual. Of the respondents, 70% specifically mentioned birds and raptors – either a perceived increase in activity, calls and even the sighting of new species. Some noticed a change in the behavior of scavengers, with less sacred ibis, crows and gulls frequenting urban areas. Could they have been feeding elsewhere, was it because people dealt with their rubbish differently or timed rubbish collection differently? Approximately 60% noticed a change in sound, with either less human generated noise (road and air traffic) being mentioned or people becoming aware of sounds they had not noticed before, like the ocean. A further 20% noticed an improvement in air quality.

It was an interesting opportunity to get people thinking about what goes on around them, which during our normal busy, noisy daily routines, may not be noticed. As one respondent said "the world seemed to go quiet and people disappeared." The global slowing of modern human activities during lockdown may have influenced wildlife movement and behavior both positively and negatively. Pooling multiple sources of data from formal research projects and citizen science observations during this period, and as restrictions ease, will provide a unique understanding of human wildlife interactions. Responses from our small sample size highlighted how important garden spaces and nature were to people during lockdown. Going forward it will be important to understand how the pandemic may have changed people's interaction with, and value of nature.



Where have all the waterbirds gone?

Text by Ian Russell, Jessica Hayes & Cloverley Lawrence
Photos by Frank Eckardt & Ian Russell

One of the few intriguing aspects of the COVID-19 lockdown in 2020-21 was the apparent wildlife behavioural changes in response to the relative absence of humans. Many were fascinated by shared images of African penguins waddling down previously busy streets in Simonstown, and lions reclaiming their turf on the Skukuza golf course. Bearing this in mind, when SANParks scientists undertook two waterbird surveys on the Wilderness lakes, firstly during hard lockdown in July 2020, and again in January 2021 when most public access to waterbodies and beaches was prohibited, the expectation was that waterbirds would be more abundant than usual.

Surprisingly this expectation was unmet, with the total count in January 2021 actually being the lowest in the 30-year history of the program, with only 4234 individuals recorded compared to a long-term average of 11655. Although declines were recorded in a number of species, the two biggest changes occurred in gulls (0 on Wilderness lakes; long-term average = 24) and the usually abundant red-knobbed coot (1635 on Wilderness lakes; long-term average = 3704). It is possible that gulls, which tend to use the lakes mostly for loafing, do so because of regular disturbances on adjacent beaches and coastlines, particularly during high people-traffic holiday periods. Lockdown restrictions over the year-end traditional holiday period, which left beaches devoid of all but 'fishermen', possibly enabled gulls to preferentially use coastal ecosystems rather than the lakes.

The situation is somewhat different for the red-knobbed coot. This waterbird feeds almost exclusively on submerged plants, which are usually abundant in the Wilderness lakes. Aquatic plant abundance, however, does vary over time, and was observed to be very low in two of the four waterbodies during waterbird surveys. It's likely that many red-knobbed coots had temporarily moved to other waterbodies in the region that offered better feeding opportunities, which accentuates that we should not lose sight of the bigger drivers in aquatic ecosystems that affect species abundances, of which human disturbance, or the absence thereof, may not always be the most influential.

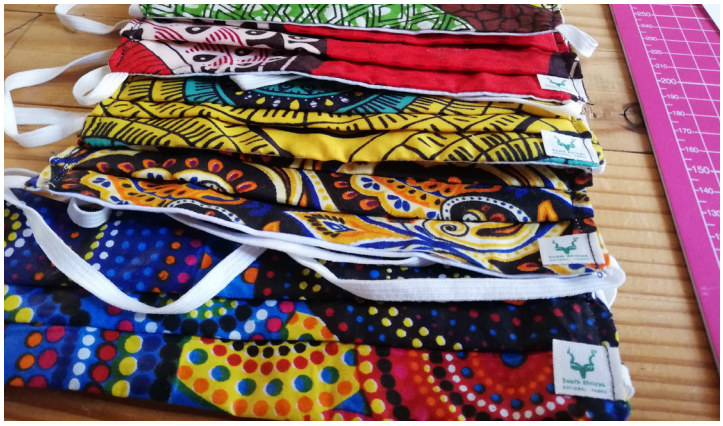
Kelp gulls are temporary visitors to the Wilderness lakes, and occur mostly on the Swartvlei and Touw estuaries where they commonly use sandbanks as areas for resting and preening.

Scientists expected an increase in waterbird numbers for periods when the beaches were closed to the public during lockdown in the Garden Route. Surprisingly, the count that took place during January 2021 on the Wilderness lakes was the lowest in 30 years for many species. Whether birds moved temporarily to other waterbodies will only be answered after the next survey.

New ways of connecting...

COVID-19 did not only create challenges but also opportunities for reaching out to others. National and international responses to the COVID-19 pandemic relating to Lockdown regulations increased unemployment rates in many communities surrounding national parks through job retrenchments and furloughs. The ecotourism sector, which is a major contributor to jobs in the country, was particularly hard hit by travel bans and business closures. SANParks and its staff tried to help where they could and a few examples include; during level 5 lockdown in May 2020, staff of the Cape Research Centre and the Table Mountain National Park operations and people and conservation units joined forces to provide food parcels to neighbouring communities of the Table Mountain National Park including the ex-forestry community in Tokai (pictured here top and left). At the same time, the Savanna node arranged with local sewing groups to make masks for distribution to traditional health practitioners (using donations from the Honorary Rangers) (left and bottom). More generally and although not by any means sufficient to deal with the crisis of food and nutrition insecurity in the region, SANParks supported indigent families that live in areas adjoining Kruger National Park through providing about 5,000 food parcels and 80 water tanks to needy communities. It also partnered with the Oak Foundation and CFAM technologies (North West University) to supply US$100,000 worth of nutritious whole-grain instant porridge fortified with various minerals and vitamins that enhances immunity.

- Text by Alison Kock and Danny Govender, photos by Hilton Blumeris and Louise Swemmer

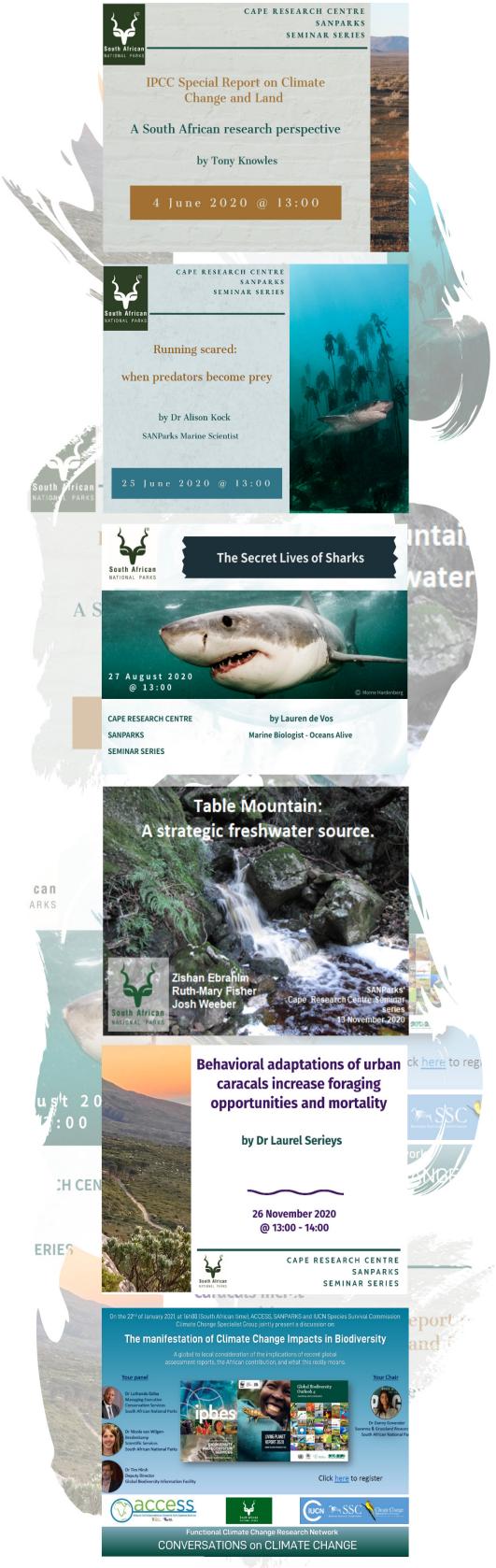


in the time of COVID-19

Shifting to a 'new normal' of meeting in cyber-space

Text by Avhavhudzani Phophe

The COVID-19 pandemic has made it very difficult to plan or conduct in person meetings or presentations. As a result, SANParks adopted a 'new normal', shifting face-to-face seminars online. The Cape Research Centre (CRC) used a series of webinars as a communication tool to report on research and monitoring conducted in and around parks as well as at a broader scale. While nothing can replace meeting in person, these online seminars have been very successful, with the audience size increasing tremendously when compared to conventional talks, and no need to fight the Cape Town traffic. Opening up the seminars in virtual space has enabled attendance by a broad audience that includes scientists and managers from SANParks, interested members of the academic and honorary ranger community, as well as a network of local and international SANParks collaborators. In the 2020/21 year, the CRC hosted 14 webinars. Twelve were led by SANParks and 2 were co-hosted with IUCN SSC Climate Change Specialist Group (CCSG) as well as a joint SANParks/IUCN/ACCESS seminar as part of the Access Conversations on Climate Change series. The latter was particularly well-attended with over 170 participants and over 150 subsequent views on YouTube.



Graphic: Marna Herbst

Researcher searching for velvet worms, Garden Route National Park, Aaron Barnes


NEW
DISCOVERIES

NEW DISCOVERIES

IN THIS SECTION
New Mayflies from Kruger
New species in Richtersveld
Fossil track sites from Garden Route
Velvet worms from Garden Route

The Olifants and Letaba Rivers are often in the news for the wrong reasons; pollution, crocodile deaths, drying up due to over-abstraction and drought. Even so, 2020 saw the discovery of two new mayfly species from these rivers. World-renowned mayfly expert, Dr Helen James from the Albany Museum in Makhanda and her counterpart, Dr Peter Malzacher from Germany, made the discoveries and named one of them after the Letaba River (*Caenis letabanensis n. sp.*) Feast your eyes on photographs of these new species taken under the microscope.

- Hendrik Sithole

Caenis albicans (male)

Caenis letabanensis (male)

BOTANICAL BEAUTIES FROM THE RICHTERSVELD

Pieter van Wyk

I grew up knowing plants from the Richtersveld. It is a journey that started when I was in pre-school with my grandmother, mother and Mr Jakop Joseph, a Nama Shepherd. From them I learnt the food and medicinal uses of the desert plants, as well as the superstitious beliefs surrounding the plants. I started working as an Environmental Monitor for Richtersveld National Park in October 2013. In 2015, I applied for a permanent position as nursery assistant, to which I was successful, and in 2018 my position was upgraded to Nursery Curator. During weekends and in my spare time, I explore the region's botanical richness. All this time in the field has resulted in some exciting new discoveries!

11 plant species rediscovered that was thought to be extinct

Cyanella marlothii was rediscovered after last seen in 1925.

26 new plant species

Microloma cf. sagittatum, a new species for Richtersveld.

6 first records of plant species for South Africa

1 new species of monkey beetle

1 new species of spider

A new species in the Aizoaceae family which may also be a new genus.

400 first records of plant species for Richtersveld

Helichrysum hamulosum is a first record of this fynbos species for Richtersveld, the closest population is 350 km to the south.

FOSSIL VERTEBRATE TRACKSITES IN GARDEN ROUTE NATIONAL PARK

Charles Helm

Left: Flamingo tracksite, Garden Route National Park; scale bar = 10 cm. Tracks were made in wet sand which metamorphises into rock over time.

The Cape South Coast Ichnology project (based at the African Centre of Coastal Palaeoscience at Nelson Mandela University) has made some exciting discoveries and published the work in three papers. The first paper, published in South African Journal of Science, featured large reptile tracks and traces. These were attributed to crocodiles and monitor lizards, neither of which currently occur in the southern Cape. This led to conclusions on warmer environments. An interesting feature on one of the surfaces containing crocodile tracks was a pair of Middle Stone Age tools.

The second paper, published in Ostrich, described a variety of coastal avian tracksites, two of which were identified in Garden Route National Park. At one of these, tracks resembled those of flamingoes, but were larger than the tracks measured currently of the Greater Flamingo. This site also yielded a global first in the fossil record: the feeding traces that flamingoes make when they rhythmically 'stomp' in order to stir up a food supply. A nearby site exhibited a trackway of a large bird, probably web-footed, that did not correspond with tracks of any existing species. Inferences could be made that Pleistocene birds were larger than their extant counterparts, with the possibility of previously undocumented Pleistocene avian extinctions in southern Africa. The flamingo site was obliterated by a storm surge in the summer of 2020.

The third paper, also published in South African Journal of Science, reported on recently identified hominin tracksites, one of which is in Garden Route National Park (two are in the adjoining Goukamma Nature Reserve). The tracks were found on the ceiling of a small cave. Tracks of varying size indicated the presence of possibly a family group moving down and along a dune surface. Southern Africa now boasts six hominin tracksites, all from the Pleistocene and all attributed to our own species, *Homo sapi-*

"Three scientific papers published in 2020 draw attention to features in the coastal section of Garden Route National Park. Through this project, more than 250 Pleistocene vertebrate tracksites have been identified between Arniston and Robberg over a fourteen-year period."

Below: Circular groove feature with central depression in Garden Route National Park; scale bar = 10 cm.

Top: Crocodile trackway in Garden Route National Park; scale bars = 10 cm.

Left: Hominin track, Garden Route National Park; track length = 24 cm.

ens. One of these sites is in West Coast National Park. It is apparent that such hominin tracksites are more common in the region than previously supposed.

These papers followed a paper published in Proceedings of the Geological Association in 2019, describing patterns in the sand (now cemented into rock) that appeared to have been made by our human ancestors. Two of these sites lay within Garden Route National Park. An intriguing feature was a circular groove, with a central depression that hinted at how it was created. Adjacent to this, and at the second site, there were patterns that suggested foraging behaviour. Three of these rocks could be recovered, and are now safely accessioned and preserved.

In combination, these studies demonstrate the remarkable ability of rock surfaces in Garden Route National Park to contribute to the understanding of Pleistocene palaeoenvironments and of climate change. Furthermore, these studies contribute to the understanding of the origins of early modern humans. The sites are fragile and ephemeral and are easily vandalised due to the soft nature of the rock, and ongoing vigilance is required to identify newly exposed sites, and to document them before they disappear.

Helm CW et al. 2020. Newly identified hominin trackways from the Cape south coast of South Africa. South African Journal of Science 116(9/10): 13 p.

Helm CW et al. 2020. Pleistocene large reptile tracks and probable swim traces on South Africa's Cape south coast. South African Journal of Science 116(3/4), 8 p.

Helm CW et al. 2020. Large Pleistocene avian tracks on the Cape south coast of South Africa. Ostrich. https://doi.org/10.2989/00306525.2020.1789772

NEW ‘OLD’ SPECIES DISCOVERED IN THE GARDEN ROUTE AFROTEMPERATE FORESTS

Text by Aaron Barnes, Melanie de Morney, Stefanie Freitag-Ronaldson & Nandi Mgwadlamba
Photos by Aaron Barnes

South Africa has two genera of velvet worms - *Peripatopsis* occurring mainly in the Cape and *Opisthopatus*, occurring in the north-east of the country. They are nocturnal predators, ambushing other invertebrates with sticky slime squirted from a pair of specialised glands on their heads. Most velvet worm species give birth to live young (most females have a placenta), have been observed caring for their young and some even have a social structure led by matriarchs, like elephants, who leave a scent for families to follow their whereabouts.

During fieldwork for a recent study of Cape velvet worms by Stellenbosch University researchers Aaron Barnes, Savel Daniels and Till Reiss, new species were discovered in the Garden Route's indigenous forests! Formerly one velvet worm was known from Knysna, *Peripatopsis clavigera*, however, there are actually five different species. Historically, species were differentiated using only morphology (i.e. what they look like, including leg counts) but species often look very similar. Therefore, the researchers used DNA analyses to confirm species classifications and better understand the evolutionary relationships and the effects of major historic climatic changes in the region.

Velvet worm movement is highly restricted, and they only occur in pristine habitats, generally in damp decaying logs within Afrotemperate forests. Based on previous findings, the researchers expected to find three species at most within geographically isolated areas. Instead, velvet worm species were found to be randomly distributed across forest patches, sometimes with several species in the same log, an unexpected finding.

The Afrotemperate Southern Cape forests distribution was shaped by climatic conditions, characterised by alternate wet and dry periods. Associated forest contraction and expansion events would have either hindered or assisted velvet worm movement. Populations probably moved slowly from one area of the forest to the next during wet conditions but were cut off from each other during dry conditions, resulting in speciation.

Indigenous forests of the Garden Route National Park present a unique 'playground' for discovering new species and understanding diverse past and present ecological processes. Studies like this highlight the importance of maintaining healthy indigenous forests and the wonders of nature they harbour, with so much more left to understand and discover.

Photographs of a single live velvet worm representative per locality from each of the five *Peripatopsis clavigera* clades and *P. tulbaghensis*, sp. nov. (A) Dorsal and (B) ventral view of *P. ferox,* sp. nov. (Clade 1). (C) Dorsal and (D) ventral view of *P. mellaria*, sp. nov. (Clade 2). (E) Dorsal and (F) ventral view of *P. edenensis*, sp. nov. (Clade 3). (G) Dorsal and (H) ventral view of *P. mira*, sp. nov. (Clade 4). (I) Dorsal and (J) ventral view of *P. clavigera* sensu stricto (Clade 5). (K) Dorsal and (L) ventral view of *P. tulbaghensis*, sp. nov.

Barnes A, Reiss T & Daniels SR. 2020. Systematics of the Peripatopsis clavigera species complex (Onychophora: Peripatopsidae) reveals cryptic cladogenic patterning, with the description of five new species. Invertebrate Systematics, 34(6), pp.569-590.


kids in parks

PEOPLE INTERACTING WITH NATURE

Kids in Park Programme, Garden Route National Park, Melanie de Mornay

Enabling meaningful people-nature interactions in National Parks

Research feature

National parks not only conserve biodiversity but also serve as places where people-nature and people-people connections take place.

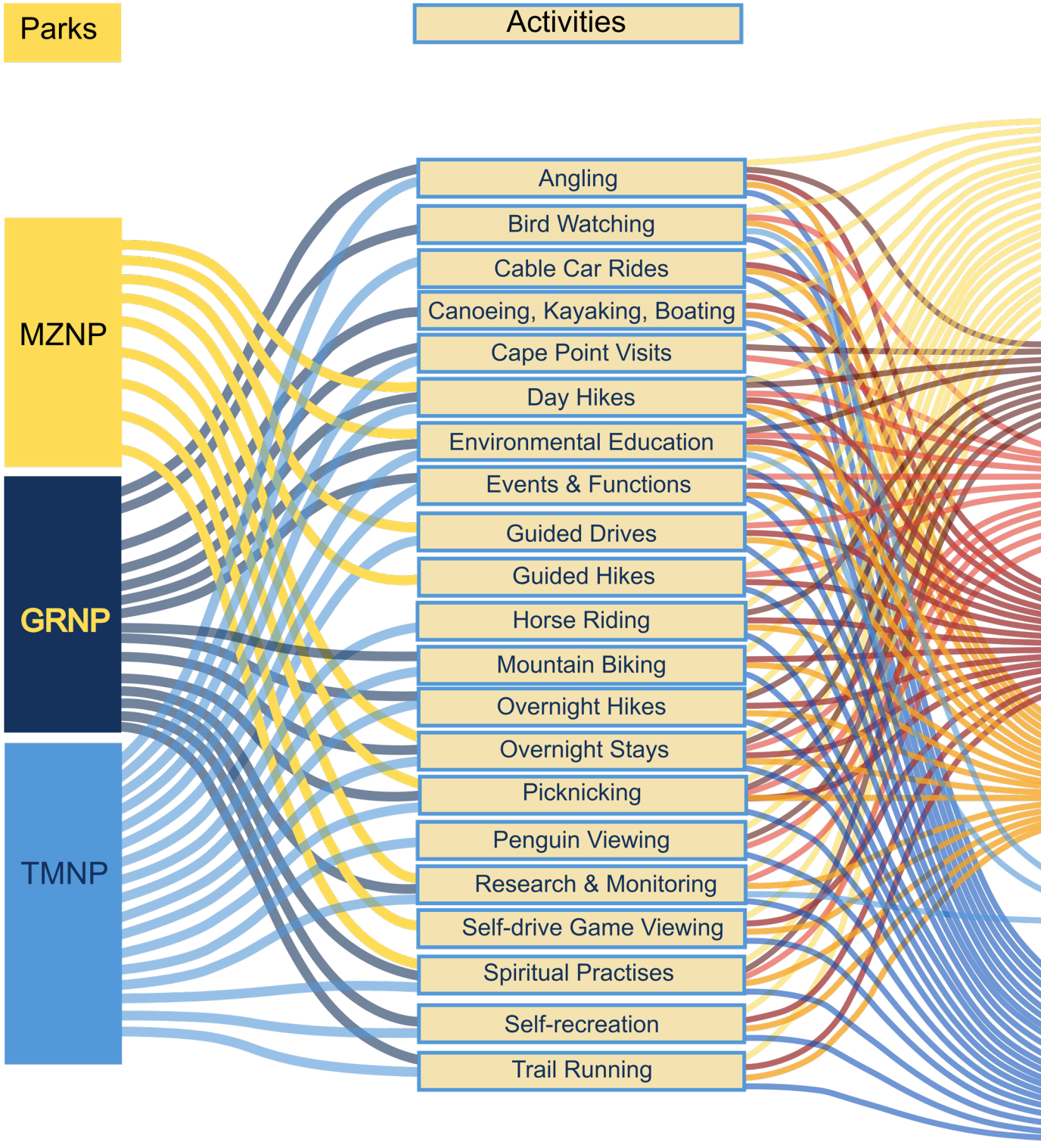
Text by Dirk Roux, Kyle Smith, Izak Smit, Stefanie Freitag-Ronaldson & Jessica Hayes
Photos by Dirk Roux

Globally, before COVID, people made approximately 8 billion visits to protected areas annually. Through these visits and their participation in various socio-cultural activities (e.g. family game drives) people experience multiple benefits related to physical and psychological health. Increasingly, people visit protected areas to escape from the 'rat race' and recover from work-related stress. For protected areas these visits are not only important from a revenue perspective, but also to expand their own value proposition from the established role of protecting biodiversity to also providing critical support for maintaining human well-being. The importance of this latter role became abundantly clear during the 2020 coronavirus lockdown when social media was abuzz with how people missed interacting with nature and enjoying outdoor activities.

Effective protection of the nation's biodiversity and cultural heritage has long been central to SANParks' mission and the organisation strives towards enabling access to national parks for all South Africans. Furthermore SANParks' financial viability depends heavily on income from park visits (contributing approximately 80% of its budget). However, understanding how different types of activities that are undertaken by people during these visits translate into diverse human benefits has not received much attention. This study was therefore undertaken to explore (a) the diversity of visitor activities that facilitate people–nature and people-people interactions in parks, (b) how participation in these activities could translate into non-material benefits (referred to as cultural ecosystem services), and (c) the enablers, threats/ constraints, opportunities and trade-offs/tensions related to promoting nature activities and associated social benefits to visitors in national parks. The study was based on group discussions with staff from three parks with diverse social-ecological contexts, diversity of nature-based activities on offer and with different tourist access models, namely Mountain Zebra, Garden Route and Table Mountain National Parks. Valuable insights were gained

National parks provide people with diverse ways of interacting with nature. Far left: In Garden Route National Park, hiking the iconic five-day Otter Trail provides exceptional value in terms of aesthetics, recreation, sense-of-place and social relations. Top left: In Mountain Zebra National Parks, a guided hike up a steep hill (Salpeterkop) combines recreation with a cultural experience when visitors arrive at a relic of the Boer War (1899 to 1902) – a chess/checkers board etched on a rock by British soldiers. Top right: In Table Mountain National Park, a land-based colony of African penguin at Boulders offers a unique opportunity for tourists to get close to these endangered birds.

Roux DJ, Smith MKS, Smit IPJ, Freitag S, Slabbert L, Mokhatla MM, Hayes J & Mpapane NP. 2020. Cultural ecosystem services as complex outcomes of people–nature interactions in protected areas. Ecosystem Services 43. https://doi.org/10.1016/j.ecoser.2020.101111



into the park-based contexts that influence the enablement of visitors' nature experiences and the non-material benefits that people derive from these.

First, we identified 21 nature activities that people could engage with across the three parks and linked these to seven non-material benefits (see Fig. 1). Two of the seven benefits (enjoyment of aesthetic value and social relations) were positively linked to all 21 activities (Fig. 1), implying that national parks are places that connect people to nature and people with people (e.g. socialising with family and making new friends). This ties in well with SANParks' vision of "A world class system of sustainable national parks reconnecting and inspiring society".

Second, while some activities were common across all three parks (e.g. overnight stays, day hikes, environmental education, research and monitoring), others were actively catered for by only two of the parks (e.g. overnight hikes and mountain biking in

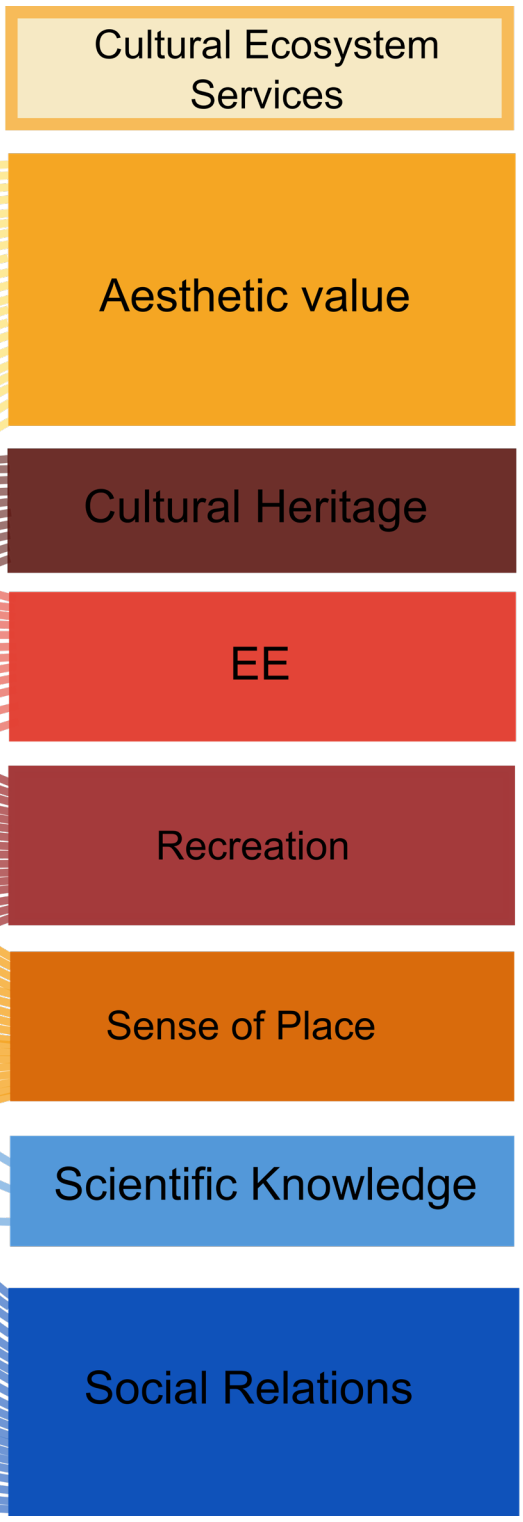


Figure 1. The landscapes and biophysical features inherent to Mountain Zebra National Park (MZNP), Garden Route National Park (GRNP) and Table Mountain National Park (TMNP) provide the potential for visitors to interact with nature.

Garden Route and Table Mountain) or were unique to a park (e.g. guided hikes in Mountain Zebra; canoeing, kayaking and boating in Garden Route; and cable car rides in Table Mountain). This raises the important point that unique park characteristics (e.g. geographical setting, inherent landscapes and biophysical features) enable conservation of different aspects of biodiversity as well as different ways in which people can experience nature. Current systematic conservation planning principles place a strong focus on creating a network of national parks that optimize the representation of biodiversity. We believe that park planning objectives should diversify to also ensure that the broadest possible range of human-nature experiences can be provided.

Third, while the natural features (e.g. wildlife and landscapes) of national parks provide the potential for delivery of nature activities and non-material benefits to people, park staff mobilize (e.g. through maintenance of a hiking trail or bird hide) and mediate (e.g. through skilled field guides) these benefits. Furthermore, the activities and benefits need to be appropriated by the public (see Fig. 1). Appropriation by visitors is likely to be influenced by factors such as accessibility, affordability, nature orientation and societal norms, previous nature experiences, and perceptions about a specific park and SANParks.

Fourth, the different ways in which visitors access and enjoy nature experiences in different parks result in different management challenges. In fenced-off Mountain Zebra, with its gated access and central booking system, there was a sense of being in control of delivering relatively predictable nature experiences. In open-access Garden Route, visitors' access and use of the park is less controllable, and in Table Mountain with its millions of visitors, there is not only a degree of uncontrollability but also an increased potential for conflict among diverse visitor groups as well as between visitors and park staff. Thus, different social skills and competencies might be required to effectively mediate nature experiences in different types of parks.

This research highlights that national parks are important mechanisms for conserving natural heritage as well as for safeguarding a wide range of meaningful experiences in nature. These experiences provide well-being benefits for visitors, and importantly also encourage pro-environmental behaviour and grow passionate conservation ambassadors in society. While there are certain synergies between conserving biodiversity and providing nature experiences (e.g., conserved landscapes may contribute to aesthetic value and sense of place), there are also trade-offs (e.g., to weigh up whether limited budgets will be used for anti-poaching activities or to maintain infrastructure for hiking, camping and picnicking in nature). To this end it is important that SANParks finds a balance between these dual objectives of conserving biodiversity and enabling nature experiences within individual parks, as well as across the network of national parks, to help reconnect people to nature and to each other.

Compensation for livestock loss from predation adjacent to the Kruger National Park

Social outreach

The Kruger National Park livestock compensation programme aims to offset the direct damages incurred to livestock owners as a result of large predators escaping from the Kruger National Park, as well as build relationships with affected communities in the context of social justice.

Text by Louise Swemmer, Helen Mmethi & Lucia Hlatswayo
Photo by Louis van Schalkwyk

The Kruger National Park livestock compensation programme has been co-designed by community representatives and the park. Of course it's about the cow, but it's not JUST about the cow. Although the programme aims to offset the direct damages incurred to livestock owners, the programme also hopes to serve as a tool to build and in some cases rebuild connections and meaningful relationships between neighbouring communities and the Kruger. As such it is carefully managed, and requires constant engagement, reflection and adaption.

A livestock farmer herding cattle in Mpumalanga province adjacent to the Kruger National Park. The park has a compensation scheme for livestock lost to predation in communities bordering the park.

Protocol consists of a co-developed set of criteria for the compensation of livestock loss. Incidents must be reported to the provincial or SANParks authorities within a certain time frame, and the relevant conservation official (provincial official unless delegated to a Kruger official) must inspect the scene to verify the incident. Unfortunately not all claims qualify for payment, and rejected claims may result in disappointment and tension. However, using open and regular communication through community forums, the knowledge of the required processes to lodge successful claims is growing, and so is the proportion of successful claims.

Compensation is complicated, can be amazing, is often difficult, can be very effective but is almost always messy. Globally, it has been demonstrated not to be the ultimate silver bullet for all human-wildlife conflict (HWC) challenges and works best when combined with a range of tools that address diverse drivers of HWC, such as responsible animal husbandry. Although compensation is just one tool in the relationship building basket, it is an important one considering that many people living adjacent to the park perceive HWC to be a major disadvantage. Interestingly, much of this sentiment is driven by perceptions as a much smaller percentage incur direct costs from HWC. Some recent research aimed at co-developing objectives and indicators for monitoring programme outcomes has highlighted how significant it is to the farmers that SANParks acknowledges that there is a level of moral responsibility on the side of SANParks to manage this process. This is important, since legally, DCAs outside of the Kruger are deemed res nullius and fall to the responsibility of the provincial conservation agencies despite the fact that they most likely originated from the park.

Human-wildlife conflict, and subsequent compensation belongs to all of us. As our planet becomes "smaller and smaller", the space for wildlife to roam freely is also shrinking, increasing the opportunities for conflict and we have a responsibility to explore ways of managing this both in the interests of people as well as wildlife if these magnificent places and extraordinary people are to thrive in an uncertain future.

Indigenous communities in Namaqualand and Richtersveld prepare to deal with dust

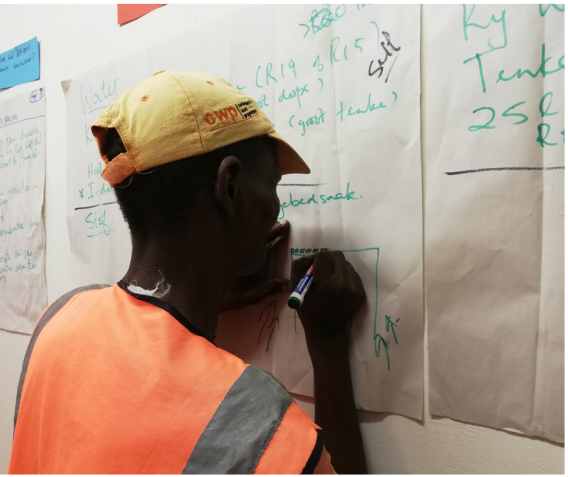
Social outreach

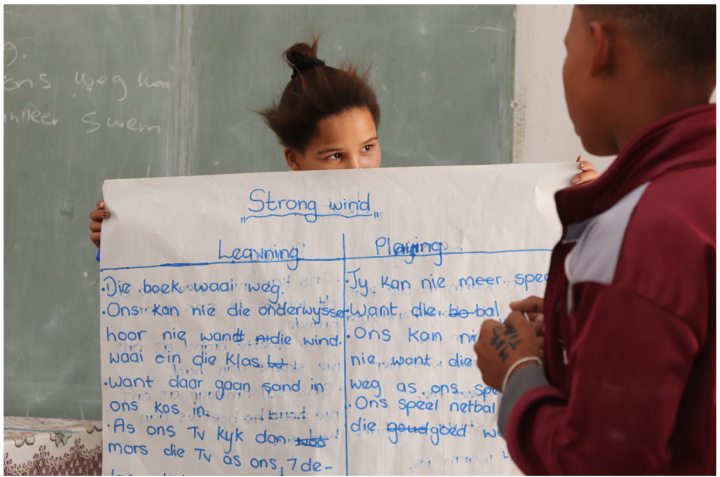
Sand and dust storms are an increasingly common occurrence in arid areas affecting biodiversity and people's living conditions and livelihoods. As such, co-developing adaptation plans will be important going forward for resilient biodiversity and communities.

Text by Mmoto Masubelele, Lesego Khomo, Avhavhudzani Phophe & Igshaan Samuels
Photos by Clement Cupido & Reginald Christiaan

When landscapes become denuded, whether through land use or abiotic factors, such as drought, the likelihood of sand and dust storms (SDS) increase. In Namaqualand and the Richtersveld, increased drought and wind speeds due to climate change, in combination with overgrazing and mining, have exacerbated sand and dust storms, posing a significant and growing threat to biodiversity and communities. These SDS are clearly demonstrated by measuring aerosol densities in the atmosphere using remotely sensed data for the region.

We used a questionnaire survey to understand socio-ecological risk and vulnerability to climate change of an indigenous community based in !Khubus in the Richtersveld World Heritage Site. Findings suggest households are at intermediate risk to climate change. Focus groups on infrastructure, livestock herding, cultural heritage, and education identified major wind events to have occurred in 1994, 2011, 2016, 2018, 2020 and 2021. The 2016 SDS resulted in loss of life through a road accident. In terms of infrastructure, the 2018 storm resulted in three 10 000 L tanks being blown over and damaged beyond repair, thus also affecting water storage and supply to !Khubus. In terms of education, learning is hindered by learners' books blowing in the wind and the fact that they cannot hear their teachers and their extramural activities are hindered because their sport equipment blows away. SDS also threatens the cultural practices of





Storm Report SA reporting on dust storms in the northern Cape on their facebook page (https://www.facebook.com/stormreportsaOFFICIAL/). Sand and dust storms have increased over time due to below rainfall and drought conditions in the region, which are further exaerbated by overgrazing and strip mining.

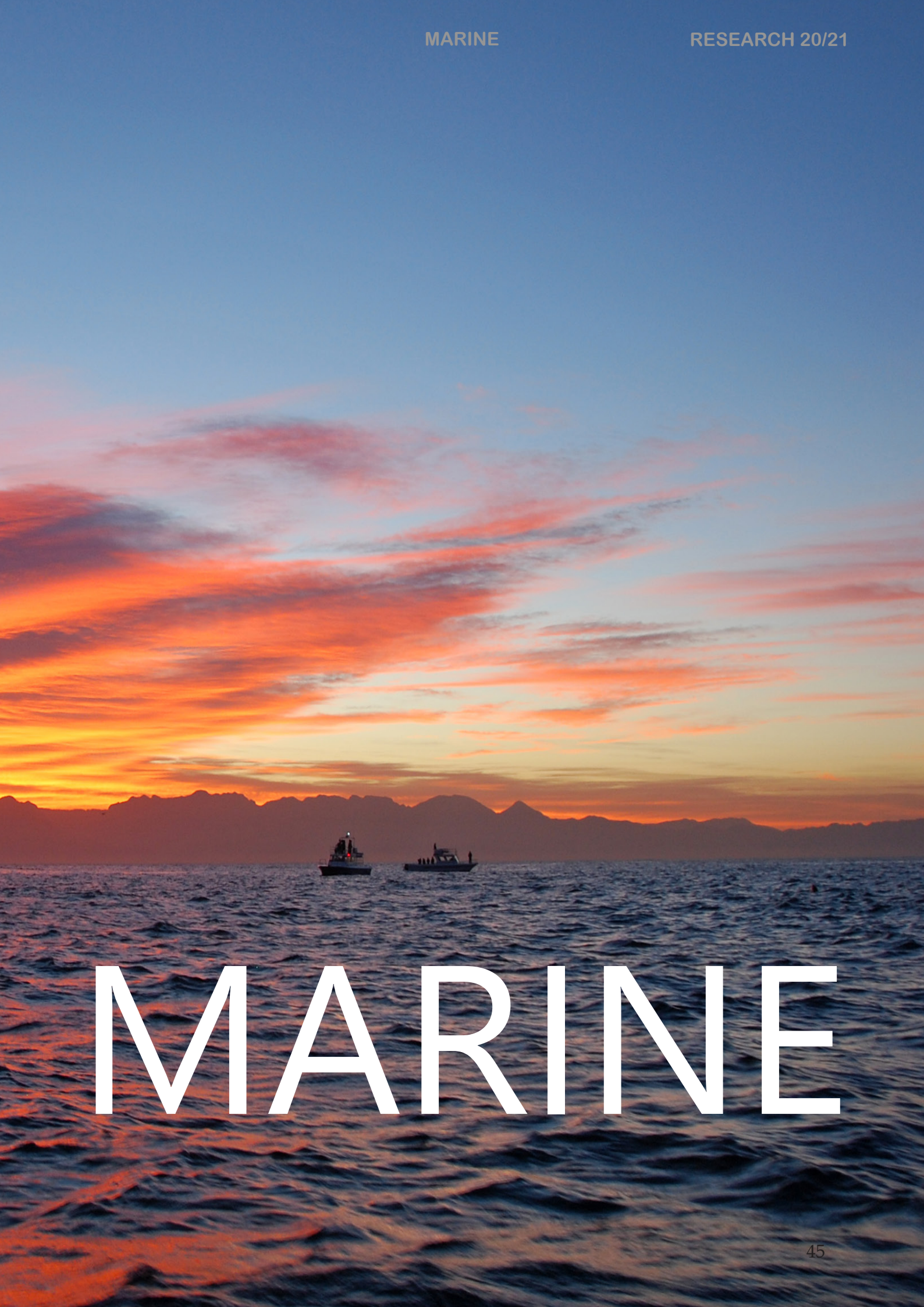
nomadic livestock herding. In !Khubus, sand engulfs plants on the side facing the predominant wind direction. Stock posts and traditional matjies huts are affected and some households lose roofs during storms, which has necessitated a redesign of roof structures.

According to the community in Soebatsfontein near Namaqua National Park SDS are a norm. Desertification due to drought has led to a continued loss in vegetation in both regions. As communities are situated downwind from the park, this has led to the perception amongst some community members that these SDSs originate inside the Park.

The !Khubus community, SANParks, ARC and The Resilience Institute (TRI), Canada, co-developed a Local Early Adaptation Plan (LEAP) with the various focus groups to solicit a response to risks posed by SDS. Priority adaptation at a landscape level includes restoration of denuded areas (vegetation and soil crust), managing livestock numbers using indigenous and novel ways, and early warning of SDS to enable better planning. At a household level, builders made small adjustments to strengthen roofs by adding parapets. Doors and windows are now constructed on the side of the building sheltered from the prevailing wind direction. It is hoped that the LEAP will contribute towards preparing the !Khubus community to better weather increasing risks posed by SDS.

Pre-COVID consulations with local communities in Namaqualand and Richtersveld identified risks posed by sand and dust storms in the region. Adaptation measures where then workshopped with the various focus groups and used to create a local early adaptation plan. This plan will help local communities prepare better for the risks posed by sand and dust storms.

Sunrise over False Bay, Table Mountain National Park, Nicola van Wilgen-Bredenkamp



MARINE

Citizen scientists help gather data on broadnose sevengill sharks

Text by Alison Kock
Photo by Mark van Coller

Research feature

The broadnose sevengill shark (also called a cowshark, *Notorynchus cepedianus*) is a top predator in temperate, coastal ecosystems around the world. It reaches over 3 meters long and is a generalist predator of fishes, other sharks and seals and is often seen in the kelp forests of the Western Cape. In South Africa, however, not much is known about their movements or growth rates. Still, they are caught in the commercial line fishery and are popular sharks to catch for sport and recreation. Ongoing exploitation of these sharks without species-specific management strategies in place puts them at risk of overexploitation.

This study used data from the Oceanographic Research Institute's Cooperative Fish Tagging Project (ORI-CFTP), a citizen-science tagging programme, to investigate the occurrence, movements and growth rates of broadnose sevengill sharks in southern Africa. The ORI-CFTP offers a low-cost source of data for investigating broad patterns in the occurrence and scale of movement of coastal species, and makes use of simple external tag and recapture techniques employed by volunteer fishermen.

A total of 3513 broadnose sevengill sharks were tagged by citizen-science anglers between 1984 and 2017, with 195 (5.6%) recaptures. Their distribution ranged from Cape Fria in northern Namibia to the Great Kei River mouth region in the Eastern Cape of South Africa, with no catches recorded along the sub-tropical east coast of South Africa or in Mozambique. Most catches occurred along the west coast of South Africa, and recaptures showed connectivity between the west and south coasts of South Africa, but not between South Africa and Namibia (Fig. 1).

The majority of broadnose sevengill sharks (66.6%, n = 130) were recaptured <50 km from the release site, with a notable number (32.8%, n = 64) of recaptures occurring less than one

BACKGROUND

Large sharks may exert strong top-down control on ecosystems, with the potential to shape marine communities over large spatial and temporal scales. However, given their wide-ranging movements and slow growth rates, they are vulnerable to over-exploitation and disturbance. Limited species-specific information is available on the life-history characteristics, population dynamics, and movement ecology in many cases hindering effective management.

A large broadnose sevengill shark swims through the kelp forests of the Table Mountain National Park Marine Protected Area.

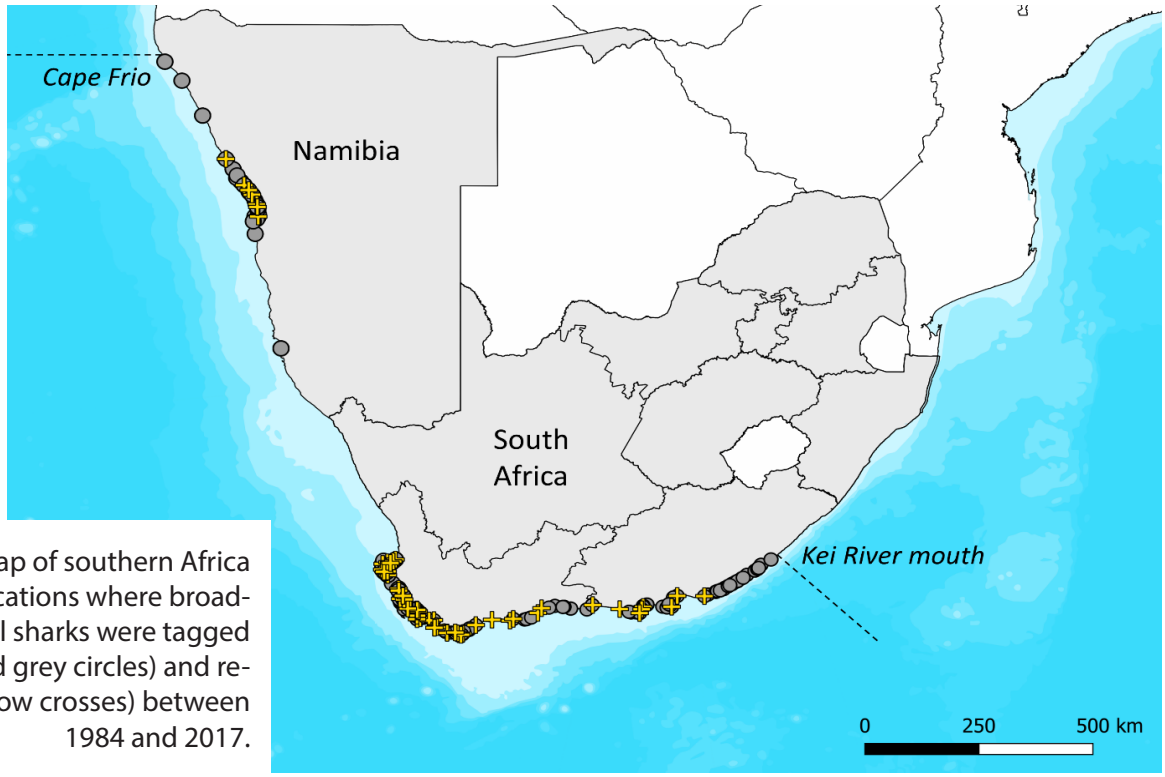


Figure 1. Map of southern Africa showing locations where broadnose sevengill sharks were tagged and released grey circles) and recaptured (yellow crosses) between 1984 and 2017.

kilometre from the release site, despite extended periods of unrestricted movement. This suggests some degree of site fidelity to preferred areas. Few sharks (22.6%, n = 44) were recaptured >100 km from the original tagging site, while only three sharks (1.5%) were recaptured >500 km from the original tagging site. There was no significant difference in total length between sharks displaying resident vs migratory behaviour and no difference in the movements of small vs large sharks.

This study provides foundational knowledge on the movement and growth rates of broadnose sevengill sharks in southern Africa. Evidence for site fidelity and migratory behaviour across all size classes highlight the need for future work using acoustic and satellite telemetry, together with environmental data, to gain a more in-depth understanding of the drivers behind the movements of this species. The slow growth of this species, coupled with high site fidelity and ongoing exploitation, emphasises the need for well-structured species-specific management plans to prevent the overexploitation of this important coastal predator.

This study formed part of Tamlyn Engelbrecht's PhD research at the University of Cape Town. Tamlyn is co-supervised by Alison Kock. Engelbrecht TM, Kock AA, O'Riain MJ, Mann BQ, Dunlop SW & Barnett A (2020) Movements and growth rates of the broadnose sevengill shark Notorynchus cepedianus in southern Africa: results from a long-term cooperative tagging programme, African Journal of Marine Science, 42:3, 347-359, DOI: 10.2989/1814232X.2020.1802776

The usefulness of Baited Remote Underwater Video Systems in monitoring marine communities

Text by Sisanda Mayekiso & Alison Kock
Photo by Xolani Magiya

The use of Baited Remote Underwater Video Systems (BRUVs) is a popular monitoring method used in marine habitats, but less so in estuarine environments. The Cape Research Centre together with West Coast National Park marine rangers initiated a monitoring program using BRUVs in 2019 to determine whether the method was suitable to use in the lagoon. Specific objectives included documenting the diversity and abundance of fish and sharks in each zone of the MPA and outside of the MPA, investigating seasonal differences, and testing two different bait types and their attraction capabilities.

A total of 90 BRUV deployments (90 hours of video) were made across all three MPA zones and outside of the MPA, over summer and winter. Preliminary analysis of the videos identified 15 species from 11 families. The most frequently observed species were steentjie (*Spondyliosoma emarginatum*), white stumpnose (*Rhabdosargus globiceps)* and white seacatfish (*Galeichthys feliceps*). Overall, Zone A had the

TOP
White stumpnose (*Rhabdosargus globiceps)* stocks have collapsed due to overexploitation but BRUVS detected plenty of these fish in Zone C of the WCNP-MPA.

LEFT
The Cape Research Centre and Park staff deploying BRUVS in West Coast National Park to monitor fish and shark diversity and abundance.

BACKGROUND
Langebaan Lagoon is a marine protected area (MPA) that protects marine biodiversity, sensitive estuarine habitats and is an important nursery area for a variety of commercially important and threatened fishes. The lagoon has use zones that seek to balance the needs of marine species with those of people.

ZONES
The lagoon is divided into zones; a sanctuary zone (Zone C) which restricts all recreational and commercial activities, a restricted zone (Zone B) which allows for low impact recreational activities and subsistence fishing, and a controlled zone (Zone A) which allows fishing under the regulations of the Marine Living Resources Act and various recreational activities.

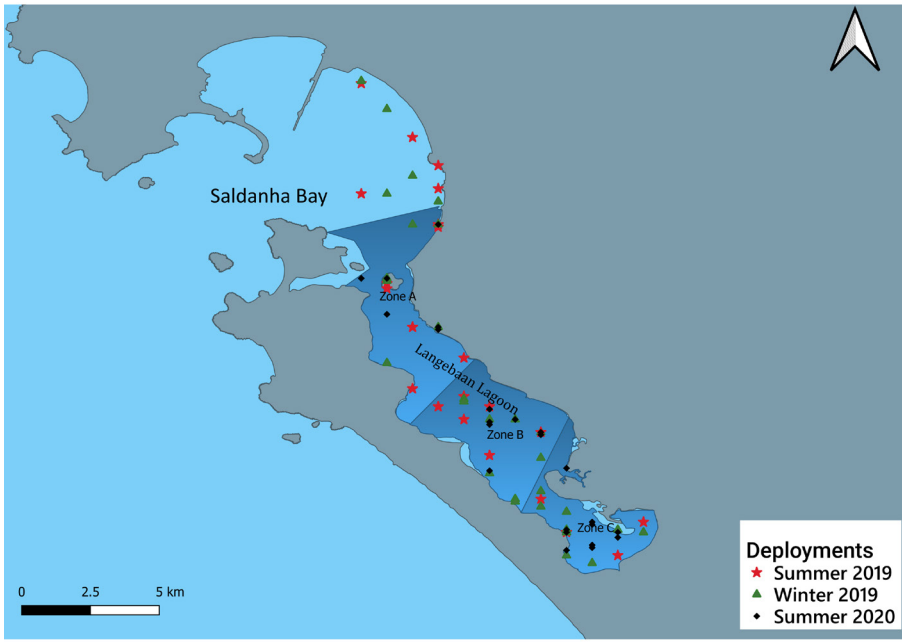


Figure 1. Map of the zonation of the West Coast National Park Marine Protected Area (Map taken from Attwood et al. 2007), showing the sanctuary zone (Zone C), a restricted zone (Zone B), and a controlled zone (Zone A) which allows fishing and various recreational activities. Zone C is the shallowest, with the most sandy bottom habitats, while Zone A encompasses reef around Schaapen Island and sandy habitats.

greatest species diversity, while Zone B had higher relative abundance of important recreational and commercial species, such as white stumpnose and Blacktail. Zone C had the greatest abundance of juvenile fish. Unfortunately, the visibility of the water outside of the MPA in Saldanha Bay was poor on most of the sampling days, and provided limited information. Summer months had greater abundance and diversity of most species and juvenile fish, most likely because the average water temperature is greater in summer (22 °C) than in winter (15.1 °C). This was especially the case for steenjies and white stumpnose. The two bait types had mixed results and more analysis is needed to determine their relative effectiveness.

The preliminary results demonstrate that BRUVs are a viable method for monitoring fish and shark species in the lagoon and detecting species of special concern, such as white stumpnose. Our recommendations are to continue deploying BRUVs as a long-term monitoring tool and to expand to the islands of the MPA when capacity and resources are available.

Due to frequent poor visibility outside of the MPA, BRUVS are likely not useful to compare outside to inside the MPA, however the technique could prove really useful to measure catch over time inside the MPA, and assess effectiveness of the suite of environments provided in the MPA at protecting fish stocks.

Saving the African penguin - can we make this fly?

Text by Ané Oosthuizen, Alison Kock, Cloverley Lawrence, Nicola van Wilgen-Bredenkamp
Photo by Nicola van Wilgen-Bredenkamp

PHOTO
Penguins nesting in better designed temperature regulating ceramic nest-boxes at Boulders. African penguin populations are in rapid decline and scientists propose that the closure of fisheries around islands will be beneficial, perhaps even crucial, for penguin survival.

African penguin populations have declined rapidly over the past century across the species' range. SANParks is the custodian of ~55% of the remaining penguin population, which is located across St Croix and Bird Islands (Addo Elephant National Park), Boulders (Table Mountain National Park) and islands in West Coast National Park. An annual census at these colonies is led by DFFE: Branch Oceans and Coasts, and supported by SANParks rangers and scientists. In 2020 however, due to COVID-19 restrictions, only one full count was carried out (at Boulders) by SANParks and the City of Cape Town while a population estimate was made for St Croix Island. The count at Boulders indicated that numbers have remained relatively stable at around 1000 breeding pairs over the last five years. At St Croix, on the other hand, the estimates indicate a continued decline, with a loss of ~3600 breeding pairs between 2017 and 2020. Trends on the West Coast up to 2019 indicate that penguins will stop breeding there altogether in the next few years if food availability remains scarce and the species is predicted to be functionally extinct by 2035 if current trends are not reversed.

SANParks maintains that the largest current threat to African penguin survival is food scarcity. Thus, prohibiting small pelagic fishing for sardine and anchovy around penguin breeding colonies is crucial to saving penguins from extinction over the long-term. Long-term island closures to small pelagic fishing for the six largest colonies, encompassing at least one generation of penguin life-history (10 years), was submitted as a recommendation to the Minister, DFFE, highlighting SANParks' concerns around the plight of African penguins. This is supported by Branch Oceans and Coasts, DFFE. However, Branch Fisheries Management, DFFE, opposes this view and advocate that such an intervention will not benefit penguins substantially.

The Minister acknowledged the differences in scientific views and requested that a collective and responsible approach be sought to avoid the extinction of the African penguin, based on credible science. Thus, a Governance Forum (GF) was established in January 2021, comprising senior officials of the DFFE Branches Oceans and Coasts, Fisheries Management and SANParks, to provide a synthesis of current scientific information relating to experimental, temporary island closures and African penguin population declines. The Minister advised that the National Environmental Management Act (1998) and the enshrined principles of conservation, sustainable use and the precautionary approach should be applied in addressing this issue. The GF established a drafting team, comprised of scientists from both DFFE branches and SANParks, to prepare the comprehensive synthesis report of the current state of knowledge relating to African Penguins.

In addition to synthesising the state of knowledge, the report outlined the areas of agreement and disagreement between marine ecologists, seabird scientists and fisheries scientists. After completion, the report was sent for comment to the Top Predator and Small Pelagic Fishing Scientific Working groups and SANParks. The report, together with the comments were sent to the Minister's office and for external review. The next step in the process is for further engagement within the GF on a way forward and what to recommend to the Minister.

There is unanimous agreement that urgent action is needed to reverse the population decline of African penguins. While further research is needed to understand other factors that might be impacting the penguins, a precautionary approach is required to ensure all possible known causes of declines are being addressed. Short-term (3 years) closures to fishing around island colonies showed a small (1%) positive effect (at Robben Island), however SANParks is optimistic that restricting fishing for a longer term, which until now has been untested, in synergy with current management interventions, will prove beneficial to the African penguin population.

Text by Nicola van Wilgen-Bredenkamp, Katta Ludynia, Faroeshka Rodgers, Alison Kock & Wendy Foden
Photos by Nicola van Wilgen-Bredenkamp

New nest boxes for African penguins at Boulders, Table Mountain National Park

TOP LEFT
A penguin makes use of an older style fibre-glass nest box at Boulders, these provide protection against predators but can become very hot.

BOTTOM LEFT
While Foxy beach at Boulders provides a successful nesting ground, nests made in the sand are vulnerable to erosion.

TOP RIGHT
Penguins pant on a hot day at Foxy Beach, Boulders colony. An abandoned egg is visible in the foreground.

BOTTOM RIGHT
Egg predation by kelp gulls and land mammals such as rats and mongooses is common.

While solutions to food scarcity continue to be evaluated, several organizations currently work together to implement management interventions across colonies. At Boulders these include SANCCOB, AZA (Association of Zoos and Aquariums), the Dyer Island Conservation Trust, and the City of Cape Town. For example, penguin-monitors identify sick or injured birds and abandoned chicks and eggs, which are taken to SANCCOB for rehabilitation and/or hand-rearing before being released back into the wild.

This year, this group added 50 new and improved nest boxes to the Boulders colony which were designed to mimic guano nests. Early attempts at artificial nests provided predation protection but were prone to becoming too hot. The new nests are constructed from environmentally friendly material and include ventilation holes to allow for better movement of air and a flysheet to prevent rain from penetrating.

In a project sponsored by WWF-US, the Cape Research Centre, in collaboration with park management and several other organizations, are monitoring temperatures in different nest types in relation to various factors such as shading, elevation and nest orientation. These factors will be correlated with breeding success (i.e. successful fledging of chicks). Thermo-sensors have been placed in nests and a weather station placed at the colony.

The project also seeks to develop an early warning system for extreme weather events, which would enable preparation for the proactive removal of chicks or eggs should extreme conditions arise. Other strategies include temporary shading of nests and cooling of adult birds by spraying them with water as well as rehabilitation of nesting sites to reduce erosion and planting of indigenous vegetation to enhance ground stability and provide cover. Given that most species will add climate change to the list of threats in the coming years, the iconic nature of the African penguin makes this project an important case study in measures to assist species in adapting to anthropogenic and climate change.

Can mass stranding events be used to monitor seahorse populations?

Mass strandings of the endangered Knysna seahorse occur periodically in Swartvlei Estuary, particularly after breaching of the estuary mouth. With breaching, water levels recede rapidly, exposing the estuary banks which are prime seahorse habitat. A citizen science program was revived in 2017, where volunteers scan the banks of the estuary for up to a week following breaching, in order to return living seahorses to the estuary and record dead individuals. We wondered whether the data could also be used to monitor seahorse population demographics.

Not all estuary breaches result in mass strandings, with numbers ranging from thousands to as little as ten. Although at first glance, the sight of a mass stranding of this endangered fish can appear alarming, it is not necessarily a sign that the population is in peril. Research and anecdotal evidence have shown that population size can fluctuate widely, and mass stranding usually only occurs when population size is above-average. The breaching of Swartvlei Estuary, like most of South Africa's estuaries, forms part of the natural functioning of the system, even though it is now breached artificially at lower levels.

To test whether we would be able to use the mass stranding data to monitor population size and demographics, we sampled seahorses using a more traditional sampling method, using a small seine net,

Text by Clement Arendse & Ian Russell
Photos by Clement Arendse & Bheki Maphanga

BOTTOM FAR LEFT
Swartvlei Estuary is periodically artifically breached (opened) to limit flooding.

BOTTOM LEFT
Citizen scientists search the banks of the Swartvlei Estuary for seahorses after artificial breaching leaves them stranded due to the sudden reatreat of water.

BOTTOM RIGHT
Here, a live stranded seahorse is being measured before being released. Data on population size and demography are gathered in this process.

BOTTOM FAR RIGHT
Researchers check the content of a seine net haul. This is a more conventional method to survey seahorses. The two methods have been compared and show very similar results, indicating that data from strandings can be used to sample seahorse populations successfully.

and compared data sets. It was found that the sex ratio and size range of stranded individuals were similar to netted individuals. This lead to the conclusions that (1) seahorse strandings appear to be random, an important requirement for making inferences about population demographics from sub-samples, and (2) data from stranded seahorses are comparable in terms of the information provided about the population to that obtained from seahorses sampled using more traditional means.

With this information, we can now be confident that the data collected using the citizen science programme will prove invaluable to the long term monitoring and management of the Knysna seahorse population in the Swartvlei Estuary.

FRESH WATER

Jacana, Kruger National Park, Nicola van Wilgen-Bredenkamp

FREE THE RIVERS!

The removal of Mingerhout Dam in the Kruger National Park

A recent Living Planet Index global assessment of the connectivity status of rivers globally found that only 37% of rivers longer than 1,000 km remain free-flowing over their entire length. Dams and reservoirs are the leading contributors to the loss of river connectivity and this interrupted connectivity has resulted in a decline of more than 3/4 of migratory freshwater fish around the world.

Between 1930 and 1990, Kruger National Park established the artificial water-for-game program where boreholes, troughs, and concrete reservoirs and dams (concrete and earthen) were constructed along various water courses in order to regulate water availability and distribution. After much research during the 1990s, it was realised that the provision of artificial water points lead to numerous ecological problems and general degradation of the landscape in many parts of the Kruger. Furthermore, monitoring showed that barriers such as dam walls and weirs disrupt the natural river flow, which in turn affect migration and breeding of fish and natural aquatic processes. The lessons learned are reflected in a move, first towards removing some of the artificial water points and more recently, the removal of barriers in rivers to create mostly free-flowing rivers in Kruger.

The Letaba River is one of five major perennial rivers in Kruger that normally flows throughout the year and is a huge biodiversity hotspot for aquatic species, including >30 fish species. Due to prolonged dry conditions following the 2015/16 drought, the Letaba River stopped flowing intermittently. Thus, Kruger management re-prioritized the removal of certain redundant barriers in order to restore the aquatic connectivity of the river system. This is so

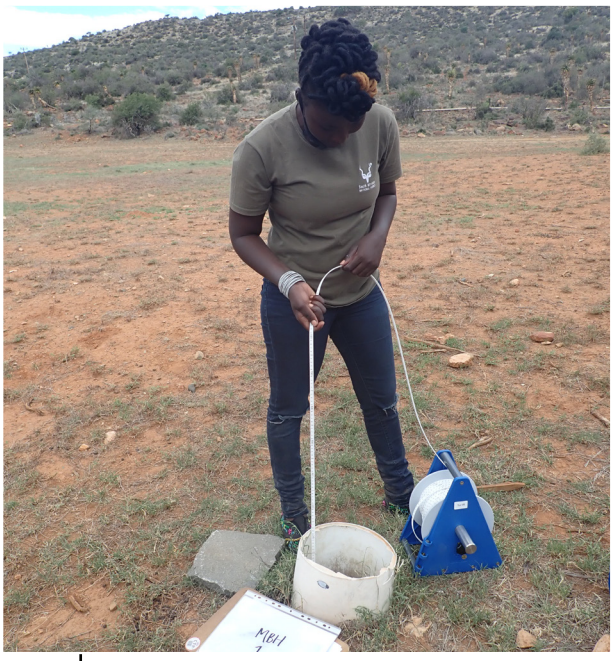
The demolition of Mingerhout Dam in the Kruger National Park took place during high flows; this series of photos document the removal of the dam wall through the use of dynamite with assistance by the SANDF. Barriers such as these create obstacles for the free movement of fish and other aquatic life which negatively affect breeding and population dynamics.

Text by Robin Petersen, Eddie Riddell, Stephen Midzi, Navashni Govender & Jacques Venter
Photos by Stephen Midzi

that the fish (some of these are rare or endangered) and other aquatic organisms are able to respond to environmental cues, especially in terms of small early season floods, known as freshets, which then enable their spawning movement. The Mingerhout Dam wall was one such barrier which was removed towards the end of the 2020 summer.

SANParks scientists in collaboration with the University of Mpumalanga monitored the ecological impacts of the Mingerhout Dam removal. The findings from this work confirmed the suspicions that the dam was creating a disconnect in the river system for tigerfish. As in other species, temperature is a natural cue for movement of tigerfish. In winter, tigerfish move downstream, away from cooler headwater streams, to downstream warmer environments. In summer, they move back upstream, benefiting from the high oxygen waters, and in response to the movement of their prey species. We found that the Mingerhout Dam was not only impeding the movement of tigerfish, but also possibly 7 other species that were only found in the downstream environment (only 4 species found in the immediate upstream environment and 12 species in the downstream environment). We predict that long-term monitoring will show species compositional increases in reaches upstream of the former dam.

An effort will be made by freshwater scientists to monitor the long-term effects of better river connectivity in the park. We are only beginning to understand the far-reaching consequences of connected river ecosystems more broadly, and for those species that depend on “free” rivers.



"Delving deep into unchartered waters in order to comprehend an understanding of how it sustains the beautiful fauna and flora." Angelo Johnson

Groundwater monitoring in SANParks

Text by Robin Petersen, Angelo Johnson, Steven Khoza, Corera Links, Portia Chake, Melanie De Morney, Nthabeliseni Munyai, Roxanne Erusan, Noel Nzima, Prisca Rikombe, Jacques Venter, Trevor Adams, Nkabeng Mzileni, Lufuno Munyai, Diba Rikhotso, Tercia Strydom, Ruth-Mary Fisher, Charlene Bisset, Jessica Hayes, Ian Russell, Cloverley Lawrence & Stefanie Freitag-Ronaldson
Photos by Melanie de Morney, Trevor Adams & Tercia Strydom

Groundwater is an invisible but precious resource. In a water-stressed country like South Africa, achieving and maintaining water security is increasingly challenging. During the recent drought, which was one of the worst droughts in recorded history, groundwater proved to be a critical buffer in sustaining public health, the environment and the economy. Nevertheless, groundwater resources are under strain due to over abstraction and pollution in many parts of the country.

Water-vulnerable areas such as the karoo, have experienced persistent drought for several years now, leading to severe water shortages in many places. As a consequence, national parks bordering drought-stricken towns are increasingly confronted with bulk water infrastructure development requests and pressures. Furthermore, the ominous future threat of shale gas extraction (fracking) on groundwater resources in the region remains. These developments highlight the need to effectively manage and monitor groundwater availability and sustainability in our parks, and to incorporate the understanding of climate variability and anthropogenic effects on water security and ecosystem services into management policies.

To ensure groundwater is sufficiently monitored and managed within national parks, we initiated a long–term groundwater monitoring programme. The aim was to improve the understanding of groundwater dynamics (i.e. supply, storage and movement) in order to make meaningful predictions of supply whilst ensuring the protection of aquifer-dependent ecosystems. The programme will be implemented in

"'It is what we think we know already that prevent us from learning'by Claude Bernard. I choose this quote because I have learnt a lot about groundwater monitoring of which I had no clue off before." Portia Chake

"A great learning experience to be part of this hydrocensus surveys and the team and at the same time appreciating the beauty of the surrounding environment of Karoo National Park..." Trevor Adams

"Our recent hydrocensus in the Karoo parks really opened my eyes to water challenges in these areas and the absolute importance of this invisible resource." Melanie De Morney

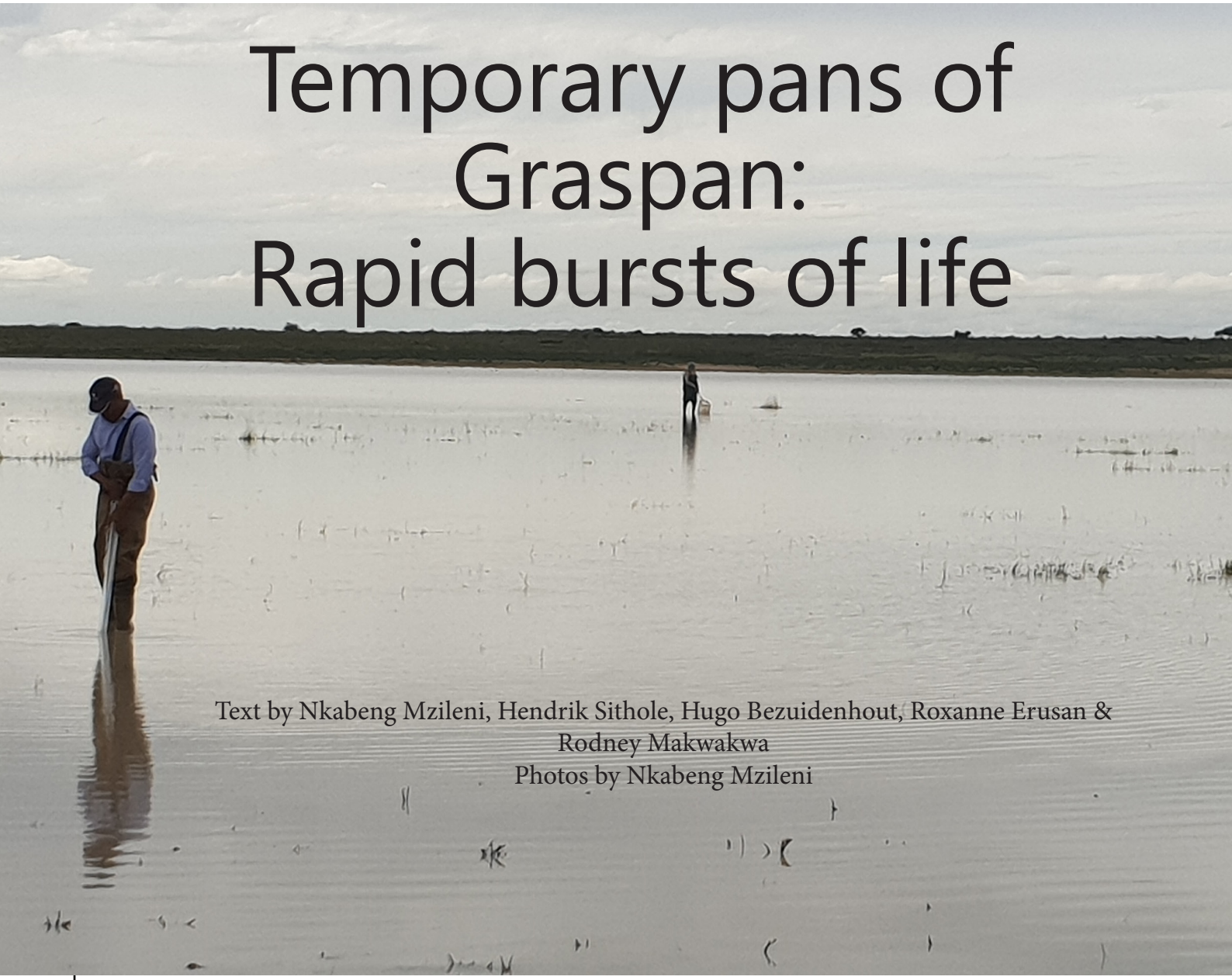
"In my mind the drilled boreholes were the only groundwater until March 2021 when we conducted hydrocensus survey..., then I learnt that springs and hand-dug wells are groundwater too. Now I know that the purpose of the hydrocensus is to establish existing water use and the groundwater qualities in the aquifers..." Diba Rikhotso

three phases over the next 10 years: (1) baseline assessment (i.e. hydro-census), (2) active monitoring and data collection, and (3) data/information consolidation and monitoring network refinement.

Four national parks (Karoo, Camdeboo, Mountain Zebra and Addo Elephant) were identified as priority parks due to high risks posed by bulk water demand and fracking. During March 2021, great progress was made on phase 1 by completing a groundwater hydro-census in these four parks. The data will feed into a national network of parks in which groundwater data have been collected and monitored, some for more than a decade, e.g. Kruger and Mapungubwe National Parks.

The close collaboration among the Scientific Services research nodes and Park Management teams, enables successful hydro-census campaigns, which generates valuable data and information. The programme is designed with a strong training and capacity-building focus, in which biotechnicians and park management personnel are able to easily adopt the methodology to continue with their own groundwater monitoring. In addition to capacity building, many thoroughly enjoyed seeing and understanding groundwater in their parks through a different lens (see anecdotal observations from a few Biotechnicians in blue).

Temporary pans of Graspan: Rapid bursts of life



Text by Nkabeng Mzileni, Hendrik Sithole, Hugo Bezuidenhout, Roxanne Erusan & Rodney Makwakwa
Photos by Nkabeng Mzileni

The Gras- and Holpan section of Mokala National Park has unique landscape features which include being at the ecotone of savanna and nama-karoo biomes, as well as having an abundance of ephemeral pans. Ephemeral pans change from terrestrial to aquatic habitats with the transience of water. These habitats when they have water host high biodiversity, including eubranchoipod crustaceans, migratory aquatic birds and various life stages of aquatic invertebrates. Although the associated biota are often dormant, a rapid burst of life occurs whenever the pans are filled with water, such as happened in 2013 and 2019 with good rains.

Five pans - two in the savanna and three in the nama-karoo sections of the park- are regularly monitored by a team from Scientific Services based in Kimberley. The water quality differed between the savanna and nama-karoo and is associated with soil texture and composition (savanna – red Aeolian sand with surface limestone and nama-karoo – shale and calcrete) which also results in the savanna pans drying up faster than the nama-karoo pans. In terms of water quality, the variation in pH and salinity were drivers of macro-invertebrates and these differed between the two types of pans.

Monitoring started in 2019 and included several aspects relating to the health of the pans, including

The pans in the Gras- and Holpan section of Mokala National Park are unpredictable and only fill with water occasionally. A team from Scientific Services, Kimberley monitors the life that appears fleetingly while the pans have water.

Some of the faunal biodiversity that appears when the pans have water includes southern African bullfrog (far left) and the tadpole shrimp (right).

water quality, aquatic life and aquatic bird diversity. During the 2019 monitoring season, we found the usual freshwater suspects including dragon flies, back swimmers and water scavenger beetles. The variety of shrimp we found in the pans included the tadpole shrimp (*Triops granarius*) a crustacean with a very limited range and therefore very rare. Triops is considered a living fossil (living fossils are species that strongly resemble the ancestral species as they appear in the fossil record). It has a 90 day life expectancy as adults and produces eggs that remain dormant in the soil until conditions are suitable for hatching Another interesting species that calls the pans home is the Giant bullfrog (P*yxicephalus adspersus*), the largest southern African bullfrog. The aquatic bird life associated with the pans included Spoonbills, Cape Teal, Cape Shoveler and several of the Grebes. This is only to name a few of the 50 bird species recorded at the pans.

Although 2021 and 2020 had high amounts of rain, the pans had no water and instead supported a luscious herbaceous plant community. This has stimulated further interest to understand factors that may affect whether or not the pans fill and the successional stages to these ephemeral pans.

POPULATIONS THROUGH TIME

Fungus, Garden Route National Park, Johan Baard

Can we predict when trees will die?

Text and photos by Graham Durrheim

A project was initiated in October 1990 to monitor tree mortality in the Garden Route National Park. The objective was to develop criteria to use for selecting indigenous trees for harvesting of timber. In the Diepwalle area a total of 2407 canopy trees of 17 species were initially inspected during 1990 for visible indications of senility. Each tree was described in terms of crown size, crown dieback, degree of stem decay, structural damage, incidence of agony shoots and increment. Harvest selection criteria were developed for eight common timber species, based on the species-specific mortality rates determined from long-term forest dynamics monitoring. Identified trees were expected to die naturally within 10 to 15 years and were re-evaluated at 5-6 year intervals over 22 years. The tree selection criteria were refined where appropriate.

The mean 10-year mortality rate for all species was 6.3%, with differences over time and between species. The most common mode of death is for trees to die standing. Most deaths occur in the smaller diameter classes that have the most trees, while some of the largest trees did not die during the evaluation period. The mean annual diameter increments (i.e. growth rates) for the period prior to commencement of the project were significantly lower for the trees that died during the 22 year monitoring period than for the trees that survived. The tree selection criteria failed to identi-

Predicting when trees will die naturally is useful as it allows the sustainable harvesting of mature trees. However, long-term monitoring in the Afro-montaine forests of the Garden Route is showing that it is not that straightforward.

TOP FAR LEFT
Ganoderma bracket fungi are a reliable indicator of severe stem decay in Ironwood *Olea capensis* subsp. *macrocarpa*. This stem will probably snap off in the near future and the tree will fall to the ground.

BOTTOM FAR LEFT
The next step. A White Pear *Apodytes dimidiata* has snapped off due to severe stem decay.

TOP AND BOTTOM LEFT
The unpredictability of death in trees: a stinkwood *Ocotea bullata* appears to be dying as a result of prolonged drought in the first photo, but produces new leaves after wetter conditions return, to survive for many more years (bottom photo).

fy many of the trees that would subsequently die and identified many trees as candidates for harvesting that would survive the 22 year period. Some candidates even displayed apparent recovery so as to no longer fall within criteria years later. The criteria were not found to be sufficiently accurate for any of the species.

A new set of harvest tree selection criteria were developed and tested. They represent an improvement on the criteria applied for 3 decades for the selection of trees for harvesting, but do still not accurately predict all trees that will die within the following 15 – 20 years. Many trees die without showing obvious signs of impending death, even 5 years before death, so it will not be possible to improve these criteria greatly in future. Various events may also have temporary effects on tree condition, such as seasonal effects, prolonged droughts, severe berg winds, mast fruiting events, etc.

It is thus important that the criteria are applied by experienced markers that have an understanding of local conditions and natural forest dynamics, and should be applied more as guidelines than as rigid criteria, with some leeway allowed where necessary.

Revisiting *Prunus africana* more than 30 years later

Text and photos by Johan Baard

Research feature

Prunus africana (red stinkwood/rooistinkhout) is a large evergreen tree with rough dark-brown chunky bark which is popularly used in traditional medicine. As a result, red stinkwood population size is declining throughout its natural range due to overexploitation. Although the species occur mostly further north of the Eastern Cape, there is a small relic population in the Western Cape in the Bloukrans Pass area of the Tsitsikamma.

Coert Geldenhuys' study, published in 1981, showed a steady decline of red stinkwood in the Bloukrans gorge compared to surveys from 1976-1978, with only 29 trees alive. A survey conducted in January 2011 found only 16 of the 29 trees. At the time, 11 plots of 400 m^2 were set out, with a *P. africana* tree at the centre, and all seedlings counted. Seedlings were found in only seven of the 11 plots; the majority were 5 - 8 cm tall with 2-4 leaves and signs of insect damage similar to that observed in 1981.

The very recognisable bark of *Prunus africana*, unsustainably collected for the medicinal plant trade and therefore decreasing across its range.

Baard JA. 2020. *Prunus africana* in the Bloukrans River Gorge, Southern Cape, South Africa: a revisit 30 years later. Dendrological Society of South Africa.

Prunus africana (red stinkwood) is popularly used in traditional medicine and as a result, its population size is declining. Although the species occur mostly further north of the Eastern Cape, there is a small relic population in the Western Cape in the Bloukrans Pass area of the Tsitsikamma. Here, a summary of this population's dynamics across 30 years is given.

BOTTOM
Prunus africana seedlings. The biggest threat in this small population is not from humans but from herbivores. The plant marked #1 is completely defoliated and plant #2 more than 50% browsed by insects.

TOP
Four *Prunus africana* seedlings permanently marked with aluminium tags. While insects predate small seedlings, the only seedlings that grow larger are in exclosures, which suggests that mammal herbivory is an additional threat.

In 2012, two small exclosure plots (2.5 m x 1.2 m x 1.2 m tall) were erected under one tree. The number of seedlings and their condition were recorded and each was permanently marked with an aluminium tag. Seedlings were monitored (monthly in 2012, quarterly from 2013-2015, and then annually since 2015, always in January). The 2018 monitoring showed nine seedlings still alive, then six years old, with a mean height of 19 cm.

P. africana fruits sufficiently, and germination was shown to be successful. Monitoring showed that leaves are eaten, probably by insects, mostly to the extent that seedlings die. The only seedlings that survived for seven years were found inside the exclosure plots, and none outside the exclosures. This suggests that mammal herbivory prevents seedlings from growing into saplings and into size classes where browsing can be escaped. While it is unlikely that herbivory alone is leading to the population's decline, no signs of resource use (e.g. bark removal) have ever been observed in this population.

The surprising habits of elephants in Kruger

Text by Joel Abraham, Emily Goldberg , Judith Botha & Carla Staver
Photo by Nicola van Wilgen-Bredenkamp

Matriarch with calf; conventional wisdom suggests that elephants have larger impacts in the dry season, but new research questions this assumption.

Elephants in Kruger are less common in areas where the trees they prefer are more common. Additionally, elephant impacts are not more intense where elephants are more concentrated. Whether this a consequence of surveying elephants in the dry season or the variable response of trees, remains to be seen.

Elephants are widely appreciated as ecosystem engineers. By stripping bark, breaking stems and branches, and knocking down trees, they are a major driver of tree mortality in savannas, helping to keep savannas open and grassy. While elephants are critical for maintaining savannas, their impacts can put certain tree species at risk, especially iconic and ecologically valuable species like marula (Sclerocarya birrea), baobab (Adansonia digitata), and knobthorn (Acacia nigrescens). As such, understanding elephant impacts is crucial for balancing the conservation of elephants with the conservation and management of their surroundings.

Anyone who has visited Kruger will know that the locations of both elephants themselves and their impacts are quite spatially variable. Which factors determine this variability? One factor that is consistently associated with elephants is water: water availability is believed to be a key determinant of elephant landscape use. However, other factors have been shown to affect elephant distributions as well short-term changes in vegetation greenness, and tree density and identity. It is unclear how all these processes combine to determine elephant distributions, which makes it difficult to predict or manage their impacts. To further complicate matters, it may seem logical to assume that elephants impact trees more heavily where there are more elephants. However, there is limited evidence that this is the case. Indeed, elephants do not only damage trees for food; male elephants may knock down trees to impress females or intimidate other males. As such, even places where elephants are not foraging intensely may still suffer severe impacts. Altogether, the idea that elephant density is the main predictor of their impacts remains untested.

To address these uncertainties, we investigated the distribution of elephants and their impacts on trees in Kruger National Park. We used spatially explicit data on elephant impacts, collected at Kruger's Veld Condition Assessment (VCA) sites, in combi-

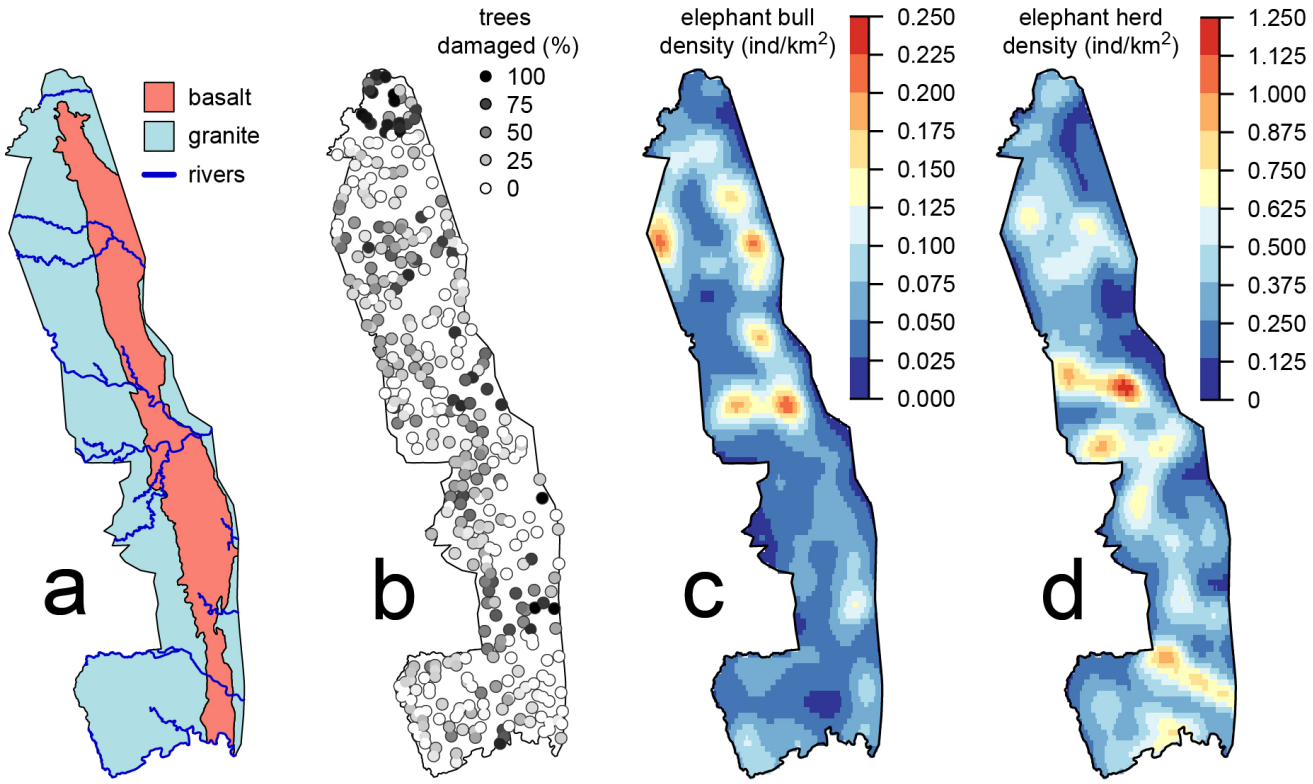


Figure 1. The distributions of (a) landscape features (soil parent geology and permanent rivers), (b) elephant impacts at VCA sites, (c) bull elephant densities, and (d) densities of elephants in mixed herds in Kruger National Park, South Africa. Note that the scales differ in (c) and (d), as elephants in mixed herds are nearly an order of magnitude more numerous than bull elephants.

nation with data from helicopter aerial censuses. We used the aerial census data to generate separate density maps for bull elephants and herds across the park (Fig. 1), and then extracted elephant densities at VCA sites from these density maps. We then modeled the predictors of elephant densities and elephant impacts, which allowed us to identify environmental and ecological factors that contribute the most to explaining the distributions of elephants and their impacts.

We found that elephants have distinct preferences for certain tree size classes and species, particularly marula (*Sclerocarya birrea)*, umbrella thorn (*Acacia tortilis)*, and mopane (*Colophospermum mopane*) (Fig. 2). Surprisingly, however, we found that elephants were not common in areas where the trees they preferred were more common. Instead, we found that bull elephants concentrate in sparsely treed basaltic sites close to artificial waterholes, whereas mixed herds aggregate strongly around permanent rivers, particularly in areas with little grass. Lastly, we found that elephant impacts were not more intense where elephants were more concentrated. Instead, impacts were greater in densely treed areas and on basaltic soils.

This is intriguing: what decouples elephants from their impacts then? One possibility is that elephant distributions are recorded at the wrong time of year for evaluating their vegetation impacts. Scientists have historically assumed (as we did in our work) that elephant impacts on vegetation are most severe during the dry season, because they eat more trees than they do in the wet season. However, elephants do forage on trees throughout the year, and they also damage trees not just for food. These activities may unlink elephant impacts from observations of elephant distributions made in the dry season.

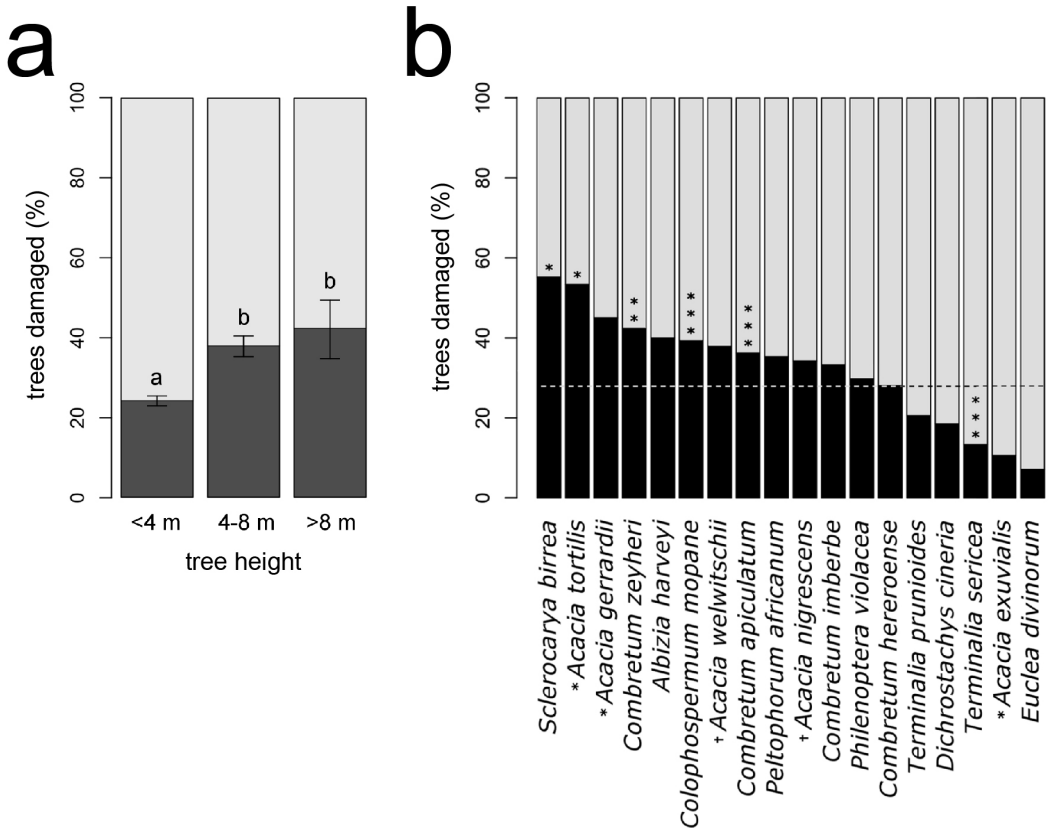


Figure 2. Elephant damage rates on trees by (a) height class and (b) by species. In (a), error bars denote 95% confidence intervals around each sample mean, and letters indicate significant difference ($P < 0.001$). In (b), the mean percentage of trees damaged (28.0%) is given by the dotted line. Species means significantly different from the universal mean are indicated by stars (*$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.001$). Discussion continues on the proper classification of the polyphyletic Acacia genus; here all species have been identified as Acacia, but those proposed to belong in Vachellia are marked with an asterisk (*) and those in Senegalia with a dagger (†).

Finally, we suggest another possibility, that focusing only on the elephants may be inappropriate for understanding their impacts. The trees themselves may matter too. Savanna trees differ in their growth rates and tolerance to elephant damage and, as such, variation in the ability of trees to tolerate and recover from elephant damage may obscure any relationship between where elephants are and where damage is observed. Trees in places where elephants are dense may be better suited to avoiding or recovering from elephant damage. Evaluating the characteristics of plants themselves may therefore be crucial to understanding the impacts elephants have on them. Altogether, predicting elephant distributions and that of their impacts remains an ongoing challenge.

Abraham JO, Goldberg ER, Botha J & Staver C. 2021. Heterogeneity in African savanna elephant distributions and their impacts on trees in Kruger National Park, South Africa. Ecology and Evolution 11(10): 5624-5634.

The curious case of the vanishing buck

Text by Corli Wigley-Coetsee, Cathy Greaver, Chenay Simms & Sam Ferreira
Photo by Cathy Greaver

"Tsessebe a somewhat local animal but very numerous in a great many places". "Roan very local, but numerous in the western centre of the Reserve. They are never found in the eastern portions." "Sable Antelope are very numerous between the Sabi and Olifants Rivers... The Crocodile River seems to form the southern boundary of this species in Africa." - Major Stevenson Hamilton, 1928

Rare sightings of sable antelope in Kruger National Park (Kruger) generates nearly as much campfire chatter as the excitement of watching a pride of lions. A hundred years ago, these were found in relatively large numbers. What may be the reason?

Most of the "rare" antelope in Kruger (i.e. tsessebe, roan, sable antelope and Lichtenstein's hartebeest) are at the southern range limit of their historic distribution. Elsewhere they occur in large numbers (e.g. sable in Zimbabwe and Tanzania; roan in Malawi and Botswana).

There are at least four theories of why these antelope species are now rare in Kruger, but available evidence makes it hard to conclude which one best fits. The first two theories relate to competition and predation. The historic wide-scale provision of artificial water allowed large herds of bulk grazers (i.e. zebra, blue wildebeest and buffalo) to become resident in areas where they previously could not reside throughout the year. Some of these areas were places that the selective feeding rare antelope, which do not need to drink water every day, could use to escape competition with bulk grazers. Lions also increased with the resident large herds of bulk grazers and started preying on the rare antelope. Rare antelopes may have ended up in an ecological trap as smaller herd sizes led to Allee effects, i.e. less individuals to detect predators, while at the same time scattered herds make it difficult to start new herds.

The third theory proposes that increasing temperatures over the past 50 years resulted in a decrease in carbon-nutrient quality of grasses, especially in the northern parts of Kruger. The selective feeding rare antelope species depend on taller stems with high carbon-nutrient quality, specifically so in the cooler, dry season. Increases in shrubs and decreases in tall woodlands in Kruger at the same time may influence rare antelope habitat, an additional effect on top of the reduced diet quality.

The fourth theory proposes a combination of all the others. Previous work on the sensitivity of species to habitat fragmentation showed that species with

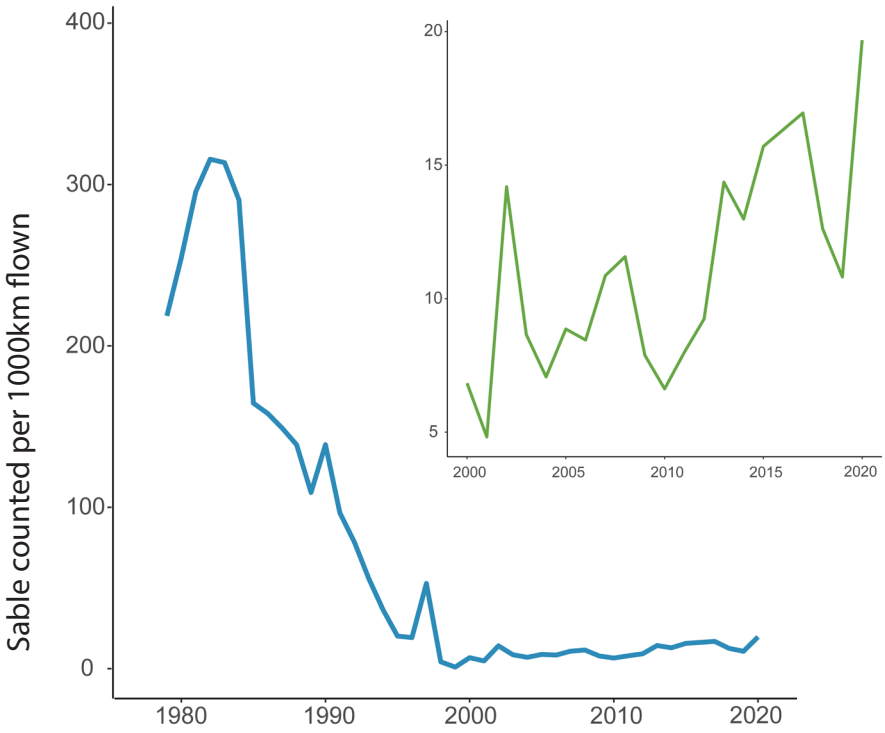


Figure 1. Although sable antelope numbers have long been in decline in the Kruger National Park; there appears to be a slow increase (green line in insert) in sable over the past 20 years. Sable numbers are shown here as sable counted per 1000 km flown.

narrow niche scores (e.g. very specialised in habitat and diet) and at the edge of their geographical range are most at risk to sudden population collapse. The rare antelope in Kruger may thus be responding to suboptimal habitat and dietary conditions, intensified by accentuated sensitivity to competition, predation, disease and drought.

Exploratory analyses used sable counts from aerial surveys between 1977 and 2019 corrected to numbers per 1000 km flown to account for variable distances flown. Sable occurred in relatively large numbers in the mid-1970s, but declined precipitously during the 1980s. Since the late 1990s, sable seems to be on a steady upward trajectory. This is probably a combination of reduced predation pressure as well as relatively favourable climatic conditions. Despite lion and hyaena numbers increasing in recent years, their abundances decreased in at least one important focal area for rare antelope. Although we want to think that reducing water provisioning played a role in the slow recovery of rare antelope, the links are circumstantial.

Sable antelope bull in the Kruger National Park; sable is at the southern edge of their natural distribution in Kruger and sub-optimum habitat conditions combined with high predator pressure probably contribute to high variability in population numbers in this park.

Kalahari Gemsbok National Park: 45 years of herbivore monitoring

Text by Nkabeng Mzileni, Marna Herbst & Corera Links
Photo by Nkabeng Mzileni

Aerial census surveys have been conducted in the Kalahari Gemsbok National Park since 1975. Here we are reflecting on the data collected during these surveys.

Monitoring

Given the vast landscape of the Kalahari Gemsbok National Park, sample counts from 23 transects are used to estimate the total population numbers of large herbivores such as red hartebeest, gemsbok, springbok, eland, and blue wildebeest.

Population fluctuations occur for various reasons. Species inherently respond differently to climatic conditions, particularly rainfall and associated forage availability. Eland and springbok, for example, are nomadic while gemsbok and red hartebeest are adaptable to local conditions, resilient and tend to be resident. Although blue wildebeest migrate in many systems, in Kalahari Gemsbok on the other hand, the blue wildebeest appears to be resident in the Auob and Nossob riverbeds. This is reflected in the more or less stable wildebeest numbers (Fig. 1) over time. The distribution and management of artificial water points likely has a direct effect on the spatial distribution of the blue wildebeest.

Migratory species such as eland and springbok show much more variability in their numbers. Long-term monitoring has shown that eland only migrates to the South African side when there is drought in the central Kalahari. Springbok, on the other hand, used to migrate over long distances but more recently only migrates locally.

The observed responses could be due to rainfall and the effect on water availability, veld condition, birth peaks, or a combination of these that will drive migration patterms to and from Botswana. Further, factors beyond the boundaries of the tranfrontier area may affect migration patterns; e.g., veterinary fences. All these factors need to be understood in longer term patterns in the Kalahari and therefore historical and continued monitoring of larger scale population numbers across the transfrontier conservation area is very important.

RIGHT
Blue wildebeest congregating at a water point in the Kalahari Gemsbok National Park. The provision of water has likely contributed to this species becoming resident in the riverbeds, rather than migrate seasonally.

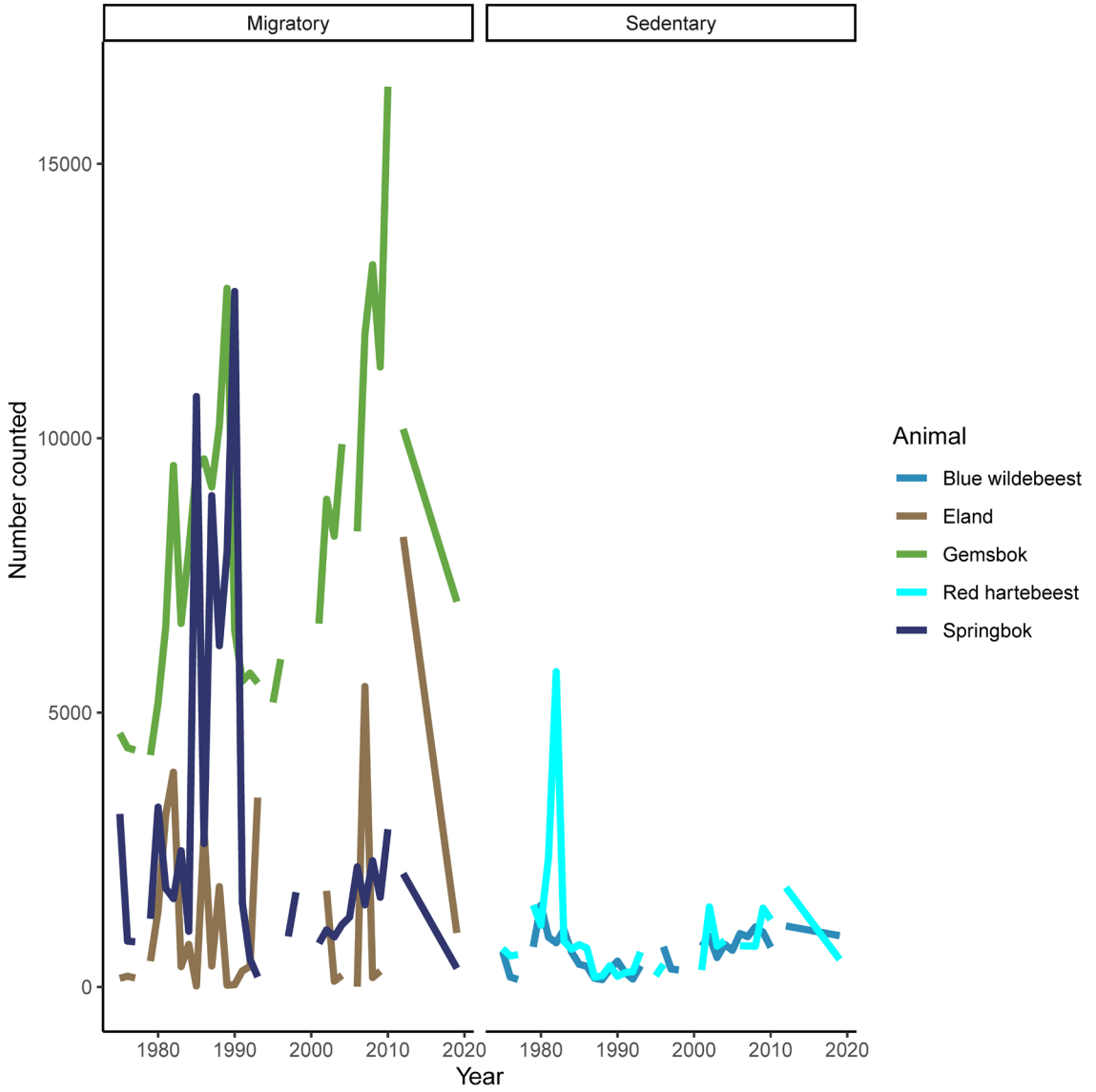


Figure 1. Summary of the animal numbers counted in the Kalahari Gemsbok National Park aerial censuses between 1975 and 2020.

First report of "summer sores" in zebra in Addo Elephant

Text by Angela Bruns, photos by Angela Bruns and Nkabeng Mzileni

In March 2020, increasing numbers of plains zebra (*Equus burchelli*) in Addo Elephant National Park, were reported to show lameness concurrent with the development of ulcerative skin lesions. At the same time the body condition of the zebra decreased significantly. This happened just after veld conditions had slightly improved with the long awaited onset of rains after the preceding drought.

To investigate the source of the skin lesions three animals were examined post mortem and samples submitted for histopathology. Histopathology revealed high loads of round and tape worm in various organs and fragments of round worm larvae in the skin lesions, indicating an infection with *Habronema* spp. or *Draschia* spp., the horses' stomach worms. These worms' life cycle depend on larval transmission via flies and larvae are often ingested. However, should larvae be deposited on the skin, they would burrow into the skin and may either die off without further development, or alternatively, could cause severe inflammation or ulceration of the skin. The resulting lesions are also called summer sores in horses, and have been reported in zebra before, but not to the extent of an outbreak as seen last year in Addo.

So why the sudden outbreak? With the onset of the rains the long dormant parasite population would have thrived and rapidly increased on the wet and lush grassy plains of Addo, whereas the immunity of the zebra would have been impaired after their fat reserves were depleted during the drought. This would have made it difficult for some of the zebra to cope with the sudden explosion in parasite numbers, leading in a downward spiral to a further decrease in body condition and ultimately death, either succumbing to their weakness or easily preyed upon by lion.

Incidentally the horses of the Zuurberg mountain horse riding trail showed the same lesions, which were successfully treated with a dewormer. This, however, was not feasible to implement in the zebra population.

The lesions disappeared in May 2020, with the onset of winter and with it the disappearance of the intermediate host, the flies, which interrupted the life cycle of the stomach worm. With continued good grazing available, the zebra regained condition and immunity and no new cases have been reported up to date.

TOP
Zebra with summer sore (see dark round patch on upper front leg, top photo), loses condition eventually (bottom photo).

RIGHT
Animal Health Technician Lolo Nkhumane is about to take a blood sample of an immobilized buffalo for disease testing. Buffalos are being anaesthetized with a new lower cost drug protocol ideal for boma work.

Better veterinary protocols

A novel immobilization protocol and searching for effective TB testing in buffalo

Text and photo by Angela Bruns

A fair amount of work for Veterinary Wildlife Services involves buffalo immobilizations for disease testing. Only animals free from the notifiable diseases bovine tuberculosis, brucellosis (contagious abortion), corridor disease (theileriosis), and foot and mouth disease are allowed to be translocated within the disease free zone. This mostly necessitates at least three immobilization events before animals can be moved.

Traditionally an opioid is combined with a tranquilizer such as azaperone, creating a synergistic effect which allows for a reduced total opioid dose (which are costly) and the concurrent benefit of reduced opioid side effects such as respiratory depression. A novel combination of opioids with the alpha-2 antagonist, medetomidine, allows for even further reduction of the total opioid dose. Whereas this combination enables a saving in opioid use, it comes with its own challenges. Alpha-2 antagonists target the same receptors as adrenaline, with the result that a prolonged chase e.g., by helicopter, will elevate adrenaline blood levels which in turn reduces the efficacy of the drug combination. This makes it less suitable for the capture of free range animals. However, in confined spaces such as holding facilities, the new protocol has proven its value in smooth and reliable induction of immobilization.

Herd testing for tuberculosis (TB) status is done by applying the comparative intradermal skin test, i.e. inoculating the animal with both bovine as well as avian mycobacterial antigens. A naïve animal will show no to minimal reaction compared to increased skin thickness as well as signs of inflammation in an animal that has been exposed to a mycobacterium before. Unfortunately this test is infamously unreliable. The gold standard for diagnosis of TB in any animal is a positive culture of infected tissue, which mostly only take place post mortem.

In the Northern Cape area we are repeatedly facing a conundrum, where skin reactions are seen but no corresponding lesions on post mortem examination are observed and cultures remain negative for *Mycobacterium bovis* growth. We suspect that we are dealing with an immunological cross reaction from one of the multitude of mostly harmless environmental mycobacterium found in soil.

To get to the bottom of these inconsistent reactions, we are currently supporting a research project at the University of Stellenbosch, supplying samples for novel immunological blood tests towards TB diagnosis as well as providing corresponding nasal swabs and soil samples towards hopefully identifying a non-tuberculous mycobacterium species associated with the positive reactions – we are holding our fingers crossed that our suspicion will be substantiated.

ENVIRONMENTAL CHANGE AND RESTORATION

Common river frog, Garden Route National Park, Melanie de Mornay

Global species loss could be halved by conserving 30% of tropical lands

Text by Wendy Foden

Where will future 'hotspots' of species richness be as species shift their ranges in response to climate change, and are they protected? A major five-year international study in the world's neotropical areas addressed this question, which helps to inform how much land needs to be protected, and the protected area management and expansion plans that need to be implemented now.

In 2016, scientists from Sub-Saharan Africa, South America and Southeast Asia combined expertise in an ambitious UN-funded project called SPARC (Spatial Planning for Protected Areas in Response to Climate Change). The SPARC team aimed to work out which areas should be protected to minimise species extinctions due to climate change, and I co-led the African component. The resulting paper, published in Ecography in February 2020, was intended to coincide with negotiations on the UN Convention on Biological Diversity's new targets for protected area coverage. The 2010-2020 target was 17% of land and 10% of coastal and marine areas. Many parties are pressing for 30% for the 2020-2050 target. We set out to see what 30% would mean for species under climate change.

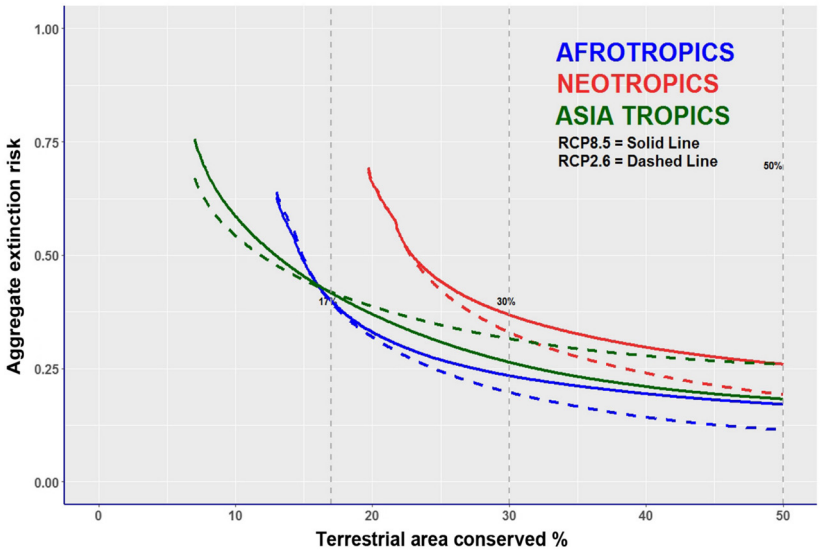


Figure 1. Modelled extinction risk reduction with increasing land conservation. Ensemble mean Aggregate Extinction Risk (AER) vs % terrestrial area conserved under RCP 2.6 (dashed lines) and RCP8.5 (solid lines) for the Afrotropics (blue), Neotropics (red) and Asia Tropics (green). Vertical lines show the aggregate extinction risk curve intersection with 17%, 30% and 50% terrestrial area conserved. AER is the mean of individual species extinction risk at each increment of conserved natural land and is scaled from 0 to 1 (zero probability extinction to likely extinction). Figure taken from Hannah et al. 2020, Ecography.

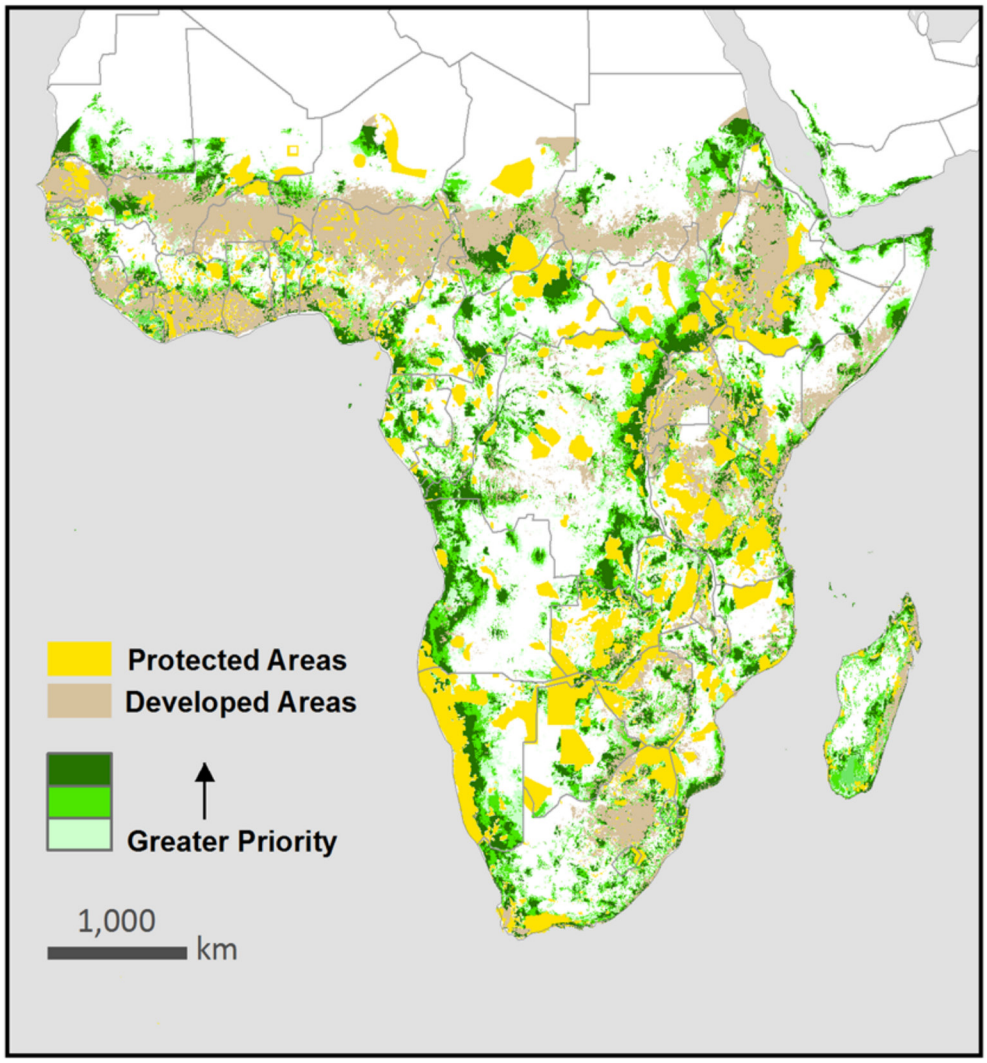


Figure 2. Map of priorities for additional conservation for tropical biodiversity in response to climate change in the Afrotropics. Conservation priorities are shown in shades of green where darkest green represents the greatest opportunities to conserve biodiversity under climate change. Areas in yellow are existing protected areas in the WDPA and areas in tan are either urban or intensive agriculture. Figure taken from Hannah et al. 2020, Ecography.

By modelling the climate change-driven movement of the ranges of more than 110,000 tropical species, we discovered that increasing protection of tropical land areas to 30%, halves the extinction risk of tropical plants, birds and mammals (see Fig. 1). We showed that increasing conservation efforts paired with limiting global warming to 2oC offers the best chance to slow species loss.

The paper also provides maps and spatial planning to help illustrate locations across the Afrotropics, Neotropics and Asia Tropics that, if protected, could most effectively reverse currently predicted extinction rates. Excitingly, these highlight Southern Africa's western escarpment from South Africa through Namibia to Angola as critical (Fig. 2). Protecting landscapes so that they can become functional for species on the move due to climate change is essential. Key recommendations include that future conserved lands need to account for climate change-driven shifts in species location and that many important conservation areas of the future have already been transformed due to agriculture.

SPARC's maps and other results have been shared with SANParks' Park Planning team and will be used to inform decisions such as land purchase priorities and to identify corridors and regufia that build climate change resilience. They will also help to identify areas in which fostering conservation by private landowners is vital, including through special management areas and conservancies. The paper and the insights it offers are valuable for helping conservation planners to coordinate efforts on the ground, and are being cited and used in international policy discussions.

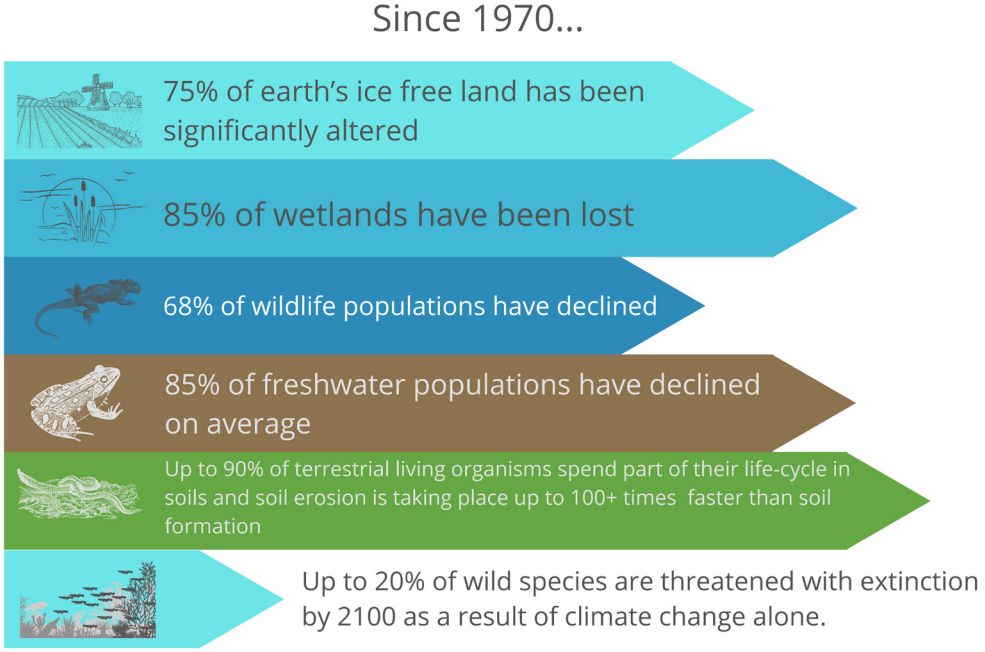
Hannah L, Roehrdanz PR, Marquet PA, Enquist BJ, Midgley G, Foden, Lovett JC, Corlett RT, Corcoran D, Butchart SHM, Boyle B, Feng X, Maitner B, Fajardo J ... & Svenning JC. 2020. 30% land conservation and climate action reduces tropical extinction risk by more than 50%. Ecography 43: 943-953.

Contributing to the Living Planet Report - Climate change

Text by Nicola van Wilgen-Bredenkamp & Wendy Foden

Wendy Foden and Nicola van Wilgen-Bredenkamp had an unique opportunity to contribute to the 2020 Living Planet Report. The living planet report is compiled every two years by WWF and consolidates information from all over the world to provide a tool for tracking how well conservation is doing. Less exciting was the report's dire findings. Monitoring data show an average decline of 68% in the abundance of over 20 000 different wildlife populations (of mammals, birds, amphibians, reptiles and fish) since 1970.

Wendy served as lead on what became the Living Planet Report's (LPR) first sub-report to focus entirely on climate change. Entitled 'Too hot to handle: a deep dive into biodiversity in a warming world', the report included contributions from Nicola, Wendy and collaborators from SANParks and Stellenbosch University. Conventionally, land use change and habitat loss were the major driving forces of biodiversity loss. While drivers like climate change have not really had much observable impact yet, this is starting to change. In South America for example, 12.5% of population declines are already attributable to climate change and continued change is expected to play a much larger role in future declines, while historical threats persist. Predictions are that up to 1 in 5 species are at risk of extinction from climate change this century.

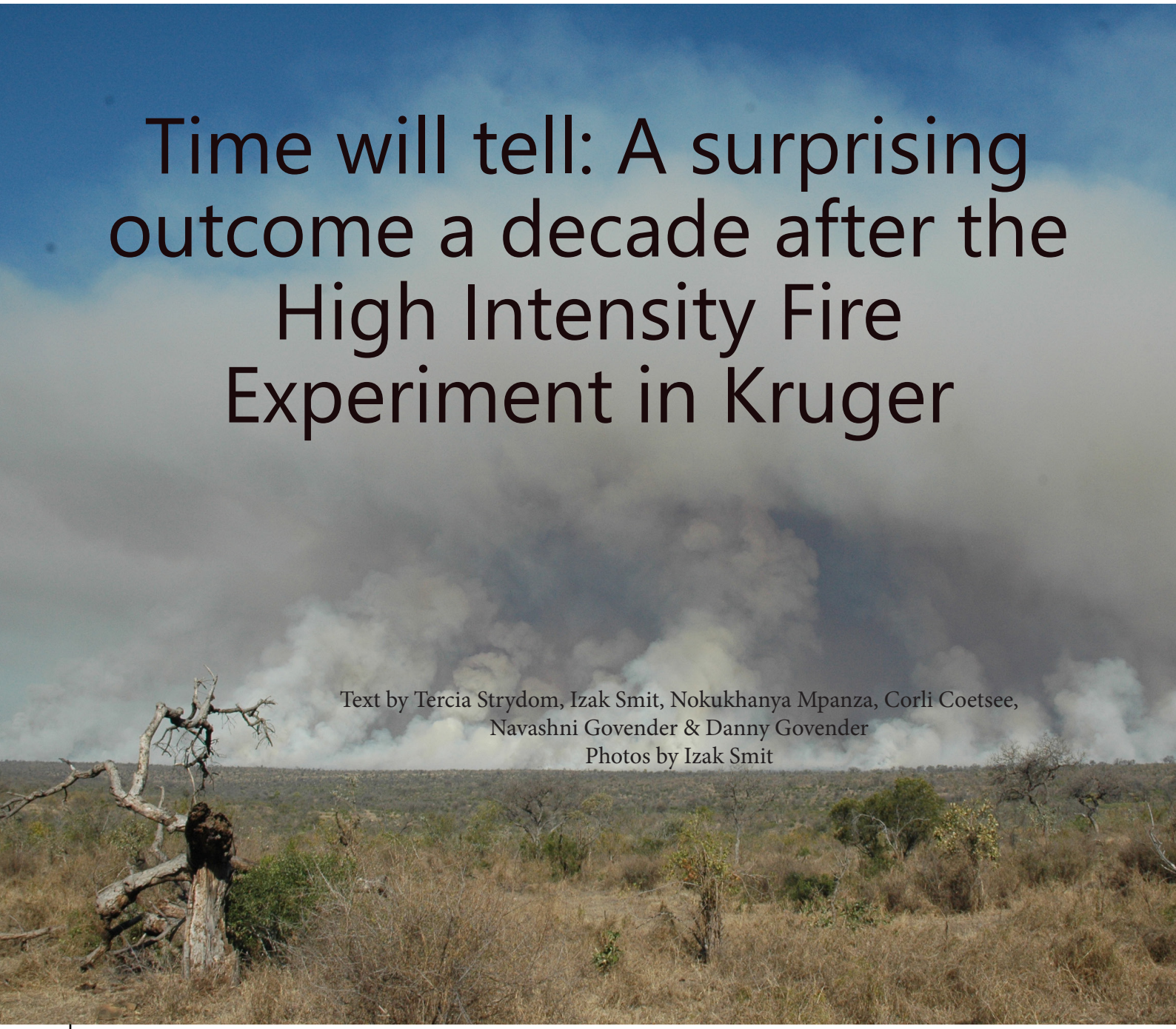


Examples of species-level impacts used in the report included dramatic images from Australia of flying foxes literally dropping from trees in their 1000s during heat waves. These large bats roost in massive colonies, making population level impacts of extreme events easy to observe. Impacts are smaller scales may be easily overlooked.

The report included an assessment of options to 'bend the curve' of biodiversity loss. The model was based on a business as usual future, where several factors were manipulated to assess the impact. These factors included supply of goods (agricultural yield on the current land), demand for goods (reducing waste and consuming fewer animal calories) as well as increasing conservation to include as large a proportion of remaining wilderness areas, up to 40% of the planet; and combinations of the three. The integrated portfolio of actions outperformed the rest, not only in reducing biodiversity loss, but also in delivering co-benefits in terms of reducing carbon emissions, pollution, and water consumption and reducing the trade-offs between conservation and agriculture. The authors of this section concluded "We show that immediate efforts, consistent with the broader sustainability agenda but of unprecedented ambition and coordination, could enable the provision of food for the growing human population while reversing the global terrestrial biodiversity trends caused by habitat conversion". While many things need to align to achieve this, the LPR also produced a supplement "voices of the living planet" which provided really solid ideas and thinking around how this might be achieved. For example, Mathis Wackernagel pointed out that environmental issues are often a side-show. "Such postulations only fuel the belief that responding to climate is an added cost. They make climate action benevolent, noble, voluntary, and hence non-existent. This issue stems from the widespread belief that we need to wait for an elusive, and frankly unlikely, global collaboration before anyone can act."

We hope that the information in the report will underscore the massive importance of attending to conservation needs. The covid-19 pandemic has provided us with a very real opportunity to step up and change business as usual. History shows that individuals do have the power to bring change and we all have the opportunity to make a big difference.

Time will tell: A surprising outcome a decade after the High Intensity Fire Experiment in Kruger



Text by Tercia Strydom, Izak Smit, Nokukhanya Mpanza, Corli Coetsee, Navashni Govender & Danny Govender
Photos by Izak Smit

Woody vegetation is becoming denser in many ecosystems around the world. This densification, often referred to as "bush encroachment", has been attributed to local (e.g. changes in fire regimes, land use, herbivory, rainfall patterns, etc.) and global (e.g. elevated atmospheric CO2, atmospheric nitrogen deposition and climate change) drivers. In South African savannas, things are no different and bush encroachment has been well-documented across many land uses including communal rangelands, farming areas and conservation areas.

In Kruger, we too have observed increases in bush encroachment in many parts of the park. Bush encroachment may potentially impact tourism and visitor experience, changes to the fire regime, vegetation structure, herbivory dynamics, landscape hydrological patterns and nutrient cycling. Kruger management began exploring possible measures to address bush encroachment more than 10 years ago.

In 2010, with the help of Working on Fire, Kruger managers and scientists initiated a large-scale high intensity fire experiment with the objective of testing whether fire could be used to combat bush encroachment. One site was burned with a high intensity fire in 2010 as well as in 2013 (High_high), while another site burned as high intensity in 2010 but medium intensity in 2013 (High_med).

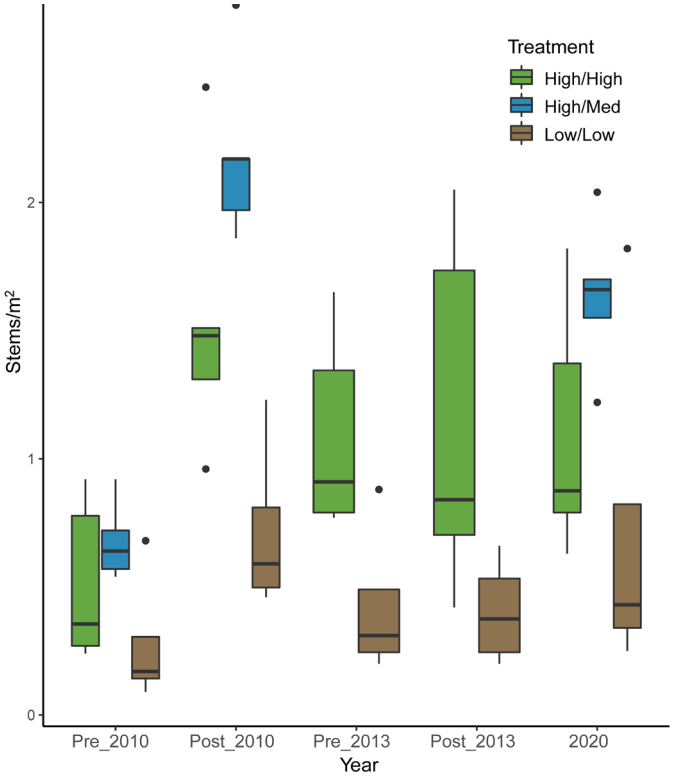


Figure 1. Effect of varying fire treatments on the number of woody stems over time. Pre- and post-2013 data were not available for High_med. The High_med treatment seemed to result in more multi-stemmed plants.

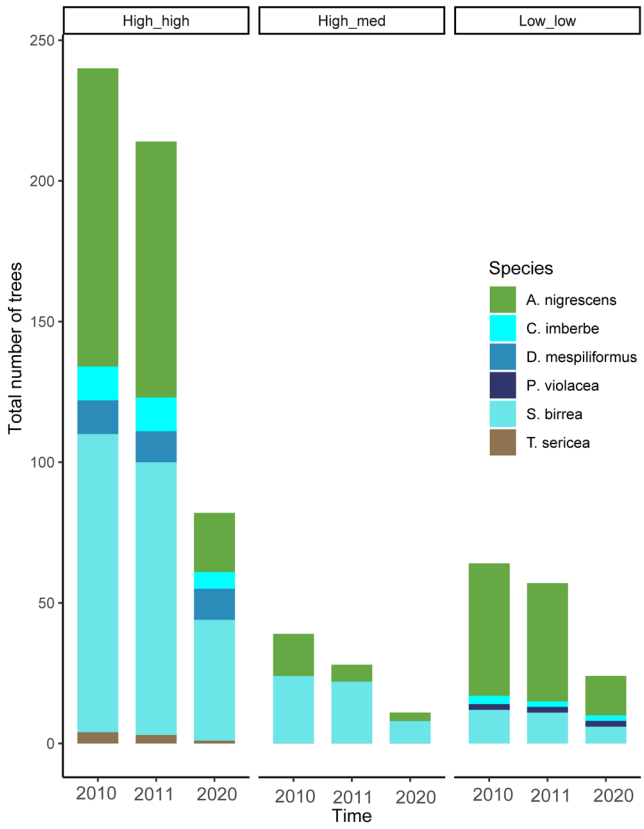


Figure 2. Loss of tall trees based on field surveys between 2010 and 2020; many tall trees were lost when two intense fires followed each other.

Lastly, a site was burned with low intensity fires both in 2010 and 2013 (Low_low). We manipulated intensity by burning more or less at the same time, but choosing different days/time of day with different weather. Using a combination of field data as well as LiDAR surveys, we were able to examine the effects of these various fire intensities on woody vegetation over the last decade (2010 – 2020).

Initially, LiDAR surveys conducted between 2010 and 2014 showed a decrease in the woody cover in the High_high and High_med fire intensity sites. However, a resurvey of shrubs in 2020 found that the number of stems increased in all three fire treatments but particularly so in the High_high treatment (Fig. 1)

With each fire in 2010 and 2013, vegetation height decreased, particularly for vegetation below 5m. However, shrubs would resprout and coppice vigorously after the burns. In 2020, the woody vegetation remained shorter than their initial 2010 heights specifically in the High_high and High_med sites. There was a significant increase in the number of shrub individuals in the High_high and High_med sites. From the LiDAR and field surveys, we observed an elevated rate of loss of large trees (>10m) following high intensity fires (Fig. 2). Pre-fire elephant damage rendered large trees particularly vulnerable to fires.

Our early results suggest that surprisingly, the high intensity experimental fires did not achieve its primary goal of reversing bush encroachment. Shrubs in general and specifically in the High/Med burn are shorter but more multi-stemmed and with slightly more individuals 10 years after the experiment was initiated.

Conducting vegetation surveys after the high-intensity burn experiment enabled researchers to monitor the long-term impacts of the different burn treatments.

New insights for alien species management

Text by Nicola van Wilgen-Bredenkamp, Chad Cheney & Llewellyn Foxcroft
Photos by Nicola van Wilgen-Bredenkamp & Chad Cheney

Alien invasive plants are species that have been introduced by people from other parts of the world to areas where they did not occur naturally. These plants have few natural enemies in their new range and can have dramatic impacts, taking over from naturally occurring species, displacing birds and other animals and impacting people through, for example, decreasing agricultural productivity, increasing fire frequency and using large amounts of water. We developed a commonness framework that can be used to class alien species; each class is associated with a specific management strategy.

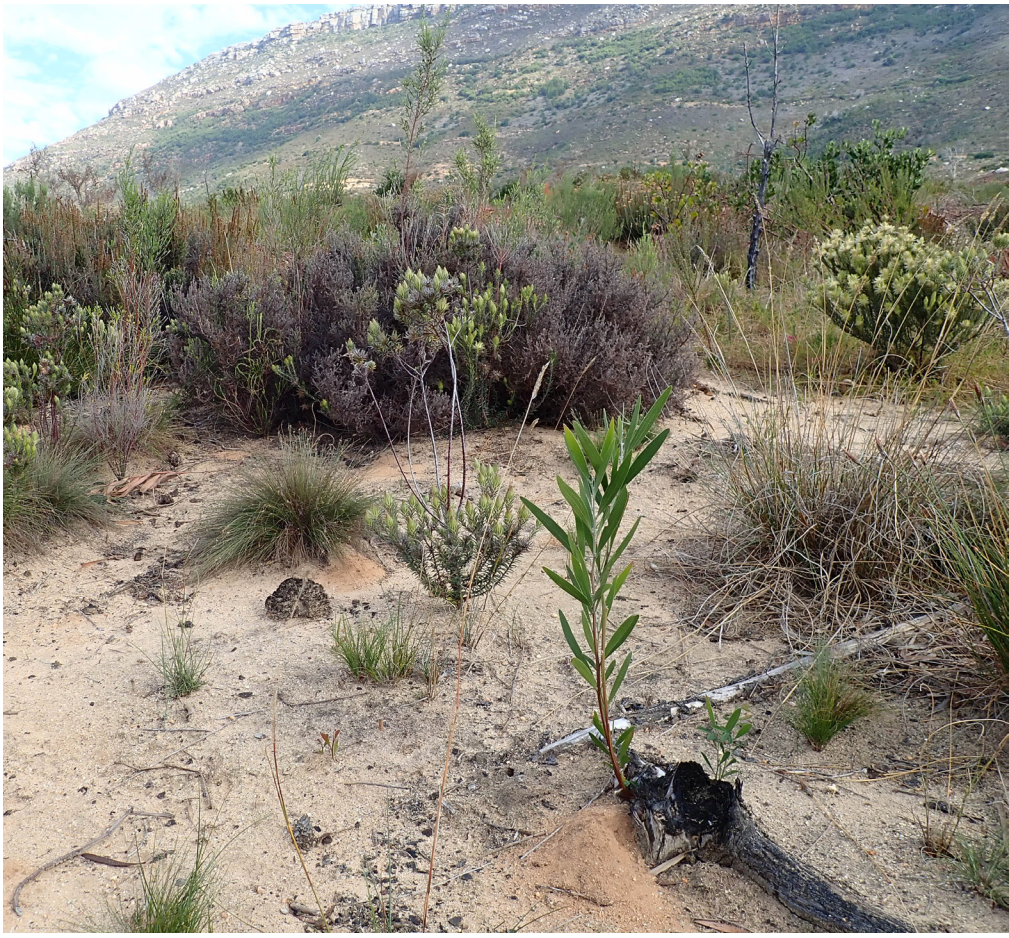
Alien mappers collected data from 10 000 plots across Table Mountain National Park and these data were used to create a framework with nine commonness classes which can be used to tailor management interventions.

Researchers from SANParks, the CIB - Stellenbosch University and La Trobe University, tested a theoretical commonness framework to demonstrate how changing the resolution of data used in alien species management can be improved. Managing alien plants is challenging and there is often a trade-off between prioritizing certain species and ensuring that priority areas are kept free of aliens. Using a 'Commonness framework' allows researchers to quantify patterns of plant invasion when viewed at increasingly coarse spatial resolution, in other words examining the distribution at small isolated patches up to the entire landscape. The framework uses data from 10 000 sample plots, to classify species into one of nine commonness classes at a given spatial scale. These classes are based on three species characteristics; lo-

cal population size (small/large), invaded geographic range (wide/narrow) and spatial pattern (even/clumped). These metrics were calculated using a comprehensive fine-scale invasive alien plant (IAP) dataset from Table Mountain National Park, at six scales of increasing spatial grain, enabling quantification of the effects of scale and species' range structure on management potential of IAPs. Each commonness class can be associated with a particular management strategy that best fits the specific scenario.

Most species exhibited the Point Source commonness type (narrow novel range and small local population) at fine spatial grains, requiring rapid response, reconnaissance or sweeping management strategies. At coarser grains, species were mostly classed within wide occupancy ranges with small population sizes (Dispersed and Sparse types). Using a phylo-tree, the study demonstrated that different management strategies were appropriate for the same species in different parts of its invasive range and also that species-specific goals at particular sites may change when viewed at increasing grain coarseness. For example, species generally deemed to be common may require Rapid Response type strategies for isolated and/or small, clumped subpopulations.

It was apparent that nuances in the best approach to clearing are often obscured through use of coarse scale data that frequently drives management decisions, indicating the need for data at finer scales to strengthen management decisions.



Protected areas have a responsibility to minimize the impact of invasive species to achieve their objectives. This study provides us with insight into how we can better achieve this, especially as we often visualise a particular species' commonness based on what we observe in the broader landscape. As a result, eradication from an area is not considered because the species is known to be widespread. Use of this framework allows us to reconcile area-based and species-based management strategies. There are a number of management strategies that are currently under-utilized by managers. For example, our data show that there are several species that could be targeted for eradication in the study area. In addition, use of a reconnaissance strategy to detect individual plants can prevent invasion of new areas.

A future 'point source' *Acacia longifolia*. Working to remove isolated invasions is a key component of alien species management that has received less attention to date, in favour of broader control strategies. The commonness framework may recommend different management actions for the same species at different scales.

Cheney C, van Wilgen NJ, Esler KJ, Foxcroft LC & McGeoch MA. 2021. Quantifying range structure to inform management in invaded landscapes. Journal of Applied Ecology, 58: 338–349.

Alien plants become naturalised away from rivers in Kruger

Text by Llewellyn Foxcroft

Monitoring alien plants across the Kruger National Park landscape, at perennial and seasonal rivers and dry savanna crest areas gives insights into the distribution and naturalization of alien species, including the detection of a new alien species to Kruger.

In Kruger National Park invasive alien plant control has been implemented for priority species, mainly along perennial rivers. However, little is known about the invasion of large tributaries or seasonal rivers, and the drier upland savanna areas have generally only received attention in areas where specific species are known to occur, such as sour prickly pear (*Opuntia stricta*).

As part of the MOSAIK programme (Monitoring Savanna Biodiversity in the Kruger National Park), 60 plots were established across the park, in four different land systems and along perennial rivers, seasonal rivers and dry upland savanna areas (Fig. 1). At each site, 50 × 50 m plots were intensively surveyed for all plants, including naturalised and invasive alien species. This first intensive survey of alien species at this scale allowed for assessment of previously unreported species. It also aimed to shed light on lesser-known species and/or those difficult to identify or easily overlooked in rapid surveys or by control teams.

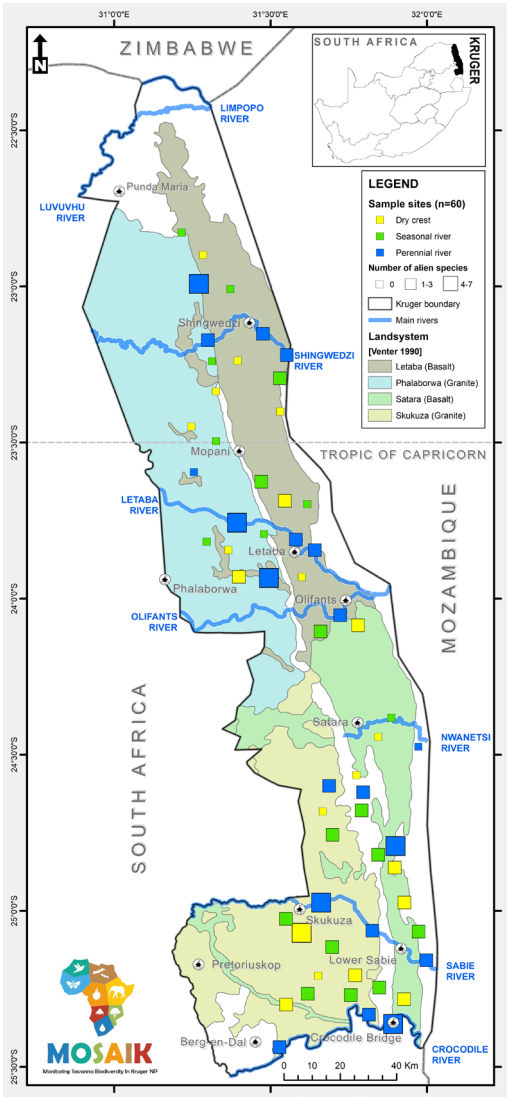


Figure 1. A map showing the location of the survey sites across KNP. Twenty naturalised species were recorded across the three habitat types (Pyšek et al. 2020).

Naturalized alien plants are species that, after having been introduced, spread and develop self-sustaining populations. Twenty naturalised species were recorded across the three habitat types. One species, spanish needles (*Bidens bipinnata*),

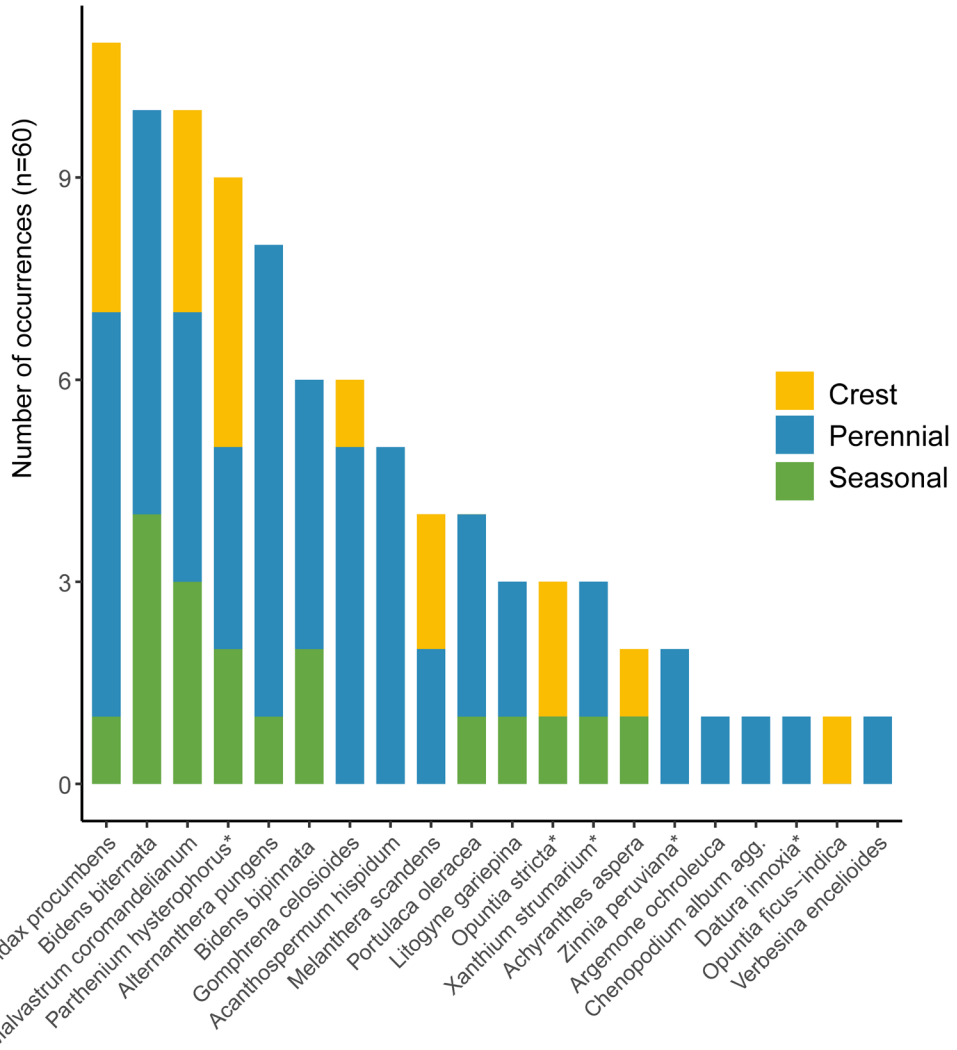


Figure 2. Distribution of alien species in the Kruger National Park according to the savanna habitats delimited within the MOSAIK project (perennial rivers, seasonal rivers, dry crest). Numbers of occurrences (n = 20 per habitat) are shown. Species with * are considered invasive in KNP. From Pyšek et al. (2020).

represented a new introduction for the park. Only four had previously been recognized as invasive; i.e. species that can spread over large areas, often in dense monocultures, and that modify the landscape, habitat and outcompete native species (Fig. 2).

The most widespread species was tridax daisy (*Tridax procumbens*), occurring in all the habitat types. The majority of aliens were concentrated along perennial rivers (17 species or 60% of all occurrences), but some were also repeatedly recorded at seasonal rivers, while two of the most invasive species in KNP, sour prickly pear and parthenium (*Parthenium hysterophorus*), also occurred on dry crests away from water.

The results highlight the need for fine scale, intensive surveys for alien plants in KNP, not only along the main rivers, but in other areas that have been considered less at risk for being invaded. It also showed that species that have not been given any attention are already widespread, and that structured intensive surveys can be used to detect new species. As the data also include abundance, follow-up surveys in the same plots after a few years will provide a good opportunity to determine if the naturalised alien species are persisting and whether any are showing the potential for becoming invasive.

Pyšek P, Hejda M, Čuda J, Zambatis G, Pyšková K, MacFadyen S, Storch D, Tropek R &, Foxcroft LC. 2020. Into the great wide open: do alien plants spread from rivers to dry savanna in the Kruger National Park? NeoBiota 60: 61–77. https://doi.org/10.3897/neobiota.60.54608

Invasive alien plants become more phytochemically diverse in their new habitats

Text by Llewellyn Foxcroft
Photos by Geoff Nichols, Stefan Lefnaer & Llewellyn Foxcroft

Higher metabolomic diversity and associated metabolic flexibility gives three invasive alien plants in Kruger National Park an advantage to overcome stresses in their new habitat.

Metabolomics is the study of metabolites inside cells, tissues or organisms. Increased metabolomic diversity in alien plants invading new areas suggests that metabolic flexibility and/or rapid evolution contribute towards their success as alien invaders. Metabolic flexibility enables quick adaptation of secondary metabolism to provide better defence against unique biotic and abiotic stresses encountered in the invaded habitats.

Our objectives were twofold, 1) to identify differences in the metabolomic profiles of plants in their invaded vs native habitats, and 2) detect patterns in metabolomic profiles and between the populations of different regions. To address these objectives we chose three species native to the USA that are invasive and potentially pose severe ecological threats in Kruger National Park (KNP), *Chromolaena odorata*, *Datura stramonium* and *Xanthium strumarium* (Figures xx). We collected samples using the Rapid Metabolome Extraction and Storage (RAMES) technology, and determined phytochemical diversity by analysis of their metabolomic profiles.

Comparing *C. odorata, D. stramonium* and *X. strumarium* in South Africa to their native counterparts in the United States shows a clear increase in phytochemical diversity in KNP (Fig.1). Further, populations collected in different regions of the KNP had distinct profiles, potentially indicating that distance (and time) from origin influences the degree of change observed in the metabolomic profile.

A larger chemical repertoire should make invasive plants superior to native species as they are more equipped to face challenges in the environment. However, it is not clear whether the differences in the biochemical composition between US and South African populations represent inherited genetic changes related to natural selection or reflect reversible epigenetic adaptations to environmental stresses, or are just coincidental with invasive behaviour.

Growing US and SA plants of the same species side by side experimentally in controlled environments may help to further unravel questions regarding inherited genetic changes vs. epigenetic (changed by the environment) adaptations to novel stresses.

Pyšek P, Hejda M, Čuda J, Zambatis G, Pyšková K, MacFadyen S, Storch D, Tropek R &, Foxcroft LC. Skubel, S. A., Su, X., Poulev, A., Foxcroft, L. C., Dushenkov, V., & Raskin, I. (2020). Metabolomic differences between invasive alien plants from native and invaded habitats. Scientific Reports, 10(1), 1-9.

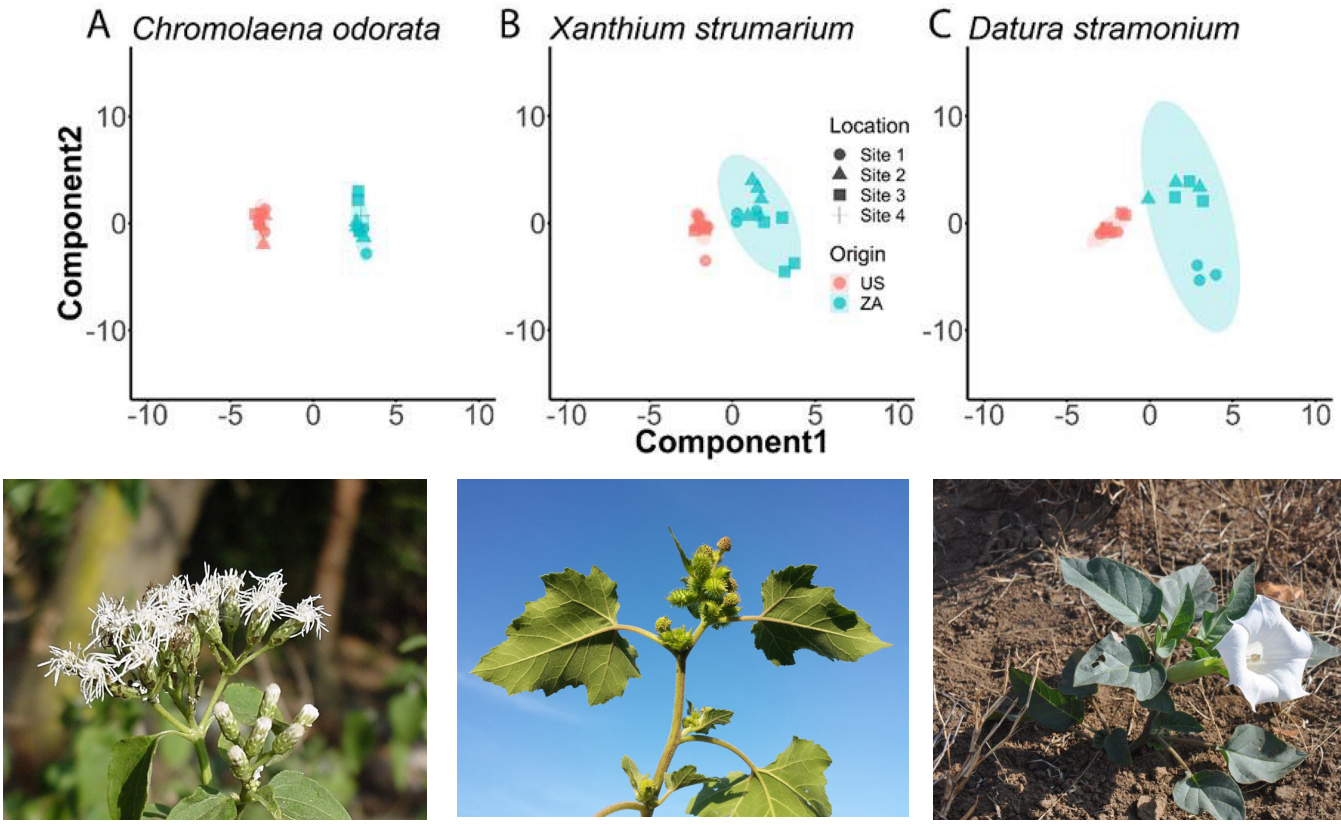


Figure 1. PLS-DA plots of metabolomic features in the thee common invasive species, *Chromolaena odorata* (A), *Xanthium stromarium* (B), and *Datura stramonium* (C). Each sample is reresented as a symbol coloured by origin. The shaded area is the 95% confidence region of PLS component distribution.

Good rains in Mokala aid in restoration

Text by Lufuno Munyai
Photos by Lufuno Munyai & Hugo Bezuidenhout

Restoration efforts in Mokala National Park have been underway to reduce soil erosion and facilitate re-vegetation in denuded areas caused by previous livestock farming and the use of herbicides. Monitoring is important in order to detect veld improvement and support adaptive management. Rainfall is a critical driver for efficient restoration of free-range areas as successful plant re-establishment requires water. After about 10 years of below-average rainfall, Mokala experienced good rains in 2020. Although restoration measures have been in place since 2017, recovery was slow. However, veld recovery was greatly accelerated when the good rains returned this past year.

Recovery of veld after restoration took place using ponding and brush packing at Stofdam in Mokala National Park in 2017 (top) and 2021 (bottom) after good rains.

GOVERNANCE IN CONSERVATION

Out to sea, Table Mountain National Park MPA, Alison Kock

Evaluation and revision of SANParks' park management plans

Text by Dirk Roux, Izak Smit, Stefanie Freitag-Ronaldson, André Spies, Peter Novellie, Eureta Rosenberg, Kristal Maze & Harry Biggs

A review of the processes behind the development, implementation and evaluation of park management plans revealed valuable insights that can be used to further refine and strengthen the ways in which national parks are being managed.

Park management plans (PMPs) are critical documents for the effective operational and strategic management of our national parks. Over the past decade, the processes used for developing, implementing and evaluating these plans have become fairly well-developed and entrenched (Fig. 1). Moreover, these processes were designed to comply with the guidelines of the national Protected Areas Act, which requires each protected area to have a PMP, signed off by the relevant national Minister or provincial MEC. Ongoing leadership in conservation and the management of protected areas require the organisation to deliberately reflect on past experiences with the purpose of developing new insights and facilitating improvement over time. Such 'reflective practice' is based on taking a conscious and critical look at experiences, actions and responses within current practice, and using that information to add to the existing knowledge base, deepen the level of understanding and improve future practice.

During mid-2020, a project was initiated to review and evaluate the inter-related PMP processes both in terms of their operational utility (e.g., are these processes contributing to effective management of parks) and rigour (e.g., do these processes comply with principles of strategic adaptive management). The review was to (a) draw extensively on the experiential knowledge of SANParks staff as well as relevant concepts and information in the scientific literature, and (b) provide lessons and recommendations that could inform the possible refinement and/or revision of the PMP processes with the ultimate aim of promoting effective management of national parks in ever-changing contexts. A SANParks Steering Committee, comprising park managers, planners and scientists, was constituted to provide guidance and accountability for the review process, and to serve as a sounding board for deliberating progress. Furthermore, the review was adopted as a project of the Global Environmental Facility 5 (GEF 5) initiative because of its alignment with the overall aim of the latter, which seeks to strengthen the protection and

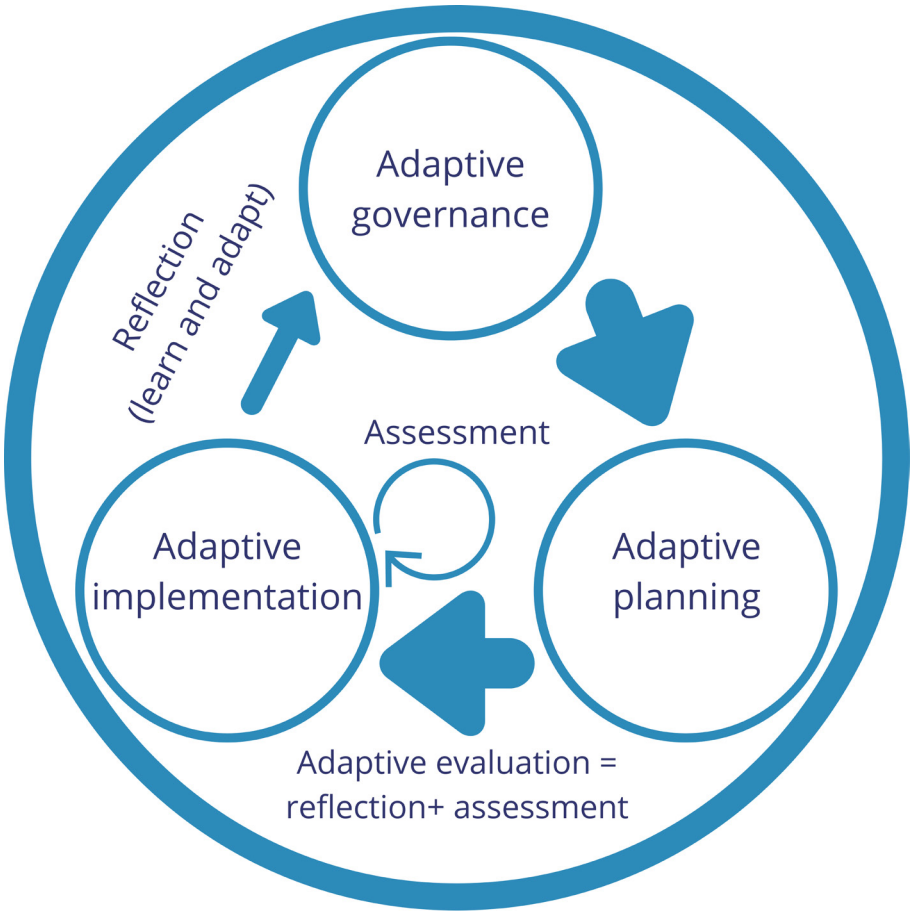


Figure 1. The inter-related sub processes of Strategic Adaptive Management that also inform the planning, implementation and evaluation of park management plans. Adaptive governance refers to the 'rules of the game' at a range of levels, from national legislation to corporate park policy and local rules shaped by stakeholder norms and values. Adaptive planning is the process whereby SANParks and stakeholders co-create a vision and a hierarchy of objectives for the management of a national park. Adaptive implementation involves the identification, design and implementation of management activities, monitoring programs and research experiments to achieve the above objectives. Adaptive evaluation refers to assessment of and reflection on the outcomes of implementation against the vision and objectives, with feedbacks to inform ongoing learning and adaptation.

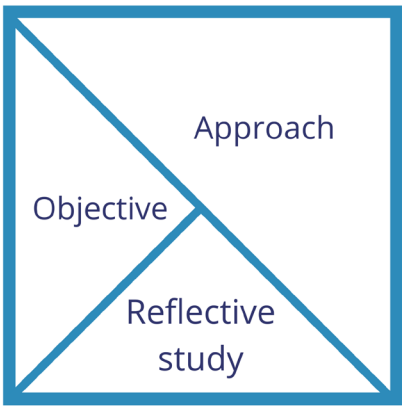
management effectiveness of the biodiversity of South Africa.

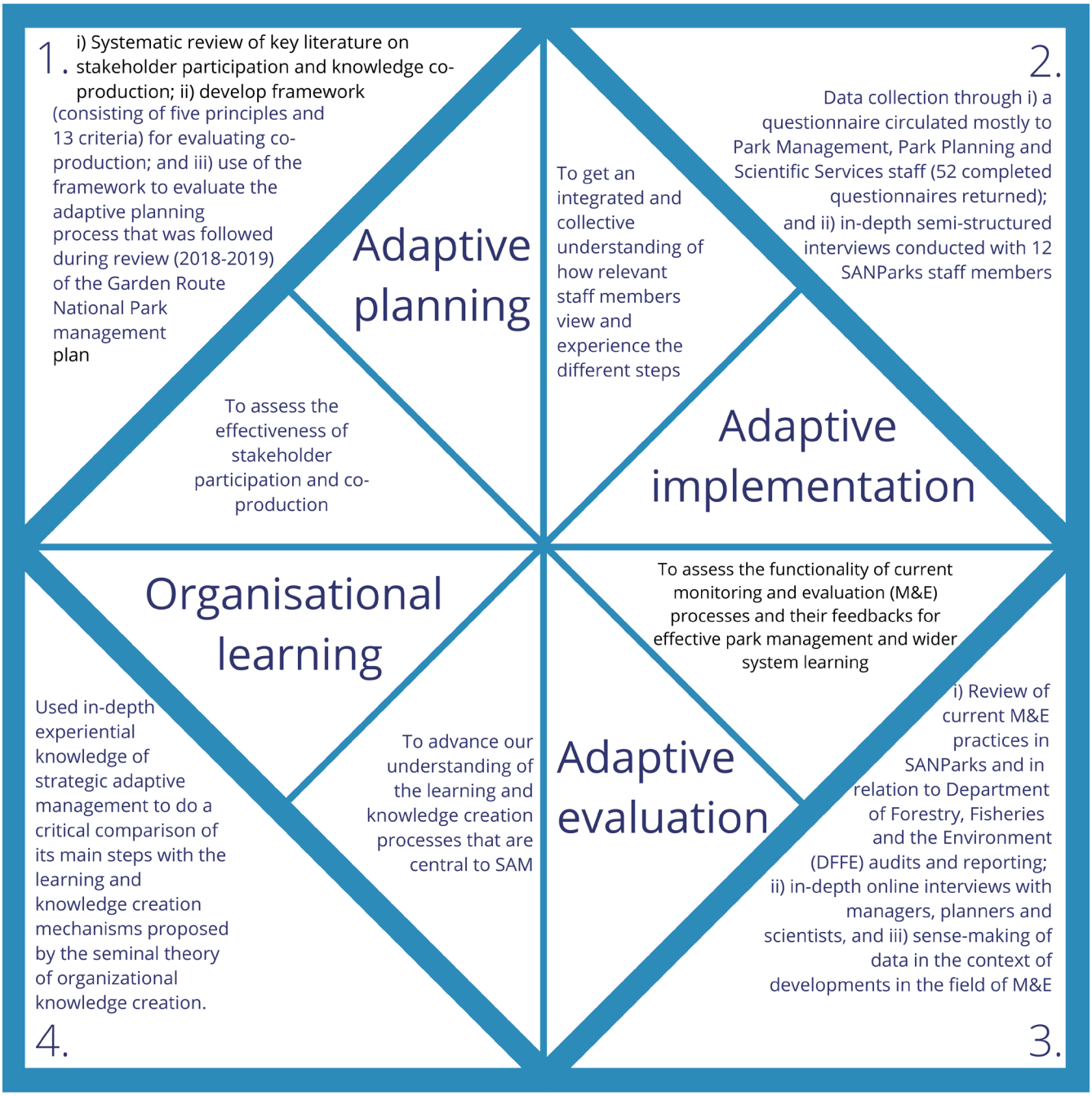
The review was designed with four complementary reflective studies, to focus on adaptive planning, adaptive implementation, adaptive evaluation and organisational learning respectively (see diagram on next page). Each of the reflective assessments were led by a core technical team involving relevant SANParks science-management practitioners and external experts, where available. Importantly, the approach for each assessment was designed semi-independently to suit the specific question(s) that were being addressed. This led to a combination of qualitative, quantitative and conceptual approaches within the overall review; this mixed-methods approach is regarded as a strength of the project.

Several important insights were drawn from the four reflective studies. These include that most colleagues saw value in the PMPs, with some aspects experienced as more valuable (e.g. stakeholder engagement; zoning) than others (e.g. evaluation instruments). However, there was general agreement that the current frequency and standardised approach for revising PMPs are not optimal and that there is a lack of continuity and explicit learning between consecutive PMPs. There was also uncertainty as to the true purpose of specific components of PMPs, notably the costing and lower-level plans. Furthermore, results from across all four studies revealed shortcomings in the planning, implementation and evaluation of PMPs that could be symptomatic of a governance approach that assumes predictable cause-and-effect relationships and underestimates the true challenge of managing complex social-ecological systems. And, although there are examples of good learning and reflection within SANParks (including between management and science functions), these are not optimally integrated with current evaluation and reporting practices.

Staff who participated in the respective studies made many suggestions on how to overcome perceived shortcomings and fur-

ther strengthen PMPs and their underlying processes. These, together with the findings of the studies, were consolidated into a list of recommendations on how to improve and revise the park planning process. At the time of writing, a series of online workshops were conducted to present these recommendations to SANParks and invite deliberation on the most desirable way forward. Overall, the process of deliberate reflection, partially facilitated by the Covid-19 pause, has proved very useful to low-down and critically evaluate the various PMP components in order to improve and adapt.





Review of the South African National Plan of Action for the Conservation and Management of Sharks

Text by Alison Kock
Photo by Wendy Foden

In May 2020, following public concern about declining shark populations along the South African coast, the Minister of Forestry, Fisheries and the Environment, appointed an Expert Panel to formally review South Africa's National Plan of Action for the Conservation and Management of Sharks (NPOA-Sharks). The Panel reviewed all actions of the current NPOA-Sharks.

The Panel also noted stakeholder concerns around the disappearance of white sharks from several aggregation sites, declines in abundance of demersal sharks (living close to the ocean floor), a perceived lack of habitat protection and spatial management for sharks, conflicts among shark tourism and fishing industries, and concerns related to the shark fisheries.

The Panel found that the South African NPOA-Sharks is in line with international standards and contributes to all ten goals of the international plan (IPOA-Sharks). The external experts' commended the hard work South Africa has undertaken so far and the external review process of the NPOA-Sharks as a unique example of accountability and transparency. The Panel scores of the individual issue clusters revealed good progress in the foundational areas of taxonomy and assessment, moderate progress in optimal utilisation, capacity and infrastructure development and compliance, and limited progress in data and reporting, sustainable management and development of regulatory tools. The Panel agreed that better communication and coordination are needed to improve the planning and implementation of actions and maximise the use of existing human capacity and resources.

The Panel recommended an increased focus on the ecosystem effects of fishing and spatial management to conserve critical habitats and reduce user conflict. Illegal, unreported and unregulated fisheries remain a problem that requires renewed focus. Shark catches need improved monitoring, reduction and optimisation. Modernisation of reporting, monitoring, and compliance systems will help South Africa be more effective in accomplishing these shark management and conservation actions. Other desirable improvements included sourcing socio-economic data, in addition to improved biological and ecological data, for informed and holistic decision making, and the development of adequate funding models to support the implementation of the NPOA-Sharks.

Dr Alison Kock was appointed by the Minister of Forestry, Fisheries and the Environment to serve on the Expert Panel as one of nine experts to review the National Plan of Action for the Conservation and Management of Sharks. The Panel's findings were communicated at a stakeholder and media event at the Two Oceans Aquarium.

Full report at https://www.environment.gov.za/sites/default/files/reports/sharksconservationmanagement_nationaplanofaction_review2020october.pdf

Protecting medicinal plants

A biodiversity management plan for medicinal plants in the Ehlanzeni District Municipality, Mpumalanga Province

Text by Louise Swemmer, Domitilla Claudia Raimondo, Neil Crouch, Mervyn Lötter, Tommie Steyn, Vivienne Williams, Karin Hannweg, Thabo Makhubedu, Nolwazi Mbongwa, Charles Hopkins & Cathy Dzerefos
Photo by Karin Hannweg

A biodiversity management plan was developed for six priority medicinal plants naturally-occurring in the Ehlanzeni District, Mpumalanga Province in order to facilitate sustainable use, conservation and benefit-flow from the plants.

Globally, traditional medicine is used to treat ailments of the mind and body, with approximately 40 million users in South Africa. Traditional medicines include plant and animal parts, with the demand for certain species exceeding the supply. Species extinctions will have predicted negative consequences for both people and the environment. To support the long-term survival of species in the wild, NEM:BA (Act No. 10 of 2004) supports the development of species-level, Biodiversity Management Plans (BMP-S).

Under the coordination and support of SANBI (South African National Biodiversity Institute), a team of specialists representing various institutions (see working group below) and other stakeholders including those involved in the traditional medicine value chain (traders and traditional health practitioners - THPs) participated in a process of developing a BMP-S for six important medicinal plant species that occur naturally in the Ehlanzeni District of Mpumalanga Province). All six species are listed as Threatened or Protected Species, are legally protected through NEM:BA and/or the provincial conservation ordinance and are being heavily utilised.

The plan was informed by ecological assessments of populations of each species, as well as a perception study involving workshops and one-on-one interviews with local users and traders to explore the use, availability and regulations of using the species. The Ehlanzeni BMP-S process identified five priority objectives for managing the six target species over the coming six years: population monitoring and habitat assessments, sustainable use, user rights and land tenure, gene, seed bank and living collections, and partnerships towards sustainability cultivation.

A Medicinal Plant Working Group including the Department of Forest, Fisheries and the Environment, SANBI, SANParks,the Agricultural Research Council, Mpumalanga Tourism and Parks Agency, Botanical Society of South Africa (BotSoc) and other Non-government organisations working with communities and the environment, most of whom were part of the development of the BMP-S, is proposed to oversee the implementation of the plan. For more information on the BMP-S Ehlanzeni project, please contact Louise Swemmer (louise.swemmer@sanparks.org).

Traditional health practitioners participated in a process of developing biodiversity management plans for six important medicinal plant species that occur naturally in the Ehlanzeni District. Workshop participants received medicinal plants (and the permit to legally possess these) as part of engagements.

Intelezi is a group of plants which is used in traditional medicine to ward off evil spirits, protects the user against lightning and in general, gets the user out of trouble.

Mathithibala refers to plant species used in love-binding spells.

CE

Siphonochilus aethiopicus

wild ginger/idungulu/ xirungulu/isiphephethu

Respiratory ailments including asthma, for menstrual pain, malaria, inflammation, microbial infection and candida, 'intelezi' and used to treat ailing horses

EN

Alepidea cordifolia

tinsel flowers/ikhathazo

Inflammation such as rheumatism, sore throat, cough, asthma, influenza, diarrhoea, stomach cramps, abdominal disorders, malaria, wounds and is used as a diuretic

VU

Bowiea volubilis

climbing onion/ugibisisila

Skin diseases, sore eyes, bladder problems, barrenness, birthing, to induce abortions, courage and invincibility in warriors, 'intelezi', 'mathithibala'

EN

Warburgia salutaris

pepperbark/ xibhaha/ isibhaha

Headaches, colds and flu, fungal and bacterial infections and malaria

VU

Dioscorea sylvatica

forest elephant's foot/ingwevu

Blood disorders, chest complaints, parasites in humans, treatment of swollen udders and uterine problems in cows, part of protective 'intelezi', steroidal and contraceptive, effective against Gram-negative *Escherichia coli*

VU

Haworthiopsis limifolia

fairy washboard/mathithibala

Wound healing properties for dermatological conditions, used in multi-plant remedies such as 'intelezi' and 'mathithibala', and to instil bravery in warriors

CREATING AND SHARING KNOWLEDGE

Flower display, Namaqua National Park, Alison Kock

Sharing knowledge with the World

Judith Botha & Chenay Simms

Sharing the knowledge generated by research within South African National Parks is an important part of the SANParks research mandate. Throughout the year conferences and peer reviewed publications in journals, or book chapters, ensure that this body of work is widely shared with the larger scientific community.

During 2020 the COVID-19 pandemic had a big impact on the way research was done and knowledge shared. The Level 5 lockdown imposed on South Africans in late March 2020 precipitated a change in the way we do business. Many field trips, especially multinational collaborations, were curtailed and attendance of traditional conferences was greatly impacted. These changes were not all negative however, with physical interactions largely replaced by online alternatives and many webinars taking the place of conferences. This allowed for wider inclusion, more frequent interactions and less wasted time traveling. In addition, spending more time in the office or working from home had positive spin-offs for analyses and publications.

A total of 176 articles and book chapters were published by both internal SANParks staff and external researchers (sometimes in partnership) for the year from April 2020 until end March 2021. This is an increase from 2019/2020 when 135 were published, and one can speculate whether that may be partly attributed to increased time to focus on publications due to the disruption caused to other activities like fieldwork and travelling. The number of publications where SANParks staff were either lead author or co-author increased from 77 in 2019/2020 to 93 in 2020/2021. Of these 93 internally authored articles in

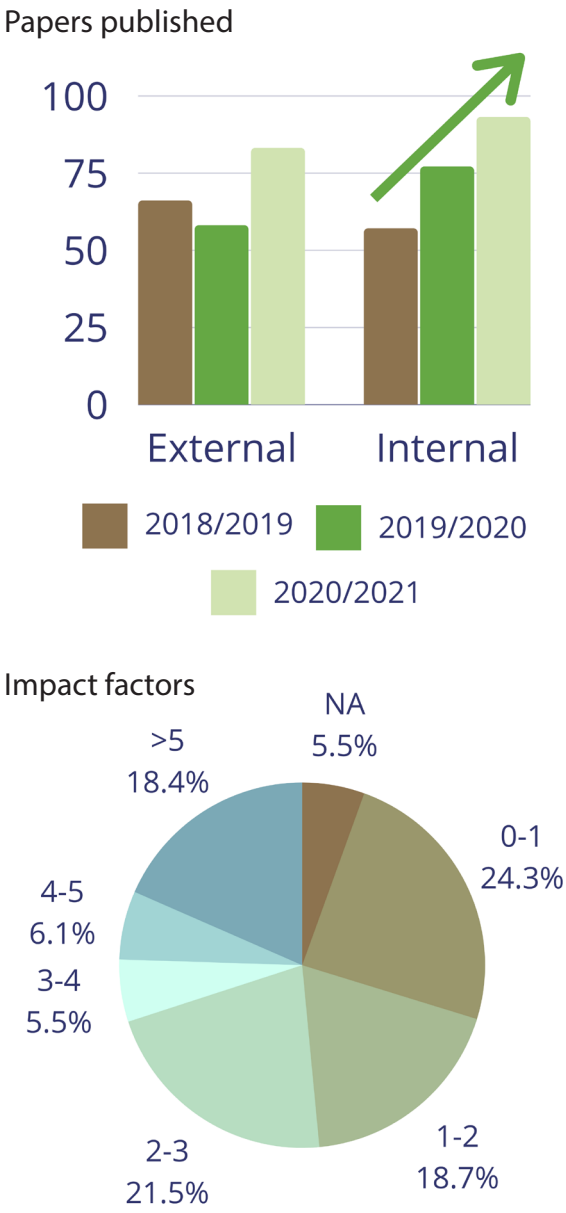


Figure 1. Number of papers published across the past three years by external researchers and internal SANParks staff. The bottom graph shows the impact factors of papers published on SANParks protected areas.

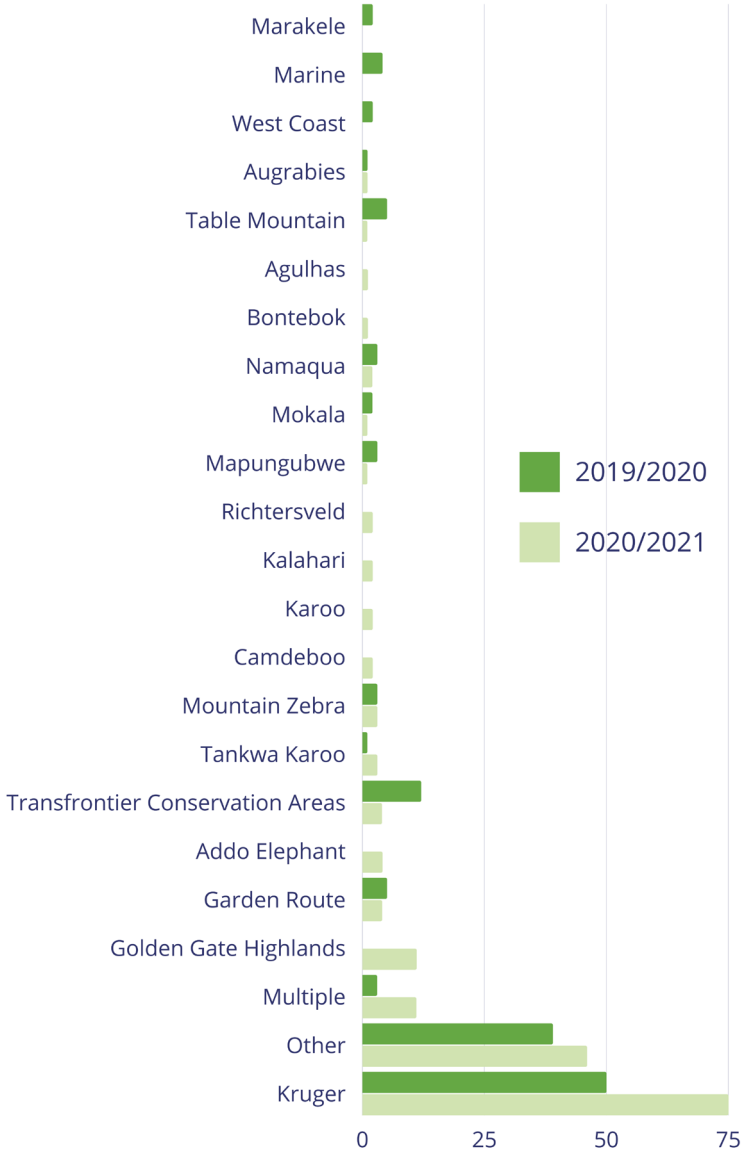


Figure 2. Number of papers published for the various SANParks protected areas over two years – April 2019 till March 2021.

2020/2021 SANParks staff members were lead author on 29 and co-author on 64.

In 2020/2021 articles were published in 99 different journals with the largest number being in Koedoe (28) and African Journal of Range and Forage Science (9). Forty articles were published in journals with Impact scores > 3, with only 10 of the 176 published works in journals without Impact factors, these 10 included book chapters that do not have Impact factors.

When one looks at the number of articles across parks it can be seen that the distribution is quite different to 2019/2020. In 2020/2021 there was a large increase in publication numbers from Golden Gate, Kruger and Garden Route. As can be expected, the number of publications from smaller parks vary between years. There was a decrease in publication in 2020/2021 from work done in the Transfrontier regions (TFCA) while the number of publications from research conducted in multiple parks increased in 2020/2021.

During the past year SANParks staff presented either oral presentations or posters at only a small number of National and International conferences. Many of the conferences like the Savanna Science Networking Meeting as well as the Garden Route Interfacing Meeting were cancelled due to COVID-19 and in many cases were replaced by webinars. Contributions in the form of presentations were made at 23 webinars and the Cape Research Centre organised 2 webinar series during the year. In addition to formal conferences SANParks staff was also involved in many workshops, forums and invited presentations to groups as well as providing inputs to Science Advisory groups. Peer reviewing of journal articles and external examination of theses for the larger scientific community were also done by SANParks staff. In total 77 peer reviewer functions were performed, 58 graduate students were assisted as either co-supervisor or supervisor and 34 editorial roles for scientific journals performed.

Information sharing to the general public took place in the form of popular articles and interviews for press, radio and television. The Scientific Services part of the SANParks website was redone and several blogs were written by staff that can be accessed directly on the website https://www.sanparks.org/scientific-services/our-stories.

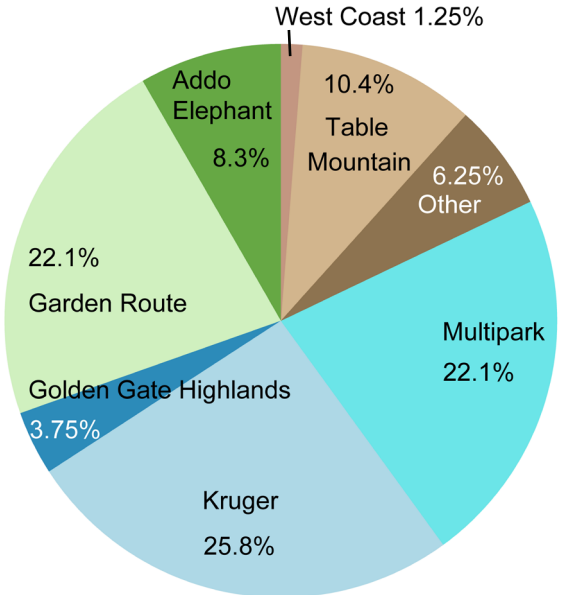
Research Projects registered with SANParks

Text by Judith Botha & Nerina Kruger

Together with the assistance of researchers from external Universities and organisations, research is conducted across the 19 National Parks to produce reliable and relevant information that contributes to the responsible management and conservation of South Africa's biodiversity assets. As the scientific staff employed by SANParks is under-resourced, collaborations with external partners are vital for knowledge generation.

The SANParks online research project registration portal was launched on 14 December 2020, enabling researchers to apply online for research permits. This new online portal facilitates the uploading of documentation directly, as well as track any projects that researchers are associated with. As with most new solutions a few bugs and improvements were identified which are in the process of being updated to ensure a smooth online project registration experience.

In 2021, most projects were registered for research in Kruger (25.8%) followed by research in Garden Route National Park (22.1%) and research conducted across multiple parks i.e. Multipark projects (22.1%). To stimulate research in some of the smaller parks, SANParks is expanding research support services such as the assistance of research assistants and accommodation where possible.



Research projects per park for 2020/21. The total number of active projects registered during this period was 240. "Other" included all parks with less than 3 projects, which include 15 projects in Augrabies, Bontebok, Camdeboo, Karoo, Mapungubwe, Meerkat, Mokala, Mountain Zebra, Namaqua, Richtersveld and Tankwa Karoo National Parks.

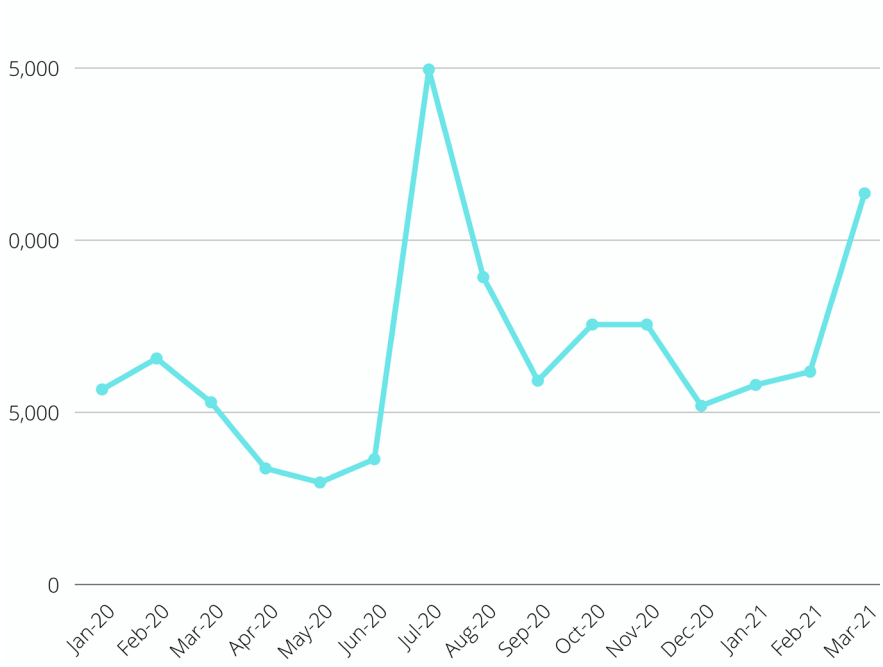
Of the current 240 projects active in parks, 81.7% were rated as essential and/or important to SANParks' key issues, aligning with the 11 research themes identified in the SANParks research strategy. The dominant themes this year were 'Ecosystem structure function and process' followed by 'Global Environment Change'. The projects registered by the Tourism colleagues at head office fall under the Tourism marketing and business research theme and were only included for one of the quarters reflecting a very small amount currently, but which will increase next year as these projects are aligned and included in the database.

The Research group launches a new website

Text by Samantha Mabuza

Over **66 000** visits to the site in 9 months

Looking at the trend in page views over time, there was a lot of interest when the new site went live (see peak in July 2020). With time we hope to keep the momentum going in our quest to #shareourscience and contribute to the ever growing field of Science Communication.



In the age of social media, a powerful online presence can have a huge impact on how people engage with your organisation and in the case of research, how knowledge that is generated, is consumed. To keep up with the times, a small team from Scientific Services, devised a new, dynamic website framework, outlining an updated layout as well as new and interesting content.

We are now able to update the site regularly ourselves, and manage the content that is shared on the site. So, with all the effort put in to make this a reality, how well are we doing and are we generating enough traffic to our site to make it all worthwhile? With the help of Google Analytics we are able to track and see how much people are engaging with our content.

So what do the numbers say? The following stats are from 01 July 2020 to 31 March 2021.

Overall, we have had over 66900 visits to our website, during the nine months since it went live. Interestingly, the most visited page is the staff profiles ("Meet the Team"), so people want to know who we are and what we do! The second most visited page (and a page where people spend quite a bit of time) is the new blog series page ("Our stories"). The page where people spend most of their time is the research registration page, an updated and streamlined process enabling researchers to apply online to do research in SANParks.

Kimberley SANParks herbarium

Text by Lethlogonolo Mokopelo
Photos by Lethlogonolo Mokopelo & Xolile Job

The Kimberley South African National Parks (KSAN) Herbarium, based in the Kimberley Scientific Services offices, was established in 1992, however collection of specimens started during the 1940's. In 2001 the KSAN Herbarium was officially registered and has since grown from strength to strength. Specimens in the herbarium are from 16 of the 18 National Parks (excluding Garden Route and Kruger National Park which have their own herbariums). Currently KSAN herbarium has approximately 16320 filed botanical specimens and more in the process of being mounted. The herbarium includes plants from invasive species to indigenous and threatened species.

Started to collect specimens:

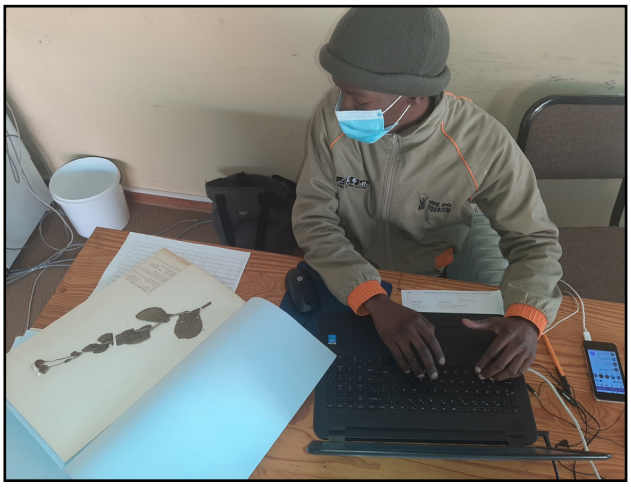
1940s

>16000

botanical specimens

Specimens from

16 parks



Letlhogonolo Mokopelo (top left) and Xolile Job (top) preparing and mounting specimens and entering specimen information into the herbarium's database (left).

Cape fur seals, Table Mountain National Park, Mark van Coller







Cape Town based Research colleagues (Cape Research Centre) out and about in Table Mountain, and Namaqua National Parks, monitoring penguins, doing surveys as well as putting up weather stations; Wendy Foden, Zishan Ebrahim, Nicola van Wilgen-Bredenkamp, Alison Kock, Faroeshka Rodgers, Trevor Adams, Debbi Winterton, Ane Oosthuizen, Marna Herbst, Ralph Kelly, Ezekiel Kosa and Sisanda Mayekiso (names here include non-research SANParks colleagues).




Research group based in Kimberley out and about in Augrabies, Mokala and Addo Elephant National Parks, here busy with monitoring duties and monitoring replanting success of cycads after being confiscated post-illegal removal from the wild; Scientific Services colleagues include Nkabeng Maruping-Mzileni, Lufuno Munyai, Roxanne Erusan, Corera Links and Hugo Bezuidenhout.

Out and About










Research and other SANParks colleagues based in Kruger National Park out and about in Kruger, Marakele and Mapungubwe National Parks, doing species of special concern surveys, burning fire-breaks, taking a break during fieldwork, conducting census, dancing the Jerusalema, doing crocodile surveys, dehorning rhinos, and distributing PPE, amongst other things. Research colleagues in the photos include: Nokukhanya Mpanza, Noel Nzima, Convivian Mkhabele, Abel Ramoelo, Izak Smit, Danny Govender, Samantha Mabuza, Patricia Khoza, Purvance Shikwambana, Cathy Greaver, Steven Khoza, Corli Coetsee, Tercia Strydom, Adolf Manganyi, Sam Ferreira, Pauli Viljoen, Louise Swemmer and Phillip Mhlaba.

Out and About










Garden Route and Frontier Research and other SANParks colleagues out and about in various sections of Garden Route National Park, Addo Elephant National Park, Greater Addo MPA- Bird Island, Camdeboo – Valley of desolation, and Mountain Zebra National Park; Research colleagues include Clement Arendse, Cloverley Lawrence, Ian Russell, Jessica Hayes, Stefanie Freitag-Ronaldson, Thabang Sibiya, Nerina Kruger, Lizette Moolman-van der Vyver, Melanie de Morney, Diba Rikhotso, Portia Chake, Nthabeliseni Munyai, Nelsiwe Mpapane and Daniëlle Seymour.

Saying goodbye to the legendary Guin Zambatis

Judith Botha & Danny Govender

Guin dedicated more than 30 years to the Biological Reference Collection in Skukuza, Kruger National Park until she retired in 2020. She was the first woman to be appointed in a conservation position in Kruger, when she took up the position of Curator of the "Herbarium en Zoologiese Museum" in 1988. By 1992 she had prepared the first computerised herbarium list with synonyms and genus numbers and since then the collection has grown to include more than 15 000 specimens. In addition to the herbarium specimens, Guin was also involved in updating and correctly curating the zoological collection.

In 30 years Guin gained the sort of knowledge about the Kruger ecosystem that cannot be found in books. She became the quintessential guide book to Kruger, and her expertise was called upon by researchers, students, staff and the general public alike. And when Guin couldn't make an identification, she was just as excited about finding out; posting specimens to national and international collaborators and undertaking the journey of discovery with you. It's that love for discovery that made her a brilliant science educator. Her science extension to school groups was definitely one of the highlights for many kids visiting Kruger for the first time.

Guin was an essential member of the Scientific Services team, and was able to elevate a small in-house collection of specimens to one of the most comprehensive National Park museum collections in the world. Her passion for discovery, and commitment to archiving the rich natural history of the Kruger National Park has provided a strong research foundation to build on.

SAYING GOODBYE

 Photos Nick Zambatis, Andrew Deacon

Purvance Shikwambana spreads her wings

Samantha Mabuza

Purvance, otherwise known as "Miss P"(lovingly coined by Danny Govender; friend, supervisor and mentor), started her working career as an intern with Veterinary Wildlife Services in Skukuza, Kruger National Park in 2009. She was involved in game capture preparation and other related activities, and preparing samples and diagnostics in the lab after every capture. What she remembers most from this time was getting to view the park from the air.

She then moved to Scientific Services in 2010, were she was involved in the leg work of establishing the Research Lab, which involved procuring equipment and setting up the lab. Through her work with Danny and the team on the Olifants River crocodile mortalities, she discovered a passion for rivers, and a huge interest in the use of diatoms as eco-status indicators for the five major rivers in Kruger. This interest resulted in a honors degree and first first-author publication, and later started her on a masters degree looking at microplastic pollution in a relatively pristine river catchment in the Kruger National Park.

In 2020, she was offered a chance to expand her horizons and use her unique skills and experience to manage a laboratory at a local academic institution.

According to Miss P, her highlight with SANParks has been the opportunity to help set up the Research Laboratory in Kruger, which is critical research infrastructure that helps us answer some of the environmental questions, while offering a communal work space that allows for connections and collaborations between diverse research groups. Go well Purvance, you leave a gap in the savanna team that cannot be easily filled.

Photos Zoliswa Nhleko, Boitumelo Ntabe

Farewell to Prof. Abel Ramoelo – a conservationist, black academic and transformative leader

Ernest Daemane

Prof. Abel Ramoelo is an NRF rated scientist with core expertise on mapping vegetation health assessment, species biochemistry and productivity as well as water quality and quantity using optical or passive and active remote sensing data at various scales. He joined SANParks in 2018 as a Regional Ecologist for the northern parks (Marakele, Mapungubwe and Holden Gate Highland). Apart from his role in science-management interface across parks, he worked closely with other scientists in multidisciplinary research and monitoring, using multiscale-remote sensing and machine learning techniques to resolve contemporary conservation issues in our dynamic and complex ecosystems.

He left SANParks in May 2021, taking a Directorship position at the Centre for Environmental Studies at University of Pretoria (UP). He is also an associate Professor at the Department of Geography, Geoinformatics and Meteorology at UP. Abel has left an indelible mark in SANParks in terms of academic transformation. Within his 3 year tenure in SANParks, he managed to supervise 3 PhDs within Scientific Services, anticipated to complete in 2021-22. He has also worked closely with the Learning and Development Division on human capital development initiatives for the organization, and served as a member of the IT steering committee. He is currently serving as the Editor-in-Chief for SANParks' Koedoe journal. He also managed to attract research funding in SANParks through collaborative research (i.e. Biodiversity Loss Modelling in collaboration with CSIR). He was one of the active members in Scientific Services tirelessly looking for international and national funding calls to secure funding for research, especially during 2020-21 when all institutions were severely affected by the COVID-19 pandemic. He represented SANParks on various working groups within the Department of Forestry, Fisheries and the Environment.

Abel does not only understand complex ecosystems, he also navigated SANParks' complex system easily. He served with excellence and will always play a part in growing this organization through his collaborative research aptitudes. We wish Abel well in his future endeavours!

 Photo Ernest Daemane

WELCOME

A dream comes true - joining SANParks as Curator of the Skukuza Reference Collection

Nikisha Singh

The 28th of October 2020 marked an important milestone in my life. It was the morning that I was contacted by SANParks confirming a job offer as the Curator of the Biological Reference Collection in Skukuza in the Kruger National Park.

Skukuza in the Kruger National Park! A huge leap from studying the ecology of an urban exploiter, the southern tree agama (*Acanthocercus atricollis*) around Pietermaritzburg for my masters degree. This was the ultimate dream of any budding ecologist in South Africa. And so I made the journey into my new life.

I discovered Skukuza is more than just a place to work. Living here, you become part of Kruger's ecology, the natural rhythm and seasons of the bush. Every minute of living here provides material for study and engenders a sense of wonder about the natural world. Over the last few months I have become part of the welcoming and generous Savanna Scientific Services family, and the extended family of the Skukuza community.

I feel honoured to be part of a multifaceted organisation that prioritises conservation, science engagement and research. I have always had an unwavering passion for the sciences which has not been matched with a profound new sense of purpose; I look forward to this new adventure with great zest.

Photo Preshnee Singh

ACHIEVEMENTS

Prof. Wendy Foden received British Ecological Society award for climate change research

Wiida Fourie-Basson

The British Ecological Society's Marsh award for climate change research, which recognises exceptional contributions of individuals to climate change research, was awarded to Professor Wendy Foden in recognition for the global reach of her work with the International Union for the Conservation of Nature (IUCN) and the Red List of Threatened Species, as well as for her interest in translating science for practical conservation use, and in fostering conservation leadership.

Wendy has chaired the Climate Change Specialist Group of the IUCN Species Survival Commission since 2014. Wendy led IUCN's development of a method for assessing species' vulnerability to climate change, later turning these into guidelines as well as an assessment that could be used alongside the IUCN Red List of Threatened Species: "We applied the method to the world's birds, amphibians, corals and the study became the first to tackle entire species groups across the world. The approach has been widely adopted and is now used by researchers and conservationists around the world," she explains.

While surprised by the award, Wendy was extremely proud to represent Africa's woman scientists. Wendy attributes her non-linear career path that allows her to be involved in research and conservation action as a key enabler for identifying gaps and opportunities for trans-disciplinary collaboration: "Most of my research has been highly collaborative, so the award recognises the work of a community of very dedicated researchers. I'm simply fortunate to be in a position to gather key people together to create really useful products while we have a good laugh. I'm glad that such 'soft skills' are increasingly recognised in science."

 Photo Neville Williams

PhD²

Dr. Louise Swemmer investigated benefit sharing approaches to assess and reflect on the societal impacts of biodiversity conservation

Louise Swemmer

Protected areas must be relevant to broader society to be sustainable. I completed my PhD through the University of the Witwatersrand, investigating ways of enhancing societal relevance (meaning and value) of protected areas through benefit sharing at a local level to adjacent communities. My case studies developed a benefit audit framework and process to assess impact on multiple human wellbeing dimensions. The study concludes that measuring both positive and negative impacts of benefit sharing programmes on the multiple dimensions of human wellbeing is important; experiences that facilitate learning are seen as beneficial by participants; and that the social capital built through meeting new people can have mutually beneficial outcomes both for conservation staff, neighbouring communities and conservation.

Dr. Cloverley Lawrence studied seagrass ecology in light of climate change

Cloverley Lawrence

In Dec 2020 I was awarded my PhD in Biological Sciences from UCT. This was the culmination of many years dedicated to understanding the ecology of the seagrass, *Zostera capensis* that forms productive habitats in many estuaries. The findings from my study highlighted the importance of identifying characteristics and adaptation strategies that allow habitats to persist under climate change, and maintain their productivity and ecosystem services. My studies taught me to appreciate the complexity of the natural environment and it's propensity for change, the value of persistence and the significance and sometimes insignificance of p values.

Photos Jireh Manasseh, Mightyman Mashele

My beginning and conclusion: A reflection on my masters

Nelsiwe Mpapane

Just two years ago I was beginning my master's degree at Nelson Mandela University, and to say I was anxious about the entire journey would be quite the understatement. I have now successfully secured my degree, have had lasting relations created during the journey and made memories of a lifetime!

My research interests have always been strongly related to understanding the myriad of values that people hold towards different aspects of nature, what access to nature means to different people and how we can account for different voices on these matters. In the past two years, I have centred my research on getting an in-depth understanding of the non-material benefits of interacting with nature in a protected area (Mountain Zebra National Park). And because I was essentially asking people to be vulnerable and share some of their deepest and meaningful experiences with me, I too had to confront myself as both researcher and human, in terms of my values, principles, background, and motives behind my environmental relations. Thus what essentially began as a simple read of Pyle's book (The thunder tree: lessons from an urban wildland), evolved into a journey where I realised the need for more conversations on the diversity of ways to approach and value different landscapes and features of nature in our rapidly changing world.

In my dissertation, I aimed at combining geographical features along with narrative data that highlights the importance of interacting with nature in a protected area, from the perspective of park visitors. The results therefore form the basis of shedding light on the various socio-cultural factors that can influence people's perceptions of cultural ecosystem services (CES), views of embodied experiences in nature, and how these experiences are capable of shaping us as human beings. All of this had to be presented in a manner that enables us to understand complex contexts surrounding the meaning of CES in its authentic form, instead of trying to generalize contexts to suit a whole population.

My data collection was somewhat rudely interrupted by the COVID-19 pandemic, but even that brought about new insights. The harsh realities of being restricted in movement reminded us of just how much we enjoy to "get out", and for me it emphasized the impact that "extinction of experiences" in nature may have on people's wellbeing. Lockdown also became a good time to reflect on the realities of so many people that are not able to visit national parks and green spaces easily around the country. I hope my journey and context from my thesis interest a wide range of people, and contribute to people talking more about incorporating the myriad of different beliefs, opinions and values related to CES into decision-making. May our national parks become places where all of South Africa's people get to experience the wonderful benefits of being close to nature. Although I have concluded my Masters, I feel as though this is a journey of research that has just begun.

 Photo Nkosiphendule Ngqwala

Polystachya ottoniana, Garden Route National Park, Johan Baard

Closure

Danny Govender: GM Savanna Research Node

Twenty-twenty and a global pandemic have indeed forced us to take stock of our relationship with our planet. As the world plans to "build back better" and engage on a "green new deal", protected areas are expected to play a critical role in conserving biodiversity, reconnecting people to nature, and serving as a catalyst for innovative thinking, practical experimentation, and reflective learning on fostering thriving people-nature systems.

Three important global assessment reports (Global Biodiversity Outlook 5, 2020 Living Planet, and the IPBES (Global Assessment) were released in the year, stressing the urgency for strong and decided leadership and action at scale, if we are to halt the ongoing onslaught of biodiversity loss. Global environmental leaders are proposing a Nature-Positive global goal that seeks to achieve a zero net loss of nature from 2020, a net positive by 2030, and a full recovery by 2050. To do this will require that human development is linked to restoring and safeguarding biodiversity, all while building towards carbon neutrality.

As we struggle to bring the current pandemic under control, we have to also think about how to prevent the next one. SANParks has been involved in reviewing and contributing to two reports in this regard: UNEPs Preventing the Next Pandemic: Zoonotic diseases and how to break the chain of transmission and the IPBES Pandemics report. Both reports highlight the need for a collaborative effort across multiple disciplines and agencies to attain optimal health for people, animals and the environment.

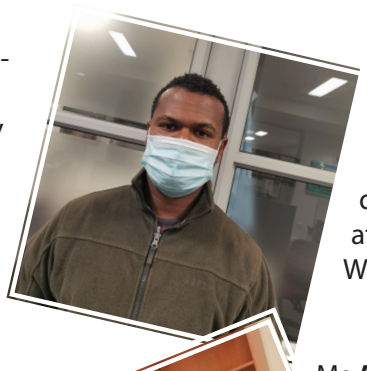
Though "One Health" is not a new term, the urgency of its application has been renewed given the gravity of the current situation, and the humbling fact that no nation — rich or poor, developed or developing — has been immune to the devastation that COVID-19 has had on lives and livelihoods. Inadequate incorporation of environmental science, scientists and practitioners as well as environmental policies in the One Health approach up to now has been identified as a key shortcoming, and both these reports highlight how important environmental considerations are in pandemic threat reduction. There is a renewed call for a unified global response that is locally responsive and builds capacity to detect and manage pandemic threats in countries where it is most needed.

The COVID-19 pandemic has been a black swan event that offers a green swan opportunity- it has redefined our normal- how we work, live, and interact. It has prompted investment in new innovations, rethinking our data and power infrastructure, and supply chains. It has forced us to question global capitalism and endless growth, equality, human rights and law enforcement, and to reimagine new metrics to evaluate a country's success that goes beyond wealth and encompass wellbeing. Let's hope we build on this opportunity that's been created.

The 2020 Research Report highlights some of our local reflections on the COVID-19 pandemic and its responses, 10 years of developing park management plans, key research and monitoring efforts, new discoveries and staff achievements. It celebrates the diversity of work and people that form part of the research team of SANParks, who despite the many challenges the year has presented, remain productive and committed.

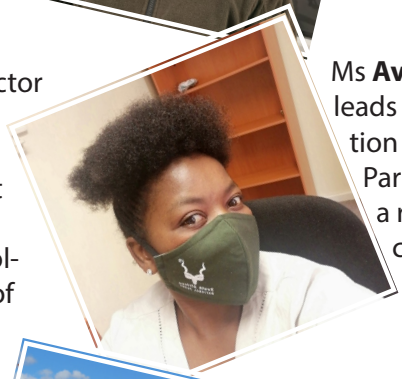
Quiver tree forest, Richtersveld National Park, Wendy Foden

Mr **Aaron Barnes** recently completed his MSc in Zoology at the University of Stellenbosch where he focused on forest biogeography, phylogeography and molecular systematics.



Mr **Angelo Johnson** is a SANParks Junior Scientist under the GEF 5 project and PhD candidate in Hydrogeology at the University of the Western Cape.

Prof **Abel Ramoelo** is Director for the Centre of Environmental Studies, and based in the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria.



Ms **Avhavhudzani Phophe** leads climate change mitigation projects within SANParks, and has published a report on SANParks' carbon footprint. She also coordinates CRC webinars.

Dr **Alison Kock** heads the Marine research unit at the Cape Research Centre and specializes in sharks and the assessment of MPA effectiveness.

Prof **Carla Staver** is at Yale University in the United States. Her work focuses on the vegetation dynamics of savanna ecosystems. She first visited Kruger on a family holiday in 1998 and has been doing research there since 2004.

Mr **André Spies** is a "Project Manager" in the SANParks Park Planning and Development Unit responsible for Park Management Plans and the METT assessments.

Dr **Cathy Dzerefos** is at TUT with research interests ranging from beneficial plants and insects to Section 24(a) of the Constitution which recognizes that the environment influences human health and well-being.

Dr **Ané Oosthuizen** has led SANParks MPA expansion for 14 years, including conservation management of the Eastern Cape penguin colonies.

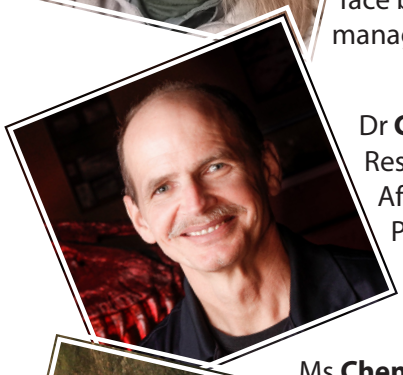
Ms **Cathy Greaver** is Regional Ecologist for Kruger and Mapungubwe where she maintains an interface between science and management. She also assists with wildlife monitoring and management in these parks.

Dr **Angela Bruns** is a clinical veterinarian in SANParks' Veterinary Wildlife Services, involved in game translocation, population management, disease investigation and research facilitation.

Dr **Chad Cheney** is a park planner at Table Mountain National Park and plays a key role in providing scientific input into alien control projects.

Dr **Charlene Bisset** is the Regional Ecologist for the Frontier Parks, based in Addo Elephant National Park and works at the interface between science and management.

Dr **Corli Coetsee** is a beach-loving ecologist with a research focus on savanna plant-animal interactions and is based in the Kruger National Park. She is increasingly interested in how science can be communicated more effectively.



Dr **Charles Helm** is a Research Associate at the African Centre for Coastal Palaeoscience, Nelson Mandela University.

Dr **Danny Govender** is the General Manager for research in the Savanna Parks. She is a veterinarian and disease ecologist by training, but is especially interested in the changing role of protected areas in the 21st century.

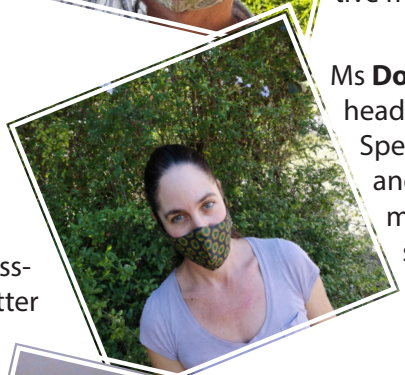
Ms **Chenay Simms** is a SANParks GIS Analyst based in Skukuza, where she is responsible for managing the GIS lab and conducting GIS and Remote Sensing projects for KNP and several other parks.

Mr **Diba Rikhotso** is a biotechnician based in the Garden Route and is engaged in monitoring and research of forests, fynbos and invasive plants.

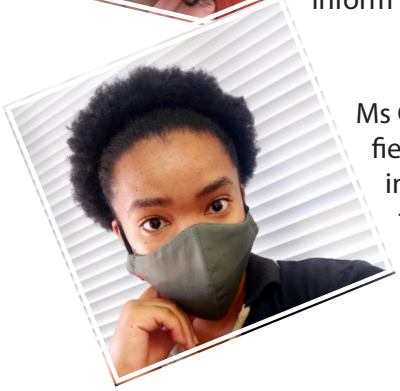
Mr **Clement Arendse** is a Marine Biologist based at Rondevlei. His interests include life history studies and management of recreational linefish species, intertidal rocky shore invertebrate and fish communities and estuarine ecology.

Prof **Dirk Roux** is a SANParks scientist working on the conservation of freshwater ecosystems, the role of protected areas in providing ecosystem services, and adaptive management.

Dr **Cloverley Lawrence** is a marine scientist working in the Garden Route/ Frontier region. Her research and monitoring are directed towards understanding processes and drivers of change to better inform decisions.

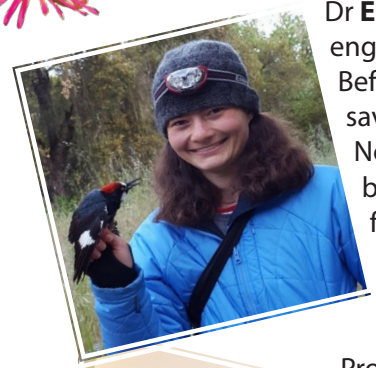


Ms **Domitilla Raimondo** heads SANBI's Threatened Species Programme, and is responsible for monitoring the threat status of South Africa's species.



Ms **Corera Links** is a field assistant based in Kgalagadi Transfrontier National Park.

Dr **Eddie Riddell** is the manager for water resources in the Kruger National Park, focused on the equitable provision of water resources for ecosystems and society, particularly in transboundary contexts.

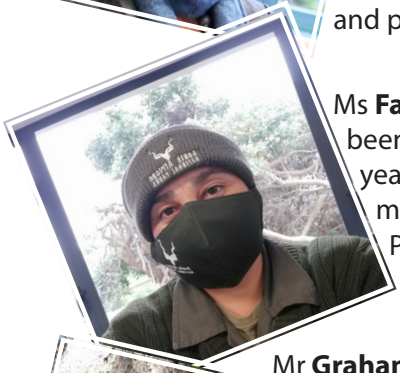


Dr **Emily Goldberg** is a mechanical engineer at PAR Systems in Minnesota. Before changing fields, she studied savanna ecology and ornithology. Now, she is interested in the use of biological systems as inspiration for robots that can respond intelligently to the world around them.

Mr **Hendrik Sithole** is a SANParks invertebrate ecologist interested in discovering and understanding the roles of invertebrates in ecosystems and is based in Kimberley.

Prof **Eureta Rosenberg** is based at Rhodes University Environmental Learning Research Centre, passionate about research, evaluation, courses and organisations that make a positive difference for planet and people.

Dr **Howard Hendriks** is the General Manager: Continuous improvement in SANParks and is based at Groenfloof.



Ms **Faroeshka Rodgers** has been with SANParks for 13 years and has been the manager of the Boulders Penguin colony since 2018.

Dr **Hugo Bezuidenhout** is a vegetation scientist based in Kimberley. He has 30 yrs experience in working with vegetation, soil ecology patterns, processes and interactions as well as Integrated Environmental Management (IEM) Practices within SANParks.

Mr **Graham Durrheim** is a professional tree hugger who undertakes long-term monitoring and research programmes and develops and implements harvesting systems for timber and non-timber products in the Garden Route forests.

Dr **Ian Russell** specialises in aquatic ecosystems, and particularly the linkages between biotic changes and ecosystem manipulation and management in intensively utilised estuaries.

Dr **Harry Biggs** is a retired SANParks scientist still contributing to systemic collaborative learning and managing of social-ecological systems.

Dr **Igshaan Samuels** is a rangeland ecologist working for ARC. He focusses on indigenous knowledge systems and their application in climate change adaptation.

Ms **Helen Mmethi** is the general manager for people and conservation in Kruger National Park, coordinating and managing a dynamic team who delivers on community engagement objectives of the park.

Dr **Izak Smit** is a scientist with a broad range of interests, spanning the biophysical and increasingly the social-ecological domains, with the aim of informing protected area management.

Mr **Jacques Venter** is a biotechnician at SANParks and co-ordinates the river flow and quality monitoring programme in the Kruger Nationhal Park.

Dr **Katta Ludynia** is a research manager at SANCCOB in Cape Town with extensive experience in seabird ecology.

Ms J**essica Hayes** is a regional ecologist in the Garden Route. Apart from working at the interface science-management, she's interested in how humans and nature interact in socio-ecological landscapes.

Dr **Kristal Maze** is head of SANParks Park Planning and Development, responsible for expansion of the system of national parks within an ecologically, socially and economically sustainable landscape approach.

Mr J**oel Abraham** is a PhD student at Princeton University, studying large savanna mammalian herbivores, focusing on the determinants of herbivore diets and space use, often in Kruger National Park.

Mr **Kyle Smith** is an ocean loving marine ecologist with a particular focus on recreational and subsistence linefisheries, estuarine fish communities and the effectiveness of marine protected areas.

Mr **Johan Baard** is a GIS and Vegetation Ecology scientist in the GRNP, with a focus on invasive alien plant control planning and research, rehabilitation, and plant inventories. Plant collection is his passion.

Dr **Lesego Khomo** is a senior lecturer at UNISA. He has published on soil and landscape ecology in various biomes in South Africa.

Ms **Judith Botha** is a Science manager; science support. She particularly enjoys analysing monitoring datasets over extended time frames and seeing how analytical tools can work across various disciplines.

Ms **Lethogonolo Mokopelo** is an EM in Kimberley, works as a herbarium assistant and assists scientific services where needed. Her interests are plant sampling, animal monitoring and rehabilitation, conservation and biodiversity protection.

Dr **Karin Hannweg** is a Senior Researcher at the ARC. Her work involves biotechnological methods for plant improvement, plant propagation strategies and associated horticultural aspects of both tropical and subtropical crops and several indigenous plant species.

Prof **Llewellyn Foxcroft** leads alien species research in Kruger and elsewhere. He is a Centre for Invasion Biology core team member and lead author on the IPBES Alien species assessment.

Dr **Louise Swemmer** is a social scientist interested in people-nature relationships and how these contribute towards or degrade human wellbeing and protected area sustainability.

Ms **Melanie de Morney** is a biotechnician in the Garden Route assisting with terrestrial fauna-related monitoring and research. She is passionate about biodiversity conservation and has a particular interest in myrmecology.

Ms **Lucia Hlatswayo** is a P&C officer in the Kruger National Park (Marula region), coordinating engagement and benefit sharing projects with two community forums, and managing the compensation claims.

Dr **Mervyn Lötter** is a biodiversity planner with MTPA. He first worked on the threatened plant program for 15 years before heading up the biodiversity planning unit.

Mr **Lufuno Munyai** is a Biotechnician for the Arid Parks. His main responsibilities include data collection during and after restoration and conducting aerial census.

Dr **Mmoto Masubelele** focuses on restoration in national parks. He also implements climate change adaptation and mitigation projects in national parks.

Mr **Mahlomola Ernest Daemane** is Acting Senior GM – Research & Development. Since joining SANParks in 2002, he has contributed immensely in biodiversity management through research and development of park management plans. His research focuses on vegetation community dynamics and restoration ecology.

Dr **Mohlamatsane Mokhatla** is an ecologist with interests in stakeholder engagement, determining the impacts of climate and land-use change on the conservation of African anurans.

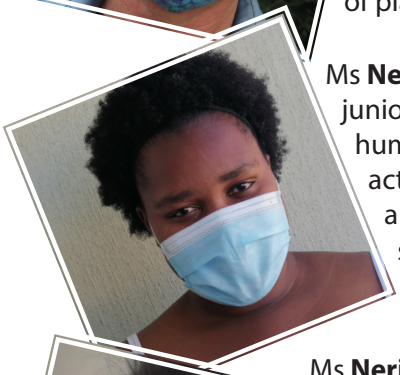
Dr **Marna Herbst** has been with SANParks for fourteen years and is the Regional Ecologist for the Cape Parks based at the Cape Research Centre and works at the interface between science and management.

Ms **Nandi Mgwadlamba** has almost 20 years' experience in the communications field, 8 of those as Regional Communications Manager for SANParks.

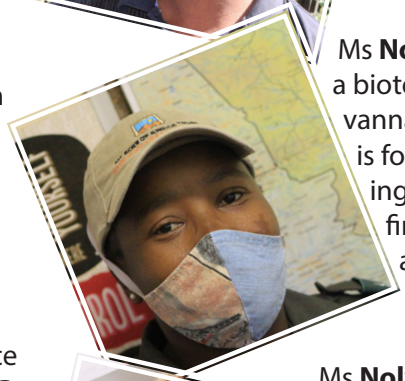
Ms **Navashni Govender** is the Senior Manager of Conservation Management in Kruger National Park. She oversees the implementation of Biodiversity Conservation Programmes in Kruger.

Prof **Neil Crouch** has worked in ethnobotany and economic botany with SANBI for nearly three decades, and has a passion for promoting the sustainable utilisation of plants by "man".

Mr **Noel Nzima** is a biotechnician within the Savanna Node. His work is mainly focused around monitoring vegetation dynamics, fire ecology and hydrology.



Ms **Nelsiwe Mpapane** is a junior scientist working on human-nature interactions in protected areas, social-ecological systems and science outreach programs.

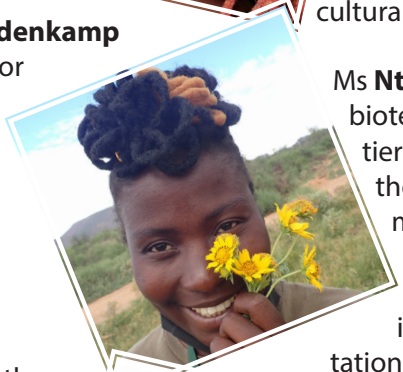


Ms **Nokukhanya Mpanza** is a biotechnician within the Savanna Node based. Her work is focused around monitoring vegetation dynamics, fire ecology, hydrology and maintenance and collection of and data.

Ms **Nerina Kruger i**s a Science Liaison and GIS officer at Rondevlei Scientific Services. Her main function is to oversee research project administration and supply logistical support to researchers working in the Garden Route and Frontier parks.

Ms **Nolwazi Mbongwa** is a PhD student at the Institute of Communities & Wildlife (UCT) and also a trained Sangoma. Her love for the environment stems from a rural background where nature is not only loved for its aesthetic value but also holds cultural significance.

Dr **Nicola van Wilgen-Bredenkamp** has been with SANParks for ten years, conducting global change research at the Cape Research Centre.



Ms **Nthabeliseni Munyai** is a biotechnician for the Frontier Parks. She assists with the implementation of monitoring and research. She is passionate about climate change and its interactions with vegetation.

Ms **Nikisha Singh** recently joined SANParks as the Curator of the Biological Reference Collection (Scientific Services, Skukuza). My research interests include urban ecology, herpetology and human-wildlife conflict.

Dr **Peter Novellie** was in SANParks till 2015, involved in governance and protected area management planning; now retired with enough time to reflect.

Dr **Nkabeng Mzileni** is the Regional Ecologist for the Arid and Central Parks which entails being the glue that brings the scientists and park management onto the same platform.

Mr **Pieter van Wyk** is the curator of the nursery in Richtersveld National Park.

Ms **Portia Chake** is a research assistant based in Addo Elephant National Park. She is responsible for assistance with coordinating and organising field work and data collection by researchers and keeping everyone safe in the field.

Dr **Sam Ferreira** is the SANParks large mammal ecologist. His primary role is to ensure that robust information underpins large mammal management decisions. He provides transdisciplinary advice across all national parks on mammals ranging from duikers to elephants.

Mr **Prisca Rikombe** is a Research Assistant based in Kruger National Park and involved in a wide range of monitoring activities.

Ms **Samantha Mabuza** is the science liaison officer for the Savanna Node. Her current interests include science communication and how to use social media to share science with the public.

Mr **Robin Petersen** is a Freshwater Ecologist in the Savanna Node. Coordinating the integrated bio- monitoring of freshwater ecosystems and groundwater resources.

Ms **Sisanda Mayekiso** is a marine junior scientist based at the Cape Research Centre. She is currently monitoring fish using baited remote underwater cameras in MPAs.

Mr **Rodney Makwakwa** is an EM at Mokala National Park - Biodiversity Social Projects Unit, providing Project Manager and Administrator with support to manage Working For Water and Working For Ecosystems restoration projects.

Dr **Stefanie Freitag-Ronaldson** believes in social-ecological science and co-learning for underpinning sustainable conservation efforts; she was the acting head of Scientific Services during most of the past financial year

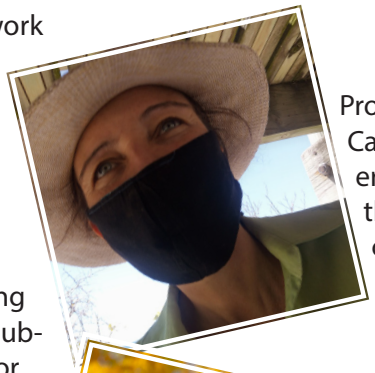
Ms **Roxanne Erusan** is a biotechnician based in Kimberley and forms part of the support team for the implementation of biodiversity monitoring and research. Her interests include species of special concern, mammals, and a holistic approach to conservation.

Mr **Stephen Midzi** is a Biodversity Conservation Manager based in Kruger, he is responsible for implementation of biodiversity conservation programs. His main interests are in management of Human-Wildlife interactions.

Ms **Ruth-Mary Fisher** is an Earth Systems Scientist currently working on the effects of fire on soils. She also does research on freshwater ecosystems.

Mr **Steven Khoza** is a biotechnician based in Marakele NP. He is responsible for biomonitoring in Marakele and Mapungubwe as well as assisting with aerial surveys in Kruger and Kgalagadi**.** He is also instrumental in capacity development of BSP EMs.

Ms **Tercia Strydom** is the Abiotic Scientist in the Savanna Node within Scientific Services. Her work focuses on fire, soils, hydrology and the interactions between **t**hese abiotic drivers.



Prof **Wendy Foden** is the Cape Research Centre general manager, and serves as the chair of the IUCN Species Survival Commission Climate Change Specialist group.

Mr **Thabo Makhubedu** is a free-lance ecological research consultant providing support services to the public and private sectors for projects including conservation and management of threatened medicinal plant species in rural communities.

Ms **Wiida Fourie-Basson** is a full-time science writer for the Faculty of Science, and a part-time specialist lecturer in science journalism in the Department of Journalism, both at Stellenbosch University.

Mr **Thabo Kgomommu** has been doing conservation services in the field of cultural heritage since 1998. In SANParks he has been mainly responsible for mainstreaming cultural heritage into SANParks operations including conservation and tourism services. He is currently the Acting Managing Executive for Conservation Services.

Mr **Tommie Steyn** is a botanist with Mpumalanga Parks and Tourism Agency and is based in Mashishing.

Mr **Trevor Adams** is a Terrestrial biotechnician at the CRC. He is responsible for the plant species of special concern monitoring program. His also provides a supportive role to the freshwater monitoring program and is SASS accredited.

Dr **Vivienne Williams** is a free-lance academic based at Wits, specialising in wildlife trade, large carnivores and ethnobotany.

Appendix A: Papers published in SANParks

Addo

• Akinyemi, Babatope E., and Abbyssinia Mushunje. Community-based ecotourism project in communities adjacent to the Addo Elephant National Park: Will households pay for it? Koedoe 62, no. 1 (2020): 1-10.
• Bezuidenhout, H., 2020. Assessment results (2015-2018) of re-established poached cycad trees in Addo Elephant National Park, Eastern Cape, South Africa. Koedoe, 62(1), pp.1-6.
• Carvalho, S.L. and Campbell, E.E., 2021. The association between bushclumps of Calcrete Bontveld and the adjacent Valley Thicket. South African Journal of Botany, 137, pp.406-413.
• Dippenaar-Schoeman, A.S., Wiese, L., Foord, S.H. and Haddad, C.R., 2020. A list of spider species found in the Addo Elephant National Park, Eastern Cape province, South Africa. koedoe, 62(1), pp.1-13.

Agulhas

• Cowell, C.R., Anderson, P.M. and Annecke, W.A., 2020. Historic herbarium specimens as biocultural assets: An examination of herbarium specimens and their in situ plant communities of the Agulhas National Park, South Africa. People and Nature, 2(2), pp.483.

Augrabies

• Fleury, G.S., Hoffman, M.T. and Todd, S.W., 2020. Land reform and its impact on the arid South African environment: Riemvasmaak as a case study. African Journal of Range & Forage Science, pp.1-12.
Bontebok
• Hedderson, T.A., 2020. Nine moss species new for South Africa with additional records for 14 rare or poorly known species. Journal of Bryology, pp.1-7.

Garden Route

• Arendse, C.J. and Russell, I.A., 2020. Morphometric regressions for the endangered Knysna seahorse, Hippocampus capensis, in the Swartvlei Estuary from mass stranding events. koedoe, 62(1), pp.1-6.
• Fagg, C., Phair, N.L., Claassens, L., Barnes, R.S.K. and von der Heyden, S., 2021. Strengthening the DNA barcode reference library for South African estuarine macrofauna. African Journal of Marine Science, pp.1-5.
• Ginal, P., Mokhatla, M., Kruger, N., Secondi, J., Herrel, A., Measey, J. and Rödder, D., 2021. Ecophysiological models for global invaders: Is Europe a big playground for the African clawed frog?. Journal of Experimental Zoology Part A: Ecological and Integrative Physiology 335 (1) pp.158-172.
• Helm, C.W., Cawthra, H.C., De Vynck, J.C., Dixon, M. and Stear, W., 2021. Elephant Tracks: A Biogenic Cause of Potholes in Pleistocene South African Coastal Rocks. Journal of Coastal Research, 37(1), pp.59-74.
• Helm, C.W., Lockley, M.G., Cawthra, H.C., De Vynck, J.C., Dixon, M.G., Helm, C.J. and Thesen, G.H., 2020. Newly identified hominin trackways from the Cape south coast of South Africa. South African Journal of Science, 116(9-10), pp.1-13.
• Schm"le, S., Brown, M. and Witteveen, M., 2020. All washed up: spatial and temporal variation in the wash-up and fate of chondrichthyan egg cases along a section of the Garden Route, South Africa. African Journal of Marine Science, 42(2), pp.141-149.
• Tchoumi, J.M.T., Coetzee, M.P.A., Rajchenberg, M. and Roux, J., 2020. Poroid Hymenochaetaceae associated with trees showing wood-rot symptoms in the Garden Route National Park of South Africa. Mycologia, 112(4), pp.722-741.
• van Wyk, A.S. and Prinsloo, G., 2021. NMR-based metabolomic analysis of the seasonal and regional variability of phytochemical compounds in Curtisia dentata stem bark. Biochemical Systematics and Ecology, 94, p.104197.

Golden Gate

• Adagbasa, E.G., Adelabu, S.A. and Okello, T.W., 2020. Development of post-fire vegetation response-ability model in grassland mountainous ecosystem using GIS and remote sensing. ISPRS Journal of Photogrammetry and Remote Sensing, 164, pp.173-183.
• Adepoju, K., Adelabu, S. and Mokubung, C., 2020. Mapping Seriphium plumosum encroachment and interaction with wildfire and environmental factors in a protected mountainous grassland. Environmental monitoring and assessment, 192(6), pp.1-15.
• Adepoju, K.A. and Adelabu, S.A., 2020. Improving accuracy of Landsat-8 OLI classification using image composite and multisource data with Google Earth Engine. Remote Sensing Letters, 11(2), pp.107-116.

• Botham, J.L., Haddad, C.R., Gryzenhout, M., Swart, V.R. and Bredenhand, E., 2020. High genetic diversity of spider species in a mosaic montane grassland landscape. Plos one, 15(6), p.e0234437.
• Ermilov, S.G, Hugo-Coetzee, E.A and Khaustov, A.A, 2020. Contribution to the knowledge of the oribatid mite genus Setoppia (Acari, Oribatida, Oppiidae), with description of a new species from South Africa. Acarologia, 60(4), pp.892-902.
• Ermilov, S.G., Hugo-Coetzee, E.A, Khaustov, A.A. and Khaustov, V.A., 2021. New faunistic and taxonomic data on oribatid mites (Acari, Oribatida) inhabiting soil and termite nests in the Golden Gate Highlands National Park (eastern South Africa). International Journal of Acarology,47(2), pp. 152-158.
• Ermilov, S.G., Hugo-Coetzee, E.A., Khaustov, A.A. and Khaustov, V.A., 2020. Ontogenetic instars of Phyllhermannia goldengatensis sp. nov.(Acari, Oribatida, Hermanniidae) from South Africa. Systematic and Applied Acarology, 25(11), pp.2115-2130.
• Shezi, T.A., O'Connor, T.G. and Witkowski, E.T.F., 2021. Impact of livestock grazing intensity on plant diversity of montane grassland in the northern Drakensberg, South Africa. African Journal of Range & Forage Science, pp.1-13.

Kalahari

• van der Merwe, S., Greve, M., Olivier, B. and le Roux, P.C., 2021. Testing the role of functional trait expression in plant–plant facilitation. Functional Ecology, 35(1), pp.255-265.
• van der Merwe, S.S., Swart, V.R., Bredenhand, E. and Haddad, C.R., 2020. Soil-dwelling arthropods as indicators of erosion in a South African grassland habitat. Pedobiologia, 80, p.150647.
• Visagie, C.M. and Houbraken, J., 2020. Updating the taxonomy of Aspergillus in South Africa. Studies in mycology, 95, pp.253-292.
• Van der Merwe, H., Van Rooyen, N., Bezuidenhout, H., Bothma, J.D.P. and van Rooyen, M.W., 2020. Woody vegetation change over more than 30 years in the interior duneveld of the Kalahari Gemsbok National Park. Bothalia - African Biodiversity & Conservation , 50(1), 1-9. https://dx.doi.org/10.38201/btha.abc.v50.i1.2

Transfrontier Conservation Area

• Chiloane, C., Dube, T. and Shoko, C., 2020. Monitoring and assessment of the seasonal and inter-annual pan inundation dynamics in the Kgalagadi Transfrontier Park, Southern Africa. Physics and Chemistry of the Earth, Parts A/B/C, 118, p.102905.
• Lekgau, R.J. and Tichaawa, T.M., 2020. Leveraging Wildlife Tourism for Employment Generation and Sustainable Livelihoods: The Case of the Kgalagadi Transfrontier Park, Southern Africa. Bulletin of Geography. Socio-economic Series, 49(49), pp.93-108.
• Saarinen, J., Moswete, N., Atlhopheng, J.R. and Hambira, W.L., 2020. Changing socio-ecologies of Kalahari: Local perceptions towards environmental change and tourism in Kgalagadi, Botswana. Development Southern Africa, 37(5), pp. 855-870.
• van der Merwe, P., Saayman, M. and Botha, E., 2020. Interpretation needs and preferences of visitors to Kgalagadi Transfrontier Park. Koedoe, 62(1), pp.1-11.

Kruger

• Adams, R.A. and Hayes, M.A., 2021. The Importance of Water Availability to Bats: Climate Warming and Increasing Global Aridity. In 50 Years of Bat Research (pp. 105-120). Springer, Cham.
• Addo-Bediako, A. and Rasifudi, L., 2021. Spatial distribution of heavy metals in the Ga-Selati River of the Olifants River System, South Africa. Chemistry and Ecology, pp.1-14.
• Awuah, K.T., Aplin, P., Marston, C.G., Powell, I. and Smit, I.P., 2020. Probabilistic mapping and spatial pattern analysis of grazing lawns in Southern African savannahs using WorldView-3 imagery and machine learning techniques. Remote Sensing, 12(20), 3357. https://doi.org/10.3390/rs12203357
• Barends, J.M., Pietersen, D., Zambatis, G., Tye, D.R. and Maritz, B., 2020. Sampling bias in reptile occurrence data for the Kruger National Park. Koedoe: African Protected Area Conservation and Science, 62(1), pp.1-9.
• Bernitz, N., Kerr, T.J., Goosen, W.J., Chileshe, J., Higgitt, R.L., Roos, E.O., Meiring, C., Gumbo, R., De Waal, C., Clarke, C., Smith, K., Goldswain, S., Sylvester, T.T., Kleynhans, L., Dippenaar, A., Buss, P.E., Cooper, D.V., Lyashchenko, K.P., Warren R.M., Van Helden P.D., Parsons S.D.C. and Miller M.A., 2021. Review of Diagnostic Tests for Detection of Mycobacterium bovis Infection in South African. Wild Frontiers in Veterinary Science, 8:588697 https://doi.org/10.3389/fvets.2021.588697
• Bouwer, D., le Roux, P.A. and van Tol, J.J., 2020. Identification of hydropedological flowpaths in Stevenson-Hamilton catena from soil morphological, chemical and hydraulic properties. Koedoe, 62(2), pp.1-11.

• Braack, L., Bornman, R., Kruger, T., Dahan-Moss, Y., Gilbert, A., Kaiser, M., Oliver, S.V., Cornel, A.J., Lee, Y., Norris, D.E. and Coetzee, M., 2020. Malaria Vectors and Vector Surveillance in Limpopo Province (South Africa): 1927 to 2018. International Journal of Environmental Research and Public Health, 17(11), 4125. https://doi.org/10.3390/ijerph17114125
• Case, M.F., Wigley, B.J., Wigley-Coetsee, C. and Carla Staver, A., 2020. Could drought constrain woody encroachers in savannas?. African Journal of Range & Forage Science, 37(1), pp.19-29.
• Combrink, L., Combrink, H.J., Botha, A.J. and Downs, C.T., 2020. Habitat preferences of Southern Ground-hornbills in the Kruger National Park: implications for future conservation measures. Scientific Reports, 10, 16195. https://doi.org/10.1038/s41598-020-73236-4
• Crookes, S., Heer, T., Castañeda, R.A., Mandrak, N.E., Heath, D.D., Weyl, O.L., MacIsaac, H.J. and Foxcroft, L.C., 2020. Monitoring the silver carp invasion in Africa: a case study using environmental DNA (eDNA) in dangerous watersheds. NeoBiota, 56, p.31
• De Waal, C.R., Kleynhans, L., Parsons, S.D.C., Goosen, W.J., Hausler, G., Buss, P.E., Warren, R.M., Van Helden, P.D., Landolfi, J.A., Miller, M.A. & Kerr, T.J., 2021, Development of a cytokine gene expression assay for the relative quantification of the African elephant (Loxodonta africana) cell-mediated immune responses. Cytokine, vol. 141, 155453. https://doi.org/10.1016/j.cyto.2021.155453
• Dlamini, T.B., Reilly, B.K., Thompson, D.I., Burkepile, D.E., Botha, J.M. and Rebelo, A.G., 2020. Differential herbivore occupancy of fire-manipulated savannas in the Satara region of the Kruger National Park, South Africa. Koedoe, 62(1), pp.1-8.
• Dwyer, R.A., Witte, C., Buss, P., Goosen, W.J. and Miller, M., 2020. Epidemiology of tuberculosis in multi-host wildlife systems: implications for black (diceros bicornis) and white (ceratotherium simum) rhinoceros. Frontiers in veterinary science, 7:580476. https://doi.org/10.3389/fvets.2020.580476
• Erasmus, L.L., Van Coller, H. and Siebert, F., 2021. Teatime in Kruger: Tailoring the application of the Tea Bag Index approach to an African savanna. South African Journal of Science, 117(1/2), pp. 117-122.
• Ferreira, S.M. and Funston, P., 2020. African Lion and Spotted Hyaena Changes in Kruger National Park, South Africa. African Studies Quarterly, 19(2), pp.37-50.
• Ferreira, S.M. and Pienaar, D., 2020. Evaluating uncertainty in estimates of large rhinoceros populations. Pachyderm, 61, pp.97-108.
• Ferreira, S.M., Le Roex, N., Greaver, C. and Dreyer, C., 2020. Comparison of mark-recapture and block-count-based estimation of black rhinoceros populations. African Journal of Wildlife Research, 50(1), pp.167-175.
• Gaget, E., Parr, C.L. and Sirami, C., 2020. Effects of fire frequency on savanna butterfly diversity and composition: A preliminary study. Koedoe, 62(1), pp.1-9.
• Gerber, R., Bouwman, H., Govender, D., Ishizuka, M., Ikenaka, Y., Yohannes, Y.B., Smit, N.J. and Wepener, V., 2021. Levels of DDTs and other organochlorine pesticides in healthy wild Nile crocodiles (Crocodylus niloticus) from a flagship conservation area. Chemosphere,264(1): 128368. https://doi.org/10.1016/j.chemosphere.2020.128368
• Gillson, L. and Ekblom, A., 2020. Using palaeoecology to explore the resilience of southern African savannas. Koedoe, 62(1), pp.1-12.
• Gryzenhout, M., Cason, E.D., Vermeulen, M., Kloppers, G.A., Bailey, B. and Ghosh, S., 2020. Fungal community structure variability between the root rhizosphere and endosphere in a granite catena system in Kruger National Park, South Africa. Koedoe, 62(2),
• Gryzenhout, M., Vermeulen, M., Pambuka, G. and Jacobs, R., 2020. First report of various Fusarium species from the Stevenson-Hamilton Supersite granite catena system in the Kruger National Park, South Africa. koedoe, 62(2), pp.1-8.
• Hassim, A., Lekota, K.E., van Dyk, D.S., Dekker, E.H. and van Heerden, H., 2020. A Unique Isolation of a Lytic Bacteriophage Infected Bacillus anthracis Isolate from Pafuri, South Africa. Microorganisms, 8(6), p.932.
• Hewlett, J., Buss, P., Olea-Popelka, F., Koeppel, K., Neiffer, D., Hausler, G., Rossouw, L., Manamela, T., Stout, E. and Miller, M., 2020. Evaluation of a partially reversible immobilization protocol using medetomidine, butorphanol, zolazepam–tiletamine, and ketamine in free-ranging warthogs (Phacochoerus africanus) in Kruger National Park, South Africa. Journal of zoo and Wildlife Medicine : Official Publication of the American Association of Zoo Veterinarians, 51(1), pp.80-87.
• Horak, I.G., Boomker, J., Junker, K. and Gallivan, G.J., 2021. Some gastrointestinal nematodes and ixodid ticks shared by several wildlife species in the Kruger National Park, South Africa. Parasitology, 148(6), pp.740-746.
• Janecke, B.B. and Bolton, J.G., 2020. Variation in mammal diversity and habitat affect heterogeneity and processes of a granite catena.ÿkoedoe,ÿ62(2), pp.1-12.
• Janecke, B.B. and van Tol, J., 2020. Connections between abiotic and biotic components of a granite catena ecosystem in Kruger National Park. koedoe, 62(2), pp.1-2.

• Janecke, B.B., 2020. Vegetation structure and spatial heterogeneity in the Granite Supersite, Kruger National Park. Koedoe, 62(2), pp.1-12.
• Janecke, B.B., van Tol, J., Smit, I.P., van Aardt, A.C., Riddell, E.S., Seaman, M.T., Swart, W.J., du Preez, P.J. and le Roux, P.A., 2020. Biotic and abiotic connections on a granitic catena: Framework for multidisciplinary research. Koedoe, 62(2), pp.1-1
• Johnson, T., Braack, L., Guarido, M., Venter, M. and Gouveia Almeida, A.P., 2020. Mosquito community composition and abundance at contrasting sites in northern South Africa, 2014–2017. Journal of Vector Ecology, 45(1), pp.104-117.
• Kerr, T.J., Goosen, W.J., Gumbo, R., De Klerk-Lorist, L-M., Pretorius, O., Buss, P.E., Kleynhans, L., Lyashchenko, P., Warren, R.M., Van Helden, P.D. and Miller, M.A., 2021, Diagnosis of Mycobacterium bovis infection in free-ranging common hippopotamus (Hippopotamus amphibius). Transboundary and Emerging Diseases, 00: pp. 1– 7. https://doi.org/10.1111/tbed.13989
• Kerr, T.J., Gumbo, R., Goosen, W.J., Rogers, P., Last, R.D. and Miller, M.A., 2020. Novel techniques for detection of Mycobacterium bovis infection in a cheetah. Emerging infectious diseases, 26(3), p.630.
• La Grange, L.J. and Mukaratirwa, S., 2020. Epidemiology and hypothetical transmission cycles of Trichinella infections in the Greater Kruger National Park of South Africa: an example of host-parasite interactions in an environment with minimal human interactions. Parasite, 27(13). https://doi.org/10.1051/parasite/2020010
• Le Roex, N. and Ferreira, S.M., 2020. Age structure changes indicate direct and indirect population impacts in illegally harvested black rhino. PloS one, 15(7), p.e0236790.
• Maarten, S., Hunting, E.R., Beechler, B.R., Guarido, M.M., Govender, D., Wiebe, N., Marietjie, V. and van Bodegom Peter, M., 2020. Human practices promote presence and abundance of disease-transmitting mosquito species. Scientific Reports, 10:13543. https://doi.org/10.1038/s41598-020-69858-3
• Malherbe, J., Smit, I.P., Wessels, K.J. and Beukes, P.J., 2020. Recent droughts in the Kruger National Park as reflected in the extreme climate index. African Journal of Range & Forage Science, 37(1), pp.1-17.
• Malzacher, P. and Barber-James, H.M., 2020. Two New Caenis Species (Insecta: Ephemeroptera: Caenidae) from the Kruger National Park, South Africa. African Entomology, 28(1), pp.62-77.
• Maruping-Mzileni, N.T., Ferreira, S., Young, K. and Funston, P.J., 2020. Ecological drivers of female lion (Panthera leo) reproduction in the Kruger National Park. Ecology and Evolution, 10(15), pp.7995-8006.
• Maruping-Mzileni, N.T., Ferreira, S.M., Funston, P.J., Mutombo, F.K. and Goodall, V., 2020. Horizontal disease transmission in lions from behavioural interfaces via social network analysis. Mammal Research, 65(4), pp.709-718.
• Matshusa, K., Thomas, P. and Leonard, L., 2020. Developing a scale for measuring influential factors towards geotourism development. Acta Commercii, 20(1), pp.1-11.
• Midgley, J.J., Coetzee, B.W., Tye, D. and Kruger, L.M., 2020. Mass sterilization of a common palm species by elephants in Kruger National Park, South Africa. Scientific reports, 10(1), pp.1-5.
• Miller, M.A., Kerr, T.J., De Waal, C.R., Goosen, W.J., Streicher, E.M., Hausler, G., Rossouw, L., Manamela, T., Van Schalkwyk, L., Kleynhans, L., Warren, R., Van Helden, P. & Buss, P.E., 2021, Mycobacterium bovis infection in free-ranging African elephants. Emerging Infectious Diseases, 27(3), pp.990-992.
• Netshakhuma, N.S., 2020. Analysis of the alliance of archives, libraries, and museums of South Africa National Parks: Kruger National Park. IFLA Journal, p.0340035220912514.
• Netshakhuma, N.S., 2021. Accessibility of Land Claims Records at Kruger National Park of South Africa. In Indigenous Research of Land, Self, and Spirit (pp. 153-167). IGI Global.
• Ntuli, H., Sundström, A., Sjöstedt, M., Muchapondwa, E., Jagers, S. and Linell, A., 2021. Understanding the drivers of subsistence poaching in the Great Limpopo Transfrontier Conservation Area: What matters for community wildlife conservation? Ecology and Society 26(1): 18. https://doi.org/10.5751/ES-12201-260118
• Pearson, V.R., Bosse, J.B., Koyuncu, O.O., Scherer, J., Toruno, C., Robinson, R., Abegglen, L.M., Schiffman, J.D., Enquist, L.W. and Rall, G.F., 2021. Identification of African Elephant Polyomavirus in wild elephants and the creation of a vector expressing its viral tumor antigens to transform elephant primary cells. PLOS ONE 16(2): e0244334. https://doi.org/10.1371/journal.pone.0244334
• Pellegrini, A.F., Refsland, T., Averill, C., Terrer, C., Staver, A.C., Brockway, D.G., Caprio, A., Clatterbuck, W., Coetsee, C., Haywood, J.D. and Hobbie, S.E., 2021. Decadal changes in fire frequencies shift tree communities and functional traits. Nature Ecology & Evolution, 5(4), pp. 504-512.
• Pohlin, F., Hooijberg, E.H., Buss, P., Huber, N., Viljoen, F.P., Blackhurst, D. and Meyer, L.C., 2020. A Comparison of Hematological, Immunological, and Stress Responses to Capture and Transport in Wild White Rhinoceros Bulls (Ceratotherium simum simum) Supplemented With Azaperone or Midazolam. Frontiers in Veterinary Science. 20(7):569576. https://doi.org/10.3389/fvets.2020.569576

• Pyšek, P., Hejda, M., Čuda, J., Zambatis, G., Pyšková, K., MacFadyen, S., Storch, D., Tropek, R. and Foxcroft, L.C., 2020. Into the great wide open: do alien plants spread from rivers to dry savanna in the Kruger National Park?. NeoBiota, 60, p.61.
• Riddell, E.S., Nel, J., van Tol, J., Fundisi, D., Jumbi, F., van Niekerk, A. and Lorentz, S., 2020. Groundwater-surface water interactions in an ephemeral savanna catchment, Kruger National Park. Koedoe, 62(2), pp.1-14.
• Sach, F., Yon, L., Henley, M.D., Bedetti, A., Buss, P., de Boer, W.F., Dierenfeld, E.S., Gardner, A., Langley-Evans, S.C., Hamilton, E. and Lark, R.M., 2020. Spatial geochemistry influences the home range of elephants. Science of the Total Environment, 729:139066. https://doi.org/10.1016/j.scitotenv.2020.139066
• Scholtz, M. and van der Merwe, P., 2020. We Can Deal with the Extra Feet, but Not the Extra Speed: the Importance of Providing a Memorable Experience in a Crowded National Park. Tourism Planning & Development, pp.1-17.
• Shabangu, N., Penzhorn, B.L., Oosthuizen, M.C., Vorster, I., van Schalkwyk, O.L., Harrison-White, R.F. and Matjla, P.T., 2021. A shared pathogen: Babesia rossi in domestic dogs, black-backed jackals (Canis mesomelas) and African wild dogs (Lycaon pictus) in South Africa. Veterinary Parasitology, 291: 109381 https://doi.org/10.1016/j.vetpar.2021.109381.
• Shahriary, E., Gill, T.E. and Langford, R.P., 2020. Bibliometric analysis of piosphere research: implications for conservation and scientific collaboration. International Journal of Sustainable Development & World Ecology, pp.1-10.
• Smit, I.P. and Bond, W.J., 2020. Observations on the natural history of a savanna drought. African Journal of Range & Forage Science, 37(1), pp.119-136.
• Smit, I.P., 2020. Integrating multi-scaled and multidisciplinary studies: A critical reflection on the Kruger National Park research supersites. Koedoe, 62(2), pp.1-5.
• Smit, I.P., Peel, M.J., Ferreira, S.M., Greaver, C. and Pienaar, D.J., 2020. Megaherbivore response to droughts under different management regimes: lessons from a large African savanna. African Journal of Range & Forage Science, 37(1), pp.65-80.
• Smith, M.K.S., Smit, I.P., Swemmer, L.K., Mokhatla, M.M., Freitag, S., Roux, D.J. and Dziba, L., 2021. Sustainability of protected areas: Vulnerabilities and opportunities as revealed by COVID-19 in a national park management agency. Biological Conservation, 255:108985
• Sonamzi, B., Burnett, M., Petersen, R., O'Brien, G. and Downs, C.T., 2020. Assessing the effect of tagging and the vulnerability to predation in tigerfish (Hydrocynus vittatus, Castelnau 1861) in a water-stressed system using telemetry methods. Koedoe, 62(1): 1649. https://doi.org/10.4102/koedoe.v62i1.1649
• Steyn, J., Motlou, P., Van Eeden, C., Pretorius, M., Stivaktas, V.I., Williams, J., Snyman, L.P., Buss, P.E., Beechler, B., Jolles, A. and Perez-Martin, E., 2020. Shuni virus in wildlife and nonequine domestic animals, South Africa. Emerging Infectious Diseases, 26(7), pp. 1521-1525. https://doi.org/10.3201/eid2607.190770.
• Swemmer, L., Landela, R., Mdungasi, P., Midzi, S., Mmatho, W., Mmethi, H., Shibambu, D., Symonds, A., Themba, S. and Twine, W., 2020. It's Not Just About the Worm. Conservation & Society, 18(2), pp.183-199.
• Theron, E.J., van Aardt, A.C. and J du Preez, P., 2020. Vegetation distribution along a granite catena, southern Kruger National Park, South Africa. Koedoe, 62(2), pp.1-11.
• Thoresen, J., Vermeire, M.L., Venter, Z., Wolfaard, G., Krumins, J.A., Cramer, M. and Hawkins, H.J., 2021. Fire and herbivory shape soil arthropod communities through habitat heterogeneity and nutrient cycling in savannas. Global Ecology and Conservation, 25: e01413. https://doi.org/10.1016/j.gecco.2020.e01413
• Urban, M., Heckel, K., Berger, C., Schratz, P., Smit, I.P., Strydom, T., Baade, J. and Schmullius, C., 2020. Woody cover mapping in the savanna ecosystem of the Kruger National Park using Sentinel-1 C-Band time series data. koedoe, 62(1), pp.1-6.
• Valverde, A., Cason, E.D., Gómez-Arias, A., Bozkale, D., Govender, D., Riddell, E. and Cowan, D., 2020. Pollution shapes the microbial communities in river water and sediments from the Olifants River catchment, South Africa. Archives of Microbiology, pp.1
• van Aardt, A.C., Codron, D., Theron, E.J. and J du Preez, P., 2020. Plant community structure and possible vegetation changes after drought on a granite catena in the Kruger National Park, South Africa. koedoe, 62(2), pp.1-11.
• van Huyssteen, C.W. and Johnson, T.L., 2020. Evaluating the use of iron-coated tubes for wetland delineation in South Africa: A pilot study in the Kruger National Park. Water SA, 46(3), pp.393-403.
• Vermeulen, M., Cason, E.D. and Swart, W.J., 2020. The rhizobiome of herbaceous plants in Clovelly and Sterkspruit soils of the Stevenson-Hamilton supersite. Koedoe, 62(2), pp.1-9.
• Voysey, M.D., Archibald, S., Bond, W.J., Donaldson, J.E., Carla Staver, A. and Greve, M., 2021. The role of browsers in maintaining the openness of savanna grazing lawns. Journal of Ecology, 109(2), pp.913-926.

• Wessels, J.A. and Douglas, A., 2020. Exploring Creative Tourism Potential in Protected Areas: The Kruger National Park Case. Journal of Hospitality & Tourism Research, p.1096348020983532.
• Wielgus, E., Cornélis, D., de Garine-Wichatitsky, M., Cain, B., Fritz, H., Miguel, E., Valls-Fox, H., Caron, A. and Chamaillé-Jammes, S., 2020. Are fission–fusion dynamics consistent among populations? A large-scale study with Cape buffalo. Ecology and Evolution, 10, pp. 9240–9256
• Wigley-Coetsee, C. and Staver, A.C., 2020. Grass community responses to drought in an African savanna. African Journal of Range & Forage Science, 37(1), pp.43-52.
• Wilcox, K.R., Koerner, S.E., Hoover, D.L., Borkenhagen, A.K., Burkepile, D.E., Collins, S.L., Hoffman, A.M., Kirkman, K.P., Knapp, A.K., Strydom, T. and Thompson, D.I., 2020. Rapid recovery of ecosystem function following extreme drought in a South African savanna grassland. Ecology, 101(4) e02983. https://doi.org/10.1002/ecy.2983
• Young, C., Fritz, H., Smithwick, E.A. and Venter, J.A., 2020. Patch-scale selection patterns of grazing herbivores in the central basalt plains of Kruger National Park. African Journal of Range & Forage Science, 37(3), pp.199-213.
• Zhou, Y., Wigley, B.J., Case, M.F., Coetsee, C. and Staver, A.C., 2020. Rooting depth as a key woody functional trait in savannas. New Phytologist, 227(5), pp. 1350-1361.

Mapungubwe

• Taylor, P.J., Nelufule, M., Parker, D.M., Toussaint, D.C. and Weier, S.M., 2020. The Limpopo River exerts a powerful but spatially limited effect on bat communities in a semi-arid region of South Africa. Acta Chiropterologica, 22(1), pp.75-86.

Mokala

• Verster, A.M., Liang, J.E., Rostal, M.K., Kemp, A., Brand, R.F., Anyamba, A., Cordel, C., Schall, R., Zwiegers, H., Paweska, J.T. and Karesh, W.B., 2020. Selected wetland soil properties correlate to Rift Valley fever livestock mortalities reported in 2009-10 in central South Africa. PLOS ONE 15(5): e0232481. https://doi.org/10.1371/journal.pone.0232481

Mountain Zebra

• Bezuidenhout, H. and Brown, L.R., 2021. Mountain Zebra National Park phytosociological classification: A case study of scale and management in the Eastern Cape, South Africa. South African Journal of Botany, 138, pp.227-241.
• Parker, D.M., van de Vyver, D.B. and Bissett, C., 2020. The influence of an apex predator introduction on an already established subordinate predator. Journal of Zoology, 313(3), pp. 224-235.
• Prinsloo, N.D., Postma, M. and de Bruyn, P.N., 2021. How unique is unique? Quantifying geometric differences in stripe patterns of Cape mountain zebra, Equus zebra zebra (Perissodactyla: Equidae). Zoological Journal of the Linnean Society, 191(2), pp.612-

Multiple parks

• Büchling, M. and Maroun, W., 2021. Accounting for Biodiversity and Extinction: The Case of South African National Parks. Social and Environmental Accountability Journal, pp.1-32.
• Coldrey, K.M. and Turpie, J.K., 2020. Potential impacts of changing climate on nature-based tourism: A case study of South Africa's national parks. Koedoe, 62(1), pp.1-12.
• de Jager, D., Glanzmann, B., Müller, M., Hoal, E., van Helden, P., Harper, C. and Bloomer, P., 2021. High diversity, inbreeding and a dynamic Pleistocene demographic history revealed by African buffalo genomes. Scientific Reports, 11(1), pp.1-15.
• Fezeka, M. and Stella, K.A., 2020. Assessment of the socio-economic impacts of Tourism on three rural communities neighbouring Addo Elephant National Park, Eastern Cape, South Africa. African Journal of Hospitality, Tourism and Leisure 9(1), - (2020) ISSN: 2223-814X.
• Hausmann, A., Toivonen, T., Fink, C., Heikinheimo, V., Kulkarni, R., Tenkanen, H. and Di Minin, E., 2020. Understanding sentiment of national park visitors from social media data. People and Nature DOI: 10.1002/pan3.10130
• Herrero, H., Southworth, J., Muir, C., Khatami, R., Bunting, E. and Child, B., 2020. An Evaluation of Vegetation Health in and around Southern African National Parks during the 21st Century (2000–2016). Applied Sciences, 10(7), p.2366.
• Hoveka, L.N., van der Bank, M. and Davies, T.J., 2020. Evaluating the performance of a protected area network in South Africa and its implications for megadiverse countries. Biological Conservation, 248, p.108577.

• Owen-Smith, N., Hopcraft, G., Morrison, T., Chamaillé-Jammes, S., Hetem, R., Bennitt, E. and Van Langevelde, F., 2020. Movement ecology of large herbivores in African savannas: current knowledge and gaps. Mammal Review, 50(3), pp.252-266.
• Pardo, L.E., Bombaci, S.P., Huebner, S., Somers, M.J., Fritz, H., Downs, C., Guthmann, A., Hetem, R.S., Keith, M., le Roux, A. and Mgqatsa, N., 2021. Snapshot Safari: A large-scale collaborative to monitor Africa's remarkable biodiversity. South African Journal of Science, 117(1/2), pp.10-13.
• Sandham, L.A., Huysamen, C., Retief, F.P., Morrison-Saunders, A., Bond, A.J., Pope, J. and Alberts, R.C., 2020. Evaluating environmental impact assessment report quality in South African national parks. Koedoe, 62(1), pp.1-9.
• Sithole, H., Tantsi, N., Bezuidenhout, H., Munyai, T.C. and Munyai, L., 2020. Reconnaissance of epigeal ants at the degraded and control sites of Mountain Zebra and Mokala National Parks. Koedoe, 62(1), pp.1-6.
• Zimmermann, D.E., Penzhorn, B.L., Vorster, I., Troskie, M. and Oosthuizen, M.C., 2021. Babesia bicornis, Theileria bicornis and Theileria equi in metapopulations of two black rhinoceros (Diceros bicornis) subspecies in South Africa and their potential impact on conservation. Ticks Tick Borne Diseases, 12(2)101635. https://doi.org/10.1016/j.ttbdis.2020.101635

Namaqua

• Cristescu, B., Teichman, K.J., Puls, S., Jansen, C. and O'Riain, M.J., 2020. Spatial distribution of leopards on farmland and Namaqua National Park, South Africa. African Journal of Wildlife Research, 50(1).

Other

• Foden, W. and van Wilgen, N, 2020. Species loss and extinction through a climate change lens. In: The Living Planet Report, sub-report: Too hot to handle: a deep dive into biodiversity in a warming world. Eds J Anna, P Pacheco, K Schuijt. WWF, Gland, Sw
• Archer, E., Dziba, L.E., Mulongoy, K.J., Maoela, M.A., Walters, M., Biggs, R., Salem, M.C., DeClerck, F., Diaw, M.C., Dunham, A.E. and Failler, P., 2020. Biodiversity and ecosystem services on the African continent–What is changing, and what are our options? Environmental Development 37: 100558. https://doi.org/10.1016/j.envdev.2020.100558
• Botts, E.A., Skowno, A., Driver, A., Holness, S., Maze, K., Smith, T., Daniels, F., Desmet, P., Sink, K., Botha, M. and Nel, J., 2020. More than just a (red) list: Over a decade of using South Africa's threatened ecosystems in policy and practice. Biologi
• Chabalala, Y., Adam, E., Oumar, Z. and Ramoelo, A., 2020. Exploiting the capabilities of Sentinel-2 and RapidEye for predicting grass nitrogen across different grass communities in a protected area. Applied Geomatics, 12(4), pp.379-395.
• Cheney, C., Esler, K.J., Foxcroft, L.C. and van Wilgen, N.J., 2020. The dominating influence of efficacy above management strategy in the long-term success of alien plant clearing programmes. Journal of Environmental Management, 271, p.110836.
• Cheney, C., van Wilgen, N.J., Esler, K.J., Foxcroft, L.C. and McGeoch, M.A., 2021. Quantifying range structure to inform management in invaded landscapes. Journal of Applied Ecology, 58(2), pp.338-349.
• Chileshe, J., Kerr, T.J., Kinnear, C., Buss, P.E., van Helden, P.D., Warren, R.M., Miller, M.A. and Parsons, S.D., 2021. Cytokine biomarker discovery in the white rhinoceros (Ceratotherium simum). Veterinary immunology and immunopathology, 232, p.110168.
• Davies, S.J., Bell, J.A., Impson, D., Mabin, C., Meyer, M., Rhoda, C., Stafford, L., Stephens, K., Tafeni, M., Turner, A.A. and van Wilgen, N.J., 2020. Coordinating invasive alien species management in a biodiversity hotspot: The CAPE Invasive Alien Animals Working Group', Bothalia 50(1), a10. http://dx.doi.org/10.38201/btha.abc.v50.i1.10
• Dziba, L., Ramoelo, A., Ryan, C., Harrison, S., Pritchard, R., Tripathi, H., Sitas, N., Selomane, O., Engelbrecht, F., Pereira, L. and Katerere, Y., 2020. Scenarios for Just and Sustainable Futures in the Miombo Woodlands. In Miombo Woodlands in NS Ribeiro, Y Katerere, PW Chirwa & IM Grundy (eds), Miombo Woodlands in a Changing Environment: Securing the Resilience and Sustainability of People and Woodlands. Springer International Publishing. https://www.springer.com/gp/book/9783030501037#otherversion=9783030501044
• Engelbrecht, T.M., Kock, A.A., O'Riain, M.J., Mann, B.Q., Dunlop, S.W. and Barnett, A., 2020. Movements and growth rates of the broadnose sevengill shark Notorynchus cepedianus in southern Africa: results from a long-term cooperative tagging programme. African Journal of Marine Science, 42(3), pp.347-359.
• Ezenwa, V.O., Budischak, S.A., Buss, P., Seguel, M., Luikart, G., Jolles, A.E. and Sakamoto, K., 2021. Natural resistance to worms exacerbates bovine tuberculosis severity independently of worm coinfection. Proceedings of the National Academy of Sciences, of the United States of America, 118(3): e2015080118. https://doi.

org/10.1073/pnas.2015080118
• Foxcroft, L.C., 2020. Changing of the guard. Koedoe 62(1): a1645. https://doi.org/10.4102/koedoe.v62i1.1645
• Goosen, W.J., Kerr, T.J., Kleynhans, L., Warren, R.M., van Helden, P.D., Persing, D.H., Parsons, S.D., Buss, P. and Miller, M.A., 2020. The Xpert MTB/RIF Ultra assay detects Mycobacterium tuberculosis complex DNA in white rhinoceros (Ceratotherium simum)
• Hanna, D.E., Roux, D.J., Currie, B. and Bennett, E.M., 2020. Identifying pathways to reduce discrepancies between desired and provided ecosystem services. Ecosystem Services, 43, p.101119.
• Hoffman, L.C., Van As, J.S., Gouws, P.A. and Govender, D., 2020. Carcass yields of African savanna buffalo (Syncerus caffer caffer). African Journal of Wildlife Research, 50(1), pp.69-74.
• Hooijberg, E.H., Cray, C., Miller, M., Buss, P., Steenkamp, G. and Goddard, A., 2020. Bias between two methods of albumin measurement in the white rhinoceros, Ceratotherium simum. Veterinary clinical pathology, 49(1), pp.91-94.
• Kingsford, R.T., Bino, G., Finlayson, M., Falster, D., Fitzsimons, J.A., Gawlik, D., Murray, N.J., Grillas, P., Gardner, R.C., Regan, T.J. and Roux, D.J., 2021. Ramsar wetlands of international importance–improving conservation outcomes. Frontiers in Environmental Science, 9:643367. https://doi.org/10.3389/fenvs.2021.643367
• Kumschick, S., Wilson, J.R. and Foxcroft, L.C., 2020. A framework to support alien species regulation: the Risk Analysis for Alien Taxa (RAAT). NeoBiota, 62, p.213.
• Majozi, N.P., Mannaerts, C.M., Ramoelo, A., Mathieu, R. and Verhoef, W., 2021. Uncertainty and Sensitivity Analysis of a Remote-Sensing-Based Penman–Monteith Model to Meteorological and Land Surface Input Variables. Remote Sensing, 13(5), p.882.
• Masemola, C., Cho, M.A. and Ramoelo, A., 2020. Sentinel-2 time series based optimal features and time window for mapping invasive Australian native Acacia species in KwaZulu Natal, South Africa. International Journal of Applied Earth Observation and Geoin
• Masemola, C., Cho, M.A. and Ramoelo, A., 2020. Towards a semi-automated mapping of Australia native invasive alien Acacia trees using Sentinel-2 and radiative transfer models in South Africa. ISPRS Journal of Photogrammetry and Remote Sensing, 166, pp.153
• Mayekiso, S., Gouws, G., Mwale, M. and Gon, O., 2020. Evidence of genetic differentiation in cigar wrasse Cheilio inermis (Labridae) within the western Indian Ocean. Genome, 63(10), pp. 493-502.
• McCleery, R.A., Fletcher, R.J., Kruger, L.M., Govender, D. and Ferreira, S.M., 2020. Conservation needs a COVID-19 bailout. Science, 369(6503), pp. 515-516.
• Moodley, D., Foxcroft, L.C., Novoa, A., Pyšková, K., Pergl, J. and Pysek, P., 2020. Invasive alien species add to the uncertain future of protected areas. NeoBiota, 57, p.1.
• Mosing, M., Waldmann, A.D., Sacks, M., Buss, P., Boesch, J.M., Zeiler, G.E., Hosgood, G., Gleed, R.D., Miller, M., Meyer, L.C. and Böhm, S.H., 2020. What hinders pulmonary gas exchange and changes distribution of ventilation in immobilized white rhinoceros (Ceratotherium simum) in lateral recumbency? Journal of Applied Physiology, 129(5), pp.1140-1149.
• Múnera-Roldán, C., Roux, D.J., Colloff, M.J. and van Kerkhoff, L., 2020. Beyond Calendars and Maps: Rethinking Time and Space for Effective Knowledge Governance in Protected Areas. Land, 9(9), p.293.
• Neiffer, D., Hewlett, J., Buss, P., Rossouw, L., Hausler, G., De Klerk, L-M., Roos, E., Olea-Popelka, F., Lubisi, B., Health, L. & Miller, M., 2021, Antibody prevalence to African Swine Fever virus, Mycobacterium bovis, Foot-and-Mouth Disease virus, Rift Valley Fever virus, Influenza A virus, and Brucella and Leptospira Spp. in free-ranging warthog (Phacochoerus africanus) populations In South Africa. Journal of Wildlife Diseases, 57(1), pp. 60-70.
• Novoa, A., Richardson, D.M., Pyšek, P., Meyerson, L.A., Bacher, S., Canavan, S., Catford, J.A., Čuda, J., Essl, F., Foxcroft, L.C. and Genovesi, P., 2020. Invasion syndromes: a systematic approach for predicting biological invasions and facilitating effective management. Biological Invasions, 22, pp. 1801–1820.
• O'Connor, R.A., Nel, J.L., Roux, D.J., Leach, J., Lim-Camacho, L., Medvecky, F., van Kerkhoff, L. and Raman, S., 2021. The role of environmental managers in knowledge co-production: Insights from two case studies. Environmental Science & Policy, 116, pp.1
• Peel, M.J. and Smit, I.P., 2020. Drought amnesia: lessons from protected areas in the eastern Lowveld of South Africa. African Journal of Range & Forage Science, 37(1), pp.81-92.
• Piers, L., Samuels, I., Masubelele, M. and Engelbrecht, A., 2020. Implications of potential biome boundary shifts for small mammal assemblages in the arid zone of South Africa. Austral Ecology, 45(7), pp.948-957.
• Pohlin, F., Buss, P., Hooijberg, E.H. and Meyer, L.C., 2020. Midazolam alters acid-base status less than azaperone during the capture and transport of southern white rhinoceroses (Ceratotherium simum simum). Animals, 10(8), p.1323.
• Pyšek, P., Hulme, P.E., Simberloff, D., Bacher, S., Blackburn, T.M., Carlton, J.T., Dawson, W., Essl, F., Foxcroft, L.C.,

Genovesi, P. and Jeschke, J.M., 2020. Scientists' warning on invasive alien species. Biological Reviews, 95(6), pp.1511-1534.
• Roux, D., Bezuidenhout, H. and Cole, N., 2020. A Multi-Scale, Participatory Approach to Developing a Protected Area Wetland Inventory in South Africa.Frontiers in Environmental Science i. 8:49.
doi: 10.3389/fenvs.2020.00049
• Roux, D., Clements, H., Currie, B., Fritz, H., Gordon, P., Kruger, N. and Freitag, S., 2020. The GRIN Meeting: A'third place'for managers and scholars of social-ecological systems. South African Journal of Science, 116(3-4), pp.1-2.
• Roux, D.J., Smith, M.K.S., Smit, I.P., Freitag, S., Slabbert, L., Mokhatla, M.M., Hayes, J. and Mpapane, N.P., 2020. Cultural ecosystem services as complex outcomes of people–nature interactions in protected areas. Ecosystem Services, 43, p.101111.
• Shikwambana, P., Taylor, J. C. ., Govender, D. and Botha, J. (2021) "Diatom responses to river water quality in the Kruger National Park, South Africa", Bothalia, African Biodiversity & Conservation, 51(1). doi: 10.38201/btha.abc.v51.i1.5.
• Skubel, S.A., Su, X., Poulev, A., Foxcroft, L.C., Dushenkov, V. & Raskin, I. Metabolomic differences between invasive alien plants from native and invaded habitats. Scientifi Reports, 10:9749. https://doi.org/10.1038/s41598-020-66477-w
• Smith, K. and Kraaij, T., 2020. Research note: Trail runners as agents of alien plant introduction into protected areas. Journal of Outdoor Recreation and Tourism, 31, p.100315.
• Steyrer, C., Miller, M., Hewlett, J., Buss, P.E. & Hooijberg, E.H., 2021, Reference intervals for haematology and clinical chemistry for the African elephant (Loxodonta africana), Frontiers in Veterinary Science, 8, https://doi:10.3389/fvets.2021.599387
• Sukhorukov, A.P., Kushunina, M., Reinhardt, C.F., Bezuidenhout, H. and Vorster, B.J., 2021. First records of Amaranthus palmeri, a new emerging weed in southern Africa with further notes on other poorly known alien amaranths in the continent. BioInvasions Records 10(1), pp.1–9. https://doi.org/10.3391/bir.2021.10.1.01
• Thurman, L.L., Stein, B.A., Beever, E.A., Foden, W., Geange, S.R., Green, N., Gross, J.E., Lawrence, D.J., LeDee, O., Olden, J.D. and Thompson, L.M., 2020. Persist in place or shift in space? Evaluating the adaptive capacity of species to climate change.
• Vermeulen, W.J., Geldenhuys, C.J., Esler, K.J., Syampungani, S. and Meke, G., 2020. Conceptual decision-making framework for the sustainable harvesting of forest and woodland species for medicinal tree bark in southern Africa. Southern Forests: a Journal
• Wernecke, B., Millar, D.A., Walters, M., Ganswindt, A., Dziba, L. and Wright, C.Y., 2020. 'Preventing the next pandemic'-A 2020 UNEP Frontiers Series Report on zoonotic diseases with reflections for South Africa. South African Journal of Science, 116(7-8)
• Wyborn, C., Davila, F., Pereira, L., Lim, M., Alvarez, I., Henderson, G., Luers, A., Harms, M.J.M., Maze, K., Montana, J. and Ryan, M., 2020. Imagining transformative biodiversity futures. Nature Sustainability, 3(9), pp.670-672.

Richtersveld

• Hawkes, P.G., 2020. A new species in the Tetramorium solidum-group (Hymenoptera, Formicidae, Myrmicinae) from the Richtersveld National Park, South Africa, with an assessment of threats and conservation status. ZooKeys, 965, p.55.
• Meregalli, M., Borovec, R., Cervella, P., Santovito, A., Toševski, I., Ottati, S. and Nakládal, O., 2021. The Namaini, a new weevil tribe with six new genera from South Africa (Coleoptera: Curculionidae: Entiminae). Zoological Journal of the Linnean Society, 142. https://doi.org/10.1093/zoolinnean/zlaa142

Multiple

• de Jager, D., Harper, C.K. and Bloomer, P., 2020. Genetic diversity, relatedness and inbreeding of ranched and fragmented Cape buffalo populations in southern Africa. PloS one, 15(8), p.e0236717.

Table Mountain

• Ebrahim, Z., de Villiers, A. and Measey, J., 2020. Assessing water conditions for Heleophryne rosei tadpoles and the conservation relevance. Koedoe, 62(1), pp.1-6.

Tankwa

• Kingsbury, C.G., Klausen, M.B., Söderlund, U., Altermann, W. and Ernst, R.E., 2021. Identification of a new 485 Ma post-orogenic mafic dyke swarm east of the Pan-African Saldania-Gariep Belt of South Africa. Precambrian Research, 354, p.106043.

• Márquez-Corro, J.I., Jiménez-Mejías, P., Helme, N.A., Luceño, M. and Martín-Bravo, S., 2020. The systematic position of the enigmatic rare South African endemic Carex acocksii: Its relevance on the biogeography and evolution of Carex sect. Schoenoxiphium (Cyperaceae). South African Journal of Botany, 113, pp. 475-483. https://doi.org/10.1016/j.sajb.2020.03.027
• Saaed, M.W., Jacobs, S.M., Masubelele, M.L., Samuels, M.I., Munch, Z. and Khomo, L., 2020. Fifteen-year resilience against further degradation of Succulent Karoo vegetation in South Africa. Journal of Arid Environments, 178, p.104152.

Appendix B: Conferences attended by SANParks staff

Ferreira, S. Feedback on rhino trends in Kruger. South Africa's Scientific Authority
Foden, W. Plenary talk: Preparing South African National Parks for climate change. British Ecological Society symposium: Protected Areas and climate change
Foden, W. Scientific evidence for changes in Aloidendron dichotomum populations: evidence to inform Red Listing. SANBI Red Listing workshop of four Arid Zone Aloe species
Foxcroft, L.C. Invasive alien species management: lessons learned from Kruger National Park, South Africa. SavaTIES 3rd online meeting. EU Danube Transnational programme
Kock, A. Running scared: when predators become prey. Marine and Coastal Educators Network Conference (Keynote)
Ramoelo, A. Combining machine learning and remote sensing techniques for grass condition assessment and monitoring 55th Annual Congress of the Grassland Society of South Africa (GSSA).
Ramoelo, A., Masubelele, M., Daemane, D. Reflection on Ecological Restoration. 5th 2020 Biodiversity Research and Evidence Indaba
Ramoelo, A., Masubelele, M., Daemane, D. Practicalities, Lesson Learned and opportunities. 5th 2020 Biodiver sity Research and Evidence Indaba
Smit, I. Management eras in the Kruger National Park through the lens of Strategic Adaptive Management. Keynote platform presentation to University of Pretoria Zoology and Entomology Department AGM
Smit, I. Wrap-up presentation at University of Pretoria Zoology and Entomology Department AGM
Smit, I. Kruger National Park Water Provision Policy. Kruger Induction Course
Smith, K. Sustainability of Protected Areas: Vulnerabilities and opportunities as revealed by COVID-19 in a Na tional Park Management agency. Conservation Symposium
Smith, K. Tsitsikamma MPA – Monitoring local community fishing. Biodiversity Working Group Meeting
Strydom, T. Fire Management and Research in Kruger National Park. Kruger Induction Course

Appendix C: Webinars organised by SANParks staff
Format: Name of webinar - type of webinar/date - audience

• The impact of the Covid 19 pandemic on tourism, conservation and communities - Webinar Series - C4 photo safaris webinar participants
• Drought in KNP: Surprising observations and lessons learned-Webinar for "Leadership for Conservation in Africa" (9 July 2020) - General public
• To move or not to move: Tourist perceptions on whale carcass management within a Marine Protected Area. - Webinar: Mossel Bay Marine Stranding Network (25 August 2020) - Members of the stranding network
• Running scared: when predators become prey - Webinar for the CRC Seminar series (6 Aug 2020) - General public
• SANParks' Climate Change Preparedness Strategy (300 participants) - Webinar: Honorary Rangers' seminar series - Honorary Rangers
• "Communities, Conservation, Covid and Compassion – engagement for people and wildlife" - Webinar Series, 15 July 2020 - SANParks Honorary Rangers, 500 pp directly, and additional thousands through facebook link
• Biodiversity for society: engagement for people and wildlife - Online webinar, 12 November 2020 - Bushwise Online Masterclass
• Global perspectives on wildfire management - Online Webinar, 27th Nov. 2020 - International academics and practitioners in Fire Management in 20 countries

• Sessions in the MPA shore break - Online webinar, 19 October 2020 - One Ocean Hub collaborators, Marine Social scientists and postgraduate students
• Elephant management in SANParks - Online webinar on 22 October 2020 - Honorary Rangers
• Combating Abalone Poaching in South Africa - Presented the historical context of abalone poaching in SA and interventions to combat poaching including protocols followed by the ECI. A research case study was presented for TMNP MPA followed by challenges to research and monitoring - Webinar, 10 Nov 2020 - U.S. National Park Service, California Department of Fish and Wildlife and South African National Parks
• Lessons and surprises from a drought in the Kruger National Park - Webinar - SANParks Honorary Rangers (close to 700 participants)
• Exploring conservation framings of staff and tourists: A case-study of reflexivity in South African National Parks. - Webinar - Interdisciplinary Conservation Network
• Results of the Living Planet report, with a particular focus on climate change - Webinar - Interdisciplinary Conservation Network hosted by ACCESS, SANParks and IUCN SSC CCSG
• Alien species and climate change management in Table Mountain National Park - Webinar - University of Hohenheim
• Restoring Rivers in the Kruger National Park - Webinar-Future of River Connectivity in Africa
• Biodiversity for society - engagement for people and wildlife - Webinar-Bushwise Master class
• Tsitsikamma MPA monitoring update and lessons learnt over a 3 year period. - Webinar - General public; MPA managers, scientists