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Society’s relationship with protected areas has evolved from a perception of parks as ‘islands’ protecting natural wonders, to an appreciation of porous boundaries, interdependencies and feedbacks between protected areas, surrounding landscapes and people. Scientific understanding has also shifted from a paradigm of ‘nature-in-equilibrium’ to accepting ecosystems as open systems which are often changing and regulated by natural disturbances. Furthermore, a gradual shift in conservation management practice from command-and-control and laissez-faire approaches to adaptive management acknowledges imperfect understanding and emphasises the importance of ongoing learning. These changing perspectives continue to shape the role of research and researchers in SANParks. Whereas researchers once functioned largely as natural historians in their parks, they now function as bridging agents, facilitating co-learning across multiple boundaries of science, management, policy and stakeholder groups.

Achieving SANParks’ research mandate relies on: (1) science and park management informing one another, and (2) collaboration with scientists, academics and research students from universities and research institutions in South Africa and abroad. Through the close partnerships between park management, in-house research and academic science, SANParks’ knowledge production is anchored in solving relevant problems and is exposed to new ideas and rigorous review. At any time there are > 350 registered research projects active across our parks. SANParks thus facilitates significant capacity development within South Africa and draws substantial international research expertise and funds into the country.

Purposeful learning with stakeholders and generating credible understanding are important operational tactics for SANParks. Science is an important component of learning, organised to produce information perceived to be reliable, relevant and legitimate. During 2014 SANParks’ research staff authored or co-authored 38 peer-reviewed journal articles across 31 scientific journals reaching national and international scientists. Furthermore, our scientists are catalysts for collaborative cross-disciplinary research collaborations which connect SANParks to a virtual workforce of researchers and students willing to address conservation problems. This is evidenced by the 153 peer-reviewed papers published during 2014 by external collaborators to SANParks.
Publication of a research paper is no longer the end point of a SANParks research or monitoring project, but the launch pad for influencing conservation policy, strategic organisational objectives, a park management plan and/or a management action. This process of integrating new scientific information with existing knowledge requires patience, respectful negotiation and empathetic listening which stretches SANParks’ scientists to also participate in value debates in the world of trade-offs.

This report is again a journey of learning and reflection within the group; a soupçon of activities, events, programmes and people that shape, effect and give personality to SANParks’ research profile. The highlights and overviews will hopefully also provide both inspiration and food for thought to the variety of readers from all groups that have a stake in our national park heritage.

As custodian of South Africa’s national park estate, SANParks relies on credible and robust science and research to contribute to the knowledge necessary to responsibly manage and conserve these assets for future generations in a rapidly changing world. SANParks’ science function aims to provide rational and critical thinking based on scientific knowledge for increasingly difficult management and policy challenges in conservation.
Scientific Services Staff Retiring from SANParks in 2014

Rina Grant and Harry Biggs

Drs Harry Biggs and Rina Grant have shaped SANParks’ social and ecological landscapes significantly over more than two decades. Their energy, passion and drive for knowledge continue to permeate thinking after their joint retirement in April 2014.

In 1990, while working in Namibia, Harry heard of a biometry support position in the then National Parks Board. Shortly thereafter a road accident immobilised him for weeks and with time to reflect, he decided to accept the new challenge. In February 1991 Harry, Rina and three small children moved to Skukuza, where they remained for 23 years. While Harry settled in fast, Rina’s initial experience of Skukuza was far from inspiring as she was expected to conform to the conservative female role prevalent in the National Parks Board of the 90s.

At that time Skukuza already attracted many researchers and Harry’s particular talent for science networking came to the fore. He soon reached beyond biometry into fruitful collaboration with external researchers. His determination to open the park to wider influences was controversial but favoured by ongoing political and paradigmatic change. He was quickly drawn to the Rivers Research Program with its exemplary programmatic approach. Inspired by C.S. ‘Buzz’ Holling and other international resilience scholars, Harry brought respect to Kruger National Park (NP) for its innovative application of resilience theory. Together with Charles Breen, Kevin Rogers, Sharon Pollard and many others, Harry blended theory and practice to develop the concept of Strategic Adaptive Management (SAM).

Harry will be particularly remembered for his role in the Andrew W. Mellon Foundation funding, which left a significant legacy in Scientific Services, as well as his contribution to adaptive collaborative governance of natural resources and his co-ordination of IUCN’s Freshwater Task Force. He spent significant time facilitating and mentoring, both of which he really enjoyed. Harry has authored or co-authored over 80 peer-reviewed scientific papers and inspired many publications by colleagues, including a special issue of Koedoe (2011) devoted to Strategic Adaptive Management.
Rina had to wait a long time for a position in Scientific Services, despite her qualifications as a vet and a researcher with a PhD. As a creative outlet, she developed entrepreneurial skills in the field of biodiversity-related publications. It was not until 2003 that Rina became part-time Programme Manager of the Kruger Park Marathon Club-funded Northern Plains Project. Sharing Harry’s talent for networking and science facilitation, Rina developed the programme to greatly improve understanding of the roles of fire and herbivory in Kruger NP. In November 2006 Rina was appointed by SANParks as Programme Manager: Systems Ecology. She authored or co-authored 68 peer-reviewed publications, including an influential paper with Mary Scholes on the role of nutrient hotspots as forage resources for grazers. Her co-ordination of monitoring the impact of elephants culminated in a report on the use of SAM to address the decline in large trees in Kruger NP.

Rina played an important role in Scientific Services, as team-player, sounding-board, knowledge integrator, idea generator and enthusiastic host to many. Her strong social engagement enhanced the AW Mellon-funded junior scientists capacity development and mentorship programme, through which she inspired and guided ten junior scientists.

Significant though their individual achievements are, Harry and Rina contributed a great deal as a team. Many SANParks colleagues benefitted from their combined support and mentorship. They both have a deep appreciation of the need for continuous adaptation and change in the face of complexity. Their own careers are inspirational in the way they adapted personally to meet emerging demands and opportunities. Their legacy will long be remembered.
Nick Hanekom

“Die wittebrood is verby” (the honeymoon is over) is a veiled threat that Nick received early in his SANParks career from a new manager after he had inadequately described the work he was doing. Not easily intimidated he recovered quickly enough from the threat but in his 32 years at SANParks, culminating with his retirement in November 2014, he never learned to blow his own trumpet.

Instead Nick went about his work quietly and efficiently. He really came to life in the field and in many respects, like a number of field ecologists, Nick in an office environment often reminded one of a caged bird.

Nick started his professional career as a research assistant/officer in the Zoology Department at Nelson Mandela Metropolitan University (NMMU), where he also obtained his MSc and PhD degrees in marine biology and estuarine ecology respectively. He initially worked as an estuarine ecologist concentrating on estuaries such as the Kromme, Sundays and Swartkops in the Eastern Cape.

His career in SANParks began at Tsitsikamma in 1982. At that time, organisational thinking was to place scientists in parks where they would become proficient as general ecologists and advise park management on a wide variety of environmental issues. Nick therefore re-treaded himself to become a general ecologist, equally at home in the marine, estuarine and terrestrial environments. As required of a marine ecologist Nick was also a qualified boat skipper and Class IV Diver.

After almost 10 years at Tsitsikamma, he transferred to the Rondevlei office of Scientific Services to be one of the founder members of the office in 1991. Although employed as a marine ecologist in SANParks and especially well known for his intertidal and subtidal rocky shore work, Nick also published on subjects as diverse as marine line fish, resource use of invertebrates in estuaries, terrestrial plants, reptiles, birds and the cryptic blue duiker – a diminutive forest-dwelling antelope.

The aspect of intertidal rocky shore work for which he is particularly well known concerns the alien invasive Mediterranean Mussel *Mytilus galloprovincialis* in the Tsitsikamma Marine Protected Area and Langebaan Lagoon. As one of the ‘100 of the world’s worst alien invasive species,’ Nick recognised it soon after it settled at Tsitsikamma and documented the growth of the population until it levelled off years later. Importantly he assessed the impact of the alien mussel on the surrounding intertidal fauna and flora, while considering options for control.
His encyclopaedic knowledge and knack for identifying plants and animals is widely known in Garden Route NP and the community generally, so it was not unusual to find people at the reception desk with pieces of vegetation or an assortment of creatures in jars and containers which they hoped to have identified. Nick obligingly did the identifications and in a similar fashion would provide data, information and ideas to colleagues and other scientists. This generous nature is one of the abiding memories that colleagues have of him and will miss.
Growing and Grooming the Science Function

SANParks' first ‘Grow & Groom’ event took place from 9-11 September in the Garden Route. The in-house initiative, designed around a social-learning approach, aims to promote the effectiveness, resilience and vitality of the SANParks science function and to ensure that this function is supported and enabled by the best possible operating environment. Approximately 40 staff members participated in this first event which focused on ‘thriving science in a conservation agency context’. This represented a valuable opportunity for knowledge sharing and general team building, and feedback from participants regarding their perceived success of the event was highly favourable. Highlights included the session on understanding individual strengths and the importance of variety and creating a productive environment and good future in our agency milieu.

Participants were welcomed to the first Grow & Groom event by Dr Howard Hendricks (Acting Manager Executive: Conservation Services), Prof Quinton Johnson (principal of the George Campus of NMMU – the venue of the event), and Ms Jill Bunding-Venter (Regional General Manager: Garden Route NP).
The Grow & Groom event was preceded by a one-day science publication seminar, attended by 22 scientists and facilitated by Dirk Roux, Llewellyn Foxcroft and Christo Fabricius (NMMU). The objective of the seminar was to reflect on the role and art of scientific publishing in an agency context. Discussion topics included: how, when and on what to develop a manuscript; the importance of, and suggestions for, carefully preparing the title, abstract and keywords; what constitutes ‘co-authorship’; plagiarism, science ethics and falsification; selecting a journal and understanding impact factors; the submission process (and dealing with submission anxiety); reasons why manuscripts get rejected; responding to the reports of reviewers (and dealing with criticism and possibly rejection); publication benchmarks and the h-index; and reviewing for journals.
Over 200 delegates from 72 institutions and 11 countries converged on Skukuza, Kruger NP to present findings on anthropogenic impacts on savannas (including climate change, land use effects, fragmentation, and tourism), multi-scale landscape patterns and processes, freshwater systems, vegetation patterns and dynamics, herbivores, wildlife diseases and large carnivores. Fifty nine platform presentations, 63 speed talks and 27 posters were presented.

The plenary discussion session considered recent science discoveries important for management, the identification of key knowledge gaps, monitoring essentials and critical science messages for protected area managers. Key conceptual insights gained include:

- the need to acknowledge legacy effects of previous management practices which influence longer-term patterns and affect predictive ability;
- the effectiveness of wildlife management as portrayed by the media is politically-biased;
- multi- and trans-disciplinary approaches are necessary to address key social-ecological knowledge gaps;
- better use of scenario tools will be critical for science to influence policy choices;
- effectively informing conservation requires reduction of data complexity, increased time allocation to turn information into wisdom, strengthened science-management integration and better communication.

Building understanding is facilitated by social interactions and networking which are key features of the meeting. Quotes from delegates were extracted from a post-conference feedback questionnaire.

“Overall a very well-run and informative conference”

“It’s a great way of expanding your knowledge and meeting people one would not meet in your day to day activities”

“It enables one to get a good feel for the overall state of research and a status report of conservation in RSA. It focuses thoughts and enables one to think of new avenues – complexity”

“Top savanna meeting in the world”

“Always a great meeting. I look forward to the next one but urge the organisers to consider inviting researchers to provide synthesis plenaries. Thank you to the organisers, a job well done”
The IUCN World Parks Congress is the definitive global forum for deliberating the achievements and potential of and challenges facing protected areas. The Congress is held every 10 years, setting the agenda for protected areas conservation for the decade to come. Sydney Olympic Park was the venue for the more than 6,000 delegates attending the 2014 Congress. Several SANParks staff members and researchers participated in the multitude of ceremonies, dialogues, symposia, plenary and stream presentations, poster displays and book launches. The diverse proceedings provided ample opportunity for knowledge sharing, generation of new ideas and networking.

‘Take home messages’ that were prominent throughout the proceedings include:

• **Protected areas provide essential biophysical support systems:** Scientists agree that protected areas established in the last century are becoming Earth’s biophysical support systems but that a fundamental increase in support for the global protected area estate is required to deliver on their potential. First, nations must recognise that protected areas are core to the future of life on our planet and incorporate this reality in their policies. Second, they have to commit sufficient resources to the effective management of protected areas. Current worldwide funding for protected areas is a fraction of global military expenditure.

• **Declining support and other challenges:** Conservation fatigue and -retreat seem to be widespread among governments globally with under-resourcing of protected area management common, particularly in the developing world. Corruption, poor governance, armed conflict and inefficient bureaucracies have alienated stakeholders and eroded support in many protected areas. Organised poaching and pressure to mine in protected areas are further drivers that pose a threat to the goals of the global protected area estate.

• **What to measure:** Celebrating the remarkable increase in number of protected areas and extent of land under protection can be misleading. The real question (and monitoring challenge) is how effectively protected areas contribute to protecting biophysical and cultural heritage, safe-guarding ecosystem services through protection of key ecological infrastructure, buffering societies against impacts of climate change and contributing to regional stability and resilience.

• **Aligning conservation and social objectives:** The societal view of protected areas is shifting, from islands of naturalness in a sea of destruction to integral features of larger social-ecological landscapes. Their existence now stems not only from an ecological rationale but also from economic and social rationales, with increasing emphasis on the role that protected areas should play in fostering economic development and achieving social equity imperatives. Growth of the green economy is seen as critical to achieving the above.
• **Connecting across borders:** Engaging the youth in conservation, extending community participation to include sustainable co-ownership of conservation efforts, and establishing conservation dialogues and partnerships with policy-makers, private business and civil society were important themes throughout the congress. In an increasingly connected world, conservation of the future might well be based on co-management arrangements and co-learning facilitated by adaptive management.

It is important for SANParks’ scientific function to take note of the above messages, align some of their research accordingly, and serve as a catalyst in pursuing the ‘Promise of Sydney’ (see http://worldparkscongress.org/about/promise_of_sydney_vision.html).
Science Communication Workshops, Cape Town and Skukuza

Inês Ferreira

**Not to communicate is to diminish the value of a research project**
(Source: Gascoigne & Metcalfe, 2012, Planning Communication into Science, Econnect Communication, Australia)

For myriad reasons scientists need to communicate their research. Attended by over 40 Scientific Services research staff and biotechnicians, two one-day Communication and media skills for research scientists workshops were held in December. The workshops were facilitated by Jenni Metcalfe (Econnect Communication) and Marina Joubert (Southern Science), and based on the particular science communication needs of the participants, as identified through a survey conducted prior to the workshop, and during the introductory session.

Reasons to communicate science (and examples of benefits to SANParks of doing so) include to:

- disseminate information to a wider audience about research in progress or findings of completed projects;
- influence policy;
- create awareness and educate, and change specific behaviour and attitudes;
- obtain information;
- forge useful relationships;
- gain support and cultivate confidence and co-operation;
- account for how public money has been spent;
- explain management decisions (for example, fire burns on Table Mountain NP and why they are necessary); and
- respond to concerns (perhaps even to initiate the discussion before concerns are raised).
Despite a few differences, relating to regional challenges, several key themes were common to both workshops: the value of communicating one’s research, the importance of ensuring relevance in one’s communication (as determined by the audience and objectives), and the need for clarity about objectives, roles and responsibilities so as to maximise the likelihood of desirable outcomes.
The Organization for Tropical Studies Celebrates 10 years of Science Achievements in SANParks

Karen Vickers, Samantha Mabuza & Laurence Kruger

2014 marked the tenth year of operations by the Organization for Tropical Studies (OTS), South Africa. Originally a small group tasked with running a single undergraduate ecology programme, OTS-SA has grown into a dynamic organisation that prepares young South Africans and Americans for future scientific careers encompassing both the environmental and health sciences. At the same time, we support the development of SANParks’ junior staff members as well as postgraduate students and research interns through mentorship and project supervision both during and between the regular course semesters.

Accomplishments

Our ten-year review process synthesised our achievements and future growth plans indicating the substantial impacts that the programme has on human capital development (Table 1). Most of those we have educated and employed have gone on to pursue postgraduate studies or careers in the environmental sector. Additionally, OTS-SA is now registered as a non-profit educational organisation in South Africa and is a principal partner in the new Skukuza Science Leadership Initiative. OTS has raised over R5 million for a new facility at Skukuza that will accommodate further training opportunities for young South African scientists. Our success however, could not have been achieved without the support of SANParks, especially the Scientific Services department in Skukuza.
**Table 1:** A summary of the Organization for Tropical Studies’ current activities and beneficiaries over the ten years of operations in South Africa. NSF = National Science Foundation.

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<td>African Ecology</td>
<td>Biannually since 2004 (21 semesters completed)</td>
<td>366 USA (27% have returned to SA for further research/education) 80 RSA (including 5 SANParks junior scientists)</td>
<td>18 lecturers 22 teaching assistants 3 logistics managers 3 seconded SANParks game guards</td>
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<tr>
<td>Global Health</td>
<td>Biannually since 2011</td>
<td>160 USA 7 RSA</td>
<td>5 lecturers 3 teaching assistants 3 logistics managers</td>
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<tr>
<td>NSF-funded International Research Experience for Undergraduate Students</td>
<td>Annually since 2009</td>
<td>27 USA 4 SANParks junior scientists</td>
<td>2 funded academics 5 volunteer academics</td>
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<td>Postgraduate Mentorship</td>
<td>Continuous</td>
<td>16 research interns 18 Honours projects 8 MSc students 5 PhD students</td>
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<td>Research Products</td>
<td>Continuous</td>
<td>12 published papers in peer-reviewed journals 21 internal research reports 4 NSF research reports</td>
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**Relevant science as SANParks partners**

One of the advantages of calling Skukuza "home" is the close interaction with Scientific Services which results in the strategic focus of our research efforts being aligned with SANParks’ ecological knowledge needs. Through the establishment of our Kruger Long-term Research Initiative we aim to help answer some complex management questions. One such example is our ongoing study of the population dynamics of large trees, to resolve questions about their demographic bottlenecks at different life stages, the dispersal and fate of their seeds, and their resilience in the different life stages to disturbances. By tagging, measuring and revisiting individual trees across years we are obtaining comprehensive information on survival and life-stage transition rates and therefore on how they are coping with current disturbance regimes.
A student measures bark thickness as part of her research on large trees in Kruger NP; to gain better knowledge of tree survival rates our research focuses on individuals at various life stages including seedlings (inset). While many other once-off studies are demonstrating that large trees are being lost at unsustainable rates (e.g. see Asner & Levick 2012) our data suggest that many species have evolved strategies to cope with disturbance, either through recovery or through seed dispersal mechanisms but this can only be fully understood by monitoring trees at broad temporal and spatial scales.

References

SANParks’ Junior Scientist Programme

Stefanie Freitag-Ronaldson, Samantha Mabuza, Tercia Strydom, Nolubabalo Tantsi, Thabang Sibiya & Nosipho Tyagana

The junior scientist mentorship and capacity development programme is one of SANParks’ strategic initiatives aimed at attracting, developing and retaining postgraduate researchers from historically disadvantaged backgrounds. Funded by the AW Mellon Foundation, SANParks and now also with donations from the Honorary Rangers, the programme is in its 12th year with 15 candidates having been associated with the programme. Students passionate about combining an academic advancement with a scientific career in conservation are exposed to the workings of SANParks and applying science to conservation management needs. In order to grow an understanding of the requirements to be a protected area agency scientist, candidates are encouraged to expand their horizons, challenge their perceptions and grow their confidence while engaging intensively and extensively with SANParks’ scientists and a broad spectrum of science-management activities. Success factors include critical mass and capacity (of junior scientist candidates and science mentors), broad exposure to SANParks’ research culture and passion for a science career in conservation.
The Junior Scientist Programme shrunk during 2014 with the untimely passing away of Mr Kevin Deenadayalan and the resignation of a second junior scientist, Ms Nashreen Williams, to pursue family business interests. Five motivated students remain on the programme: Tercia Strydom, Samantha Mabuza, Thabang Sibiya and Nolubabalo Tantsi based in Kruger NP, and Nosipho Tyagana based out of the Cape Research Centre (CRC).

Reflections of some junior scientists in their own words…

Samantha Mabuza: working on large tree recruitment and encouraging scientists to tweet their science. “Since becoming a junior scientist in 2013 I have had the opportunity to engage with people whose work I read and admire. Although the past two years have been an emotional rollercoaster, sharing a house and experiences with fellow junior scientists, and being part of a team that values your opinion and contributions has had a positive impact on how I see myself as a young scientist. One highlight has been working with young pupils through a mentor programme hosted by South African Environmental Observation Network (SAEON). My plans are to complete my MSc and start a new adventure, which may include pursuing a doctorate, contributing more to community outreach and making a contribution to science through my work.”

Tercia Strydom: a role model and inspiration while working towards a PhD in hydrology. “In 2011 I left my parental home in Cape Town to join the junior scientist programme in Kruger NP where my young career was jumpstarted. Fortunately I soon became acquainted with fellow anxious junior scientists where strong friendships rooted in much more than just mutual academic pursuits have budded over the years. I have experienced many highlights which include completing my MSc in hydrology, publishing my first Water Research Commission report under the guidance of my supervisors, and winning Best Student Presentation at many conferences, including at an international symposium in Lithuania in 2013. In the next few years, I hope to complete my PhD and remain part of the dynamic, inspiring and vibrant department that is Scientific Services.”
Thabang Sibiya: passionate about natural sciences and currently studying riparian geomorphology and invasive aliens. “I joined SANParks just after varsity and Kruger was always my first choice. Since joining the programme in 2013 I’ve grown immensely under the guidance of Kruger scientists, have had the liberty to experience the amazing work Kruger undertakes, plus I’ve had the opportunity to rub shoulders with some of the most dedicated, passionate and celebrated scientists in conservation. Kruger has been a wealth of inspiration; I feel blessed to have been given the chance to make my mark on a world renowned research hub. Spearheading my own research ideas is my greatest high and my low has been the shuffling of friends. In the coming years I hope to have finished my masters and be working on a PhD on landscape interactions.”

Nolubabalo Tantsi: exploring possibilities and parks. “I joined the junior scientist programme in November 2011 while polishing the last chapters of my MSc dissertation. After graduating in 2013, I became involved in various projects, such as rehabilitation and restoration, tree surveys, veld condition assessments and post fire surveys, which have provided a great opportunity to rub shoulders with some of the most dedicated, passionate and celebrated scientists in conservation. I am currently working with the rhino team, researching the effects of media reports on rhino poaching and helping with rhino monitoring. This has been a humbling experience as it shows how much work is still needed to turn the tide. I hope to pursue a PhD on rehabilitation and restoration of degraded and/or alien plant invaded areas within protected areas.”

Nosipho Tyagana: learning across research nodes. “I started my journey with Scientific Services in Kruger NP in 2011 as an in-service student, and transferred to the CRC in 2012 when I joined the junior scientist programme; the programme has been a great learning opportunity. I’m currently making progress with my studies in Nature Conservation, managing the CRC library, learning to manage my own projects and working with reputable SANParks staff and external researchers. Last year I visited Garden Route NP to learn from their experiences and research. I also attended a science communication workshop where I picked up valuable tips on improving my writing skills.”
Benefit Sharing and Resource Use

Research and monitoring in support of sharing the benefits of biodiversity more effectively

Louise Swemmer

Why and what are benefits?

Protected areas globally are mandated with biodiversity conservation, both for intrinsic or moral reasons, as well as for the benefits that society derives from nature. These benefits are diverse and are viewed differently by various stakeholder groups. Benefits include ecosystem goods (e.g. food, freshwater, medicines, building material and livestock fodder), regulating (e.g. climate regulation, erosion regulation) supporting (e.g. waste treatment, pollination, primary production) and cultural services (e.g. spiritual enrichment, aesthetic experience, ecotourism, heritage and wilderness). Non-ecological benefits include employment, economic opportunities, development and growth, awareness, education and capacity building. All contribute in their own way towards human well-being which incorporates components of material, physical, social, spiritual well-being, security and freedom of choice (Fig. 1).

Benefit – Any interaction with the natural environment in and around protected areas that has a positive impact on well-being.

In many cases, benefits are accompanied by costs. These costs relate to the negative consequences of parks or the activities therein on human well-being or the natural environment. Balancing costs with benefits both within and between stakeholder groups and between stakeholders and the environment requires a process during which trade-offs between different types of outcomes can be evaluated. It is in making these trade-offs that benefits are effectively shared.
Figure 1: Benefits (interactions impacting positively on human well-being) from the SANParks system that are accrued by society at large through formal or informal association with SANParks projects and programmes.

**Benefit Sharing** – The process of making informed and fair trade-offs between social, economic and ecological costs and benefits within and between stakeholder groups, and between stakeholders and the natural environment in a way that is satisfactory to most parties.

Costs and benefits accrue at various levels, often simultaneously, yet are seldom assessed together and the collective impact is almost never acknowledged nor measured. Balancing costs and benefits is a critical component of sharing benefits and in so doing, in managing relationships. It requires a holistic approach that enables assessment at both an organisational as well as a project level (Fig. 1) through a process of making trade-offs at multiple levels (e.g. aesthetic gain from having the Big 5 versus livelihood cost when Damage Causing Animals escape from parks causing damage to crops or killing livestock).
Who decides who benefits and how?

Due to contrasting stakeholder perceptions driving the value different people place on various benefits, not all benefits are feasible, appropriate, legitimate or desirable in all parks. The park-specific social, economic, ecological, historical, stakeholder and local context plays an important role when prioritising or planning benefit sharing arrangements for individual parks with stakeholders (Swemmer et al. 2015). Effective stakeholder engagement, co-development of objectives with stakeholders and collective and participatory monitoring and evaluation can contribute towards enabling conservation decision makers to see benefit needs through a multi-stakeholder lens. Doing this is a critical part of being able to facilitate the accrual of appropriate and fair benefits at various levels, which is believed to lead to a stronger conservation constituency.

Historically, benefits from protected areas were not shared by all. Fortress conservation efforts characterised by successful conservation of biodiversity and promotion of tourism and pristine wilderness in the absence of people simultaneously imposed restrictions on access to land and natural resources. Many parks in South Africa have such histories and as a result, SANParks has made a concerted effort since the mid-1990s to engage with and provide more benefits to neighbours. In reality, however, the outcomes of community-based approaches all over the world have been and are both positive and negative, specifically in terms of who gains and who loses, at various scales.

Monitoring, indicators and feedbacks

Implementing monitoring enables the assessment of the degree to which project and programme objectives have been met. A major challenge in monitoring the benefit sharing objectives includes the difficulty in defining clear indicators for qualitative outcomes, especially in a culture where tabulated performance and audit charts call for a more quantitative approach. One consequence of the latter approach is that performance review and target setting are driven by numbers as opposed to the outcomes of objectives (e.g. number of resource use projects versus an assessment of the social and economic benefits and costs). Currently SANParks is experimenting with applying SAM to people objectives through park-specific projects involving resource use, human-wildlife conflict and employment relating to the Expanded Public Works Programme. Although applying SAM in this context has shown to be incredibly valuable, effective SAM requires resources as well as capacity – and this remains a challenge for its implementation.

Going forward

Two significant organisational level issues need attention if SANParks is to apply the principles of environmental justice towards the effective and fair sharing of biodiversity benefits (that will have the required positive conservation and human well-being outcomes): First, the number of local beneficiaries needs to increase. Although there are
an increasing number of initiatives aimed at benefiting rural neighbours, tourists remain the major beneficiaries, while rural communities bear the bulk of the costs (human-wildlife conflict, wildlife/livestock disease, etc.). Second, co-ownership and mutual partnerships between conservation authorities and stakeholders are required. Creating fair and equal partnerships with neighbours, where benefits are co-defined, implementation and monitoring processes are developed with stakeholders and responsibility is shared throughout, should be key focus areas.

Finally, making the trade-offs between income generation (which is an increasing reality as government funding for conservation dwindles) and sharing tangible and high impact benefits with stakeholders to make a large scale difference shall remain a challenge going forward.

References
Frequent but erratic outbreaks of mopane worms represent important opportunities for local communities neighbouring Kruger NP who rely on the worms as a protein resource and income supplement. According to the results of a project undertaken to understand the factors influencing these outbreaks, rainfall and soil depth are important drivers of mopane worm outbreaks in Kruger NP. Additional surveys are necessary to better understand these and other factors influencing outbreak dynamics, and to ensure harvesting continues to be sustainable.

Investigating factors influencing the outbreak of mopane worm (*Imbrasia belina*) in Kruger National Park

*Mopane worms, the larval stage of the mopane moth, *Imbrasia belina*, are an important protein source and income supplement for many indigenous people of southern Africa. They are well-known in the Lowveld for frequent eruptions across mopane-dominated vegetation types, where they are central to the livelihoods of local communities. The erratic nature of outbreaks prompted communities neighbouring Kruger NP to seek harvesting privileges inside park boundaries during periods of low mopane worm yields outside the park. Their request was granted for consumption harvest, with the proviso that further research be conducted to understand the ecology of these outbreaks. As such, SANParks implemented a research project to identify the dominant ecological factors influencing mopane worm outbreaks in Kruger NP. The project focuses on understanding the distribution of mopane worms and the abiotic and biotic factors that may be influencing the outbreaks.

It is widely accepted that outbreaks are restricted to mopane-dominated vegetation types, which in Kruger NP occur north of the Olifants River. Accordingly, project sample sites were replicated across sink and source plant communities: (1) sink plant communities – where outbreaks never occur, and (2) source plant communities – where outbreaks have historically always occurred (Fig. 1). Transects were surveyed to determine dominant habitat characteristics.

**Preliminary results**

Outbreaks are largely influenced by the amount and seasonal timing (early, mid or late summer) of rainfall. In 2013, relatively high rainfalls (April to December) triggered outbreaks in all source sites with no outbreaks recorded in the sink sites. No outbreaks were recorded in either source or sink sites during the lower rainfall conditions of 2014. A conditional inference tree of habitat characteristics and rainfall indicates that rainfall and soil depth are important drivers of mopane worm outbreaks. Rainfall is the major driver, in that mopane worms are significantly absent from areas where rainfall is ≤ 96 mm. In areas with > 96 mm of rainfall however, mopane worms are significantly present where soil depths are < 0.2 m. More detailed soil depth and texture information is required to fully understand these results in the context of mopane worm research in Kruger NP. Surveys will continue with the addition of further habitat characteristics to help disentangle environmental drivers, and mopane worm harvest amounts to understand resource limits.

Read about SANParks’ adaptive management approach to benefit sharing on page 20.
Figure 1: Kruger NP map showing the distribution of mopane-dominated vegetation types in different shades of green and those without mopane plant species in lighter pastel shades. Known sink communities are marked with red and source communities with blue outlines. Final sample site replicates are indicated with red (sink) or blue (source) squares.
Benefits accrued through participatory research in Langebaan Lagoon Marine Protected Area, West Coast National Park

Mbulelo Dopolo

By collaborating with the Langebaan gillnet fishermen, SANParks scientists have gained valuable knowledge about the resources being harvested in the lagoon. This information is integral to improving the current management of the lagoon. By connecting and building trust with the Langebaan fishing community SANParks is enhancing inclusivity in evaluation of resource use impacts and thus the legitimacy of science-based management decisions.

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Harvesting of living marine resources is inextricably linked to the cultural and economic identity of the people of Langebaan, West Coast. Depending on the manner in which fish are sold, gillnet fisheries generate between R 220,000 and R 1,3 m per annum in revenue, of which approximately 40% is distributed among different role players, such as bakkie mates, petrol suppliers, boat owners, and thus play a crucial role in local economy.

Fishery research focuses primarily on observation rather than experimentation. This is because in most cases, it is not possible to have controls or repeat observations. To date there has been a lack of in situ observational research on gillnets fisheries, including the one in Langebaan Lagoon, to enable spatial management regimes informed by empirical evidence. This has been due to limited funding and possibly reluctance by gillnet fishermen to provide spatially explicit information about their catches to the Department of Agriculture, Forestry and Fisheries (DAFF). The participatory research initiated in July 2010 between SANParks and Langebaan Lagoon gillnet fishery rights holders paved the way to acquire such critically important observation data on this fishery to help improve its management.
Based on knowledge gained through this research, four fish species have been recorded for the first time in the lagoon namely: pinkie or olive grunter *Pomadasys olivaceum*; two-tone fingerfin *Chirodactylus brachydactylus*; silverfish (also known as carpenter) *Argyrozoa argyrozona*; and jutjaw *Parascorpius typus*. In addition, we recorded ripe and running sea barbel or white seacatfish, *Galeichthys feliceps*, and flathead mullet or springer, *Mugil cephalus*, neither of which had been previously reported in the lagoon. Furthermore, the information obtained from this participatory research has substantially improved our understanding of the harder (gillnet fishery) dynamics in relation to space and time for both target species (harders or mullets), and non-target species (those which get caught accidentally). This will provide justification for any changes in current management regime for the fishery.

As a result of the collaboration between gillnet fishermen and scientists, valuable information about some of the resources being harvested in the Langebaan Lagoon has been gained. The data collected represent well over 2 000 fishing trips equivalent to the same number of boat days to which the fuel and labour costs incurred by the fishermen must be added. The estimated cost of conducting the research independently over a period of 3 years is over R 2.5 million. Through the collaborative approach taken, SANParks and the fisheries authority (DAFF) have made huge financial savings in terms of research running costs by just paying a fraction of the actual costs. More importantly, forging relations with the gillnet fishermen, and cultivating trust among the fishing community in fisheries scientists will further help to enhance legitimacy for and acceptance of the management decisions based on science.
Can medicinal bark be stripped sustainably from *Ocotea bullata* and *Curtisia dentata* in the indigenous forests of the Garden Route?

Ntombizodwa Ngubeni, Wessel Vermeulen & George Sass

**Resource use in SANParks**

The importance of resource use in national parks is imbedded in SANParks’ mission “To develop, expand, manage and promote a system of sustainable national parks that represents biodiversity and heritage assets, through innovation and best practice for the just and equitable benefit of current and future generations”. This includes both consumptive and non-consumptive use of natural resources from national parks. Sustainability is of overriding importance, and has the associated challenge of finding a successful equilibrium between resource exploitation and maintenance of viable populations of species that are harvested. To achieve this, resource use needs to be supported by sound, goal-orientated monitoring of the socio-economic and ecological dimensions of sustainability, with due consideration of stakeholder needs and compliance with relevant internal policy, legislation and international conventions. The SANParks Resource Use Biodiversity Monitoring Programme outlines monitoring approaches related to the extractive use of natural resources from national parks.

**Research overview on species response to bark harvesting and management implications**

It is estimated that up to 72% of black South Africans, both in rural and urban areas, use medicinal plants for primary healthcare, consuming 70 000 tonnes of plant material each year, with at least 134 000 income-earning opportunities generated by the trade of medicinal plants (Mander et al. 2007). *Ocotea bullata* (stinkwood) and *Curtisia dentata* (assegai) are among the 69 species reportedly used for medicinal purposes in the Garden Route. *Ocotea bullata* bark is used medicinally to remedy headaches and urinary diseases, as an emetic for emotional and nervous disorders and for treating diarrhoea. The bark of *C. dentata* has been reported to be traditionally used for stomach ailments, diarrhoea, as a blood strengthener and aphrodisiac, and to treat pimples.

The exploitation of plants for medicinal purposes has a variable effect depending on the parts harvested. Harvesting of bark and roots has been reported to be particularly damaging in terms of tree survival (Vermeulen et al. 2012). The wounding of a tree exposes it to pathogens and may disrupt physiological processes. Internal stresses caused by wounding may lead to progressive or instant death depending on the extent of harvesting. The lack of quantitative data on the ecological impact of bark harvesting hinders the identification of sustainable harvest levels and the development of sustainable harvesting methods/systems to avoid species overexploitation.

To gain a better understanding of bark regrowth and the ecological consequences of bark harvesting on *O. bullata* and *C. dentata*, an experimental bark harvesting project...
was established in the Garden Route in 2001. The research aimed to determine: (1) tree response to harvesting in terms of bark regrowth, (2) decay consequences, and (3) factors that favour or impede bark regrowth and spread of decay.

The experiment involved 89 trees of *O. bullata* and 90 of *C. dentata*. Bark was harvested experimentally in vertical strips of different strip widths from trees of different diameter classes, and during different seasons. Measurements of variables such as bark regrowth and susceptibility to fungal and insect attack were taken over a ten year period (2001-2012). Twenty of the bark-stripped trees were felled ten years after treatment, wood discs collected and Computer Tomography image analyses conducted to assess anatomical consequences of bark stripping.

The species-specific response to bark harvesting showed good bark regrowth and minimal decay of *O. bullata*. Wood decay was found to be confined to the wound area, with no reported spread of decay to the rest of the bark-stripped stem. The positive correlation between tree diameter growth and rate of wound occlusion allowed for the formulation of a preliminary model that will assist forest managers in the formulation of bark harvesting prescriptions. Furthermore, smaller-diameter trees showed poor bark regrowth and a significantly higher mortality compared to trees with larger diameters, which suggests that a minimum tree size for harvesting needs to be stipulated in the harvest prescriptions. Wound width and season were found not to influence the wound occlusion progress. Good bark regrowth and the species’ ability to contain decay indicate a good potential for bark harvesting of *O. bullata*, which could be a viable management option in multiple-use forest management.

In contrast, *C. dentata* showed poor bark regrowth and a high extent of decay in stems following bark stripping, with decay invading the central portion of the stem and extending well above and below the wound. A significantly higher mortality of bark-stripped trees was also found. Poor performance of this species renders it unsuitable for bark stripping as a sustainable method of harvesting. Alternative bark harvesting strategies need to be explored for *C. dentata*.

**References**


Australian blackwood management in the forests of Garden Route National Park  
Lizette van der Vyver & Diba Rikhotso

The alien tree, Australian blackwood (*Acacia melanoxylon*), was introduced in the southern Cape's forests in the mid-1800s. From 1968 to 1973 blackwood was actively planted in forest gaps for the commercial furniture industry. Today the alien tree is well established in the southern Cape's indigenous forests and its surrounding open areas.

Blackwood trees growing in the forest interior generate better quality grain timber compared to those growing on the outside of the forests. As a result, forest interior blackwood has become a sought-after resource for the local timber industry, and is used for high quality furniture. Although the indigenous timber species such as yellowwood and stinkwood are still the most sought-after and more expensive timbers, due to its large available volumes, blackwood has become the highest income-generating timber species. This presented a challenge to Garden Route NP management – on the one hand blackwood provided valuable timber, on the other hand, it represented a potential risk as an alien invasive species. In 1997, Scientific Services and park management staff jointly developed the Blackwood Management Plan drawing on the blackwood's invader qualities as well as its economic value as a basis. The plan aimed to provide an ecological benefit by controlling blackwood as an alien invader, and an economic benefit by optimally using it as an available timber resource. Consequently, trees in the forest interior were not actively controlled but allowed to grow to maturity to yield good quality timber.

In contrast, in areas more prone to invasion (forest margins and riverine areas), the trees were actively controlled. The blackwood management system therefore involved zonation of the forest into two different zones with different management prescriptions and objectives for blackwood eradication and harvesting.
This dichotomous approach generated controversy as some felt that blackwood should be treated as an alien species in all areas and therefore also be actively controlled in the forest interior. The decision making process for the proposed blackwood management actions, however, relied heavily on previous findings which indicated that although blackwood is an aggressive invader in open or disturbed forests (including ecotones and riverine areas), it is not an aggressive invader in closed, evergreen forests (Geldenhuys 1996). These findings suggested that under a management system that utilises blackwood as a timber resource, the blackwood populations in the forest interior would eventually stabilise at a level of low ecological impact. A condition for the plan’s approval was that blackwood population responses be monitored as part of a 10-year monitoring programme. This programme set out to gather information on which future blackwood management decisions could be anchored and policies re-assessed. It addressed blackwood population dynamics and blackwood incidences of spread.

Re-measurement of monitoring plots took place between 2009 and 2012. The results indicated that forest interior blackwood populations responded differently across the forest landscape. Although some low-density blackwood populations in larger forest patches in the park seemed to have stabilised, other populations occurring at high densities in smaller forest patches were on the increase and often showed successful recruitment during the last decade, even after large-scale blackwood timber off-takes. Across all the areas combined, the forest interior blackwood population increased at 3.5% per annum.

An expanding blackwood population in the forest interior is a serious concern, especially considering its potential to upset forest dynamics and natural disturbance regimes. Mature blackwood trees in the forest interior have large emergent crowns, greater crown volumes than dominant indigenous species and very shallow root systems. They are therefore more prone to windfalls and could cause larger gaps than indigenous species. The monitoring data supported some of these concerns, showing that blackwood had much higher windfall incidents than the indigenous tree species. They also showed that large wind-felled blackwood trees would often fall on and knock over indigenous trees, which in turn substantially increased the windfall rates for most of the indigenous tree species. Therefore, under the prescribed management action, by allowing blackwood trees to mature in the forest interior, more time was given for blackwood trees to fall over and interrupt or alter natural forest dynamics patterns. An expanding forest interior blackwood population, in concert with its windfall patterns and management practices that allow blackwood trees to mature, could therefore gradually create a more suitable habitat for blackwood regeneration, and if so, would have an undesirable impact on the forest system.

Related
Read about the reintroduction of indigenous plant species as alien pine trees are removed from Tokai forest on page 47
In a meeting attended by Scientific Services and management staff in 2014, the blackwood monitoring results were presented. Consensus was reached that blackwood will, in future, be treated as an alien species and not be allowed to grow to maturity in the forest interiors. The blackwood management plan has since been adapted accordingly.

The development of the Blackwood Management Plan, the subsequent monitoring as well as the decision to alter the plan’s management actions were undertaken by working teams involving both management and science staff. The monitoring programme was crucial in providing the feedback needed to assess our own management actions, and the interfacing between the scientists and managers was imperative in adapting our actions for a more positive conservation outcome.

References
If a fisherman could catch fish, how many fish would a fisherman catch?

Kyle Smith

Ask any recreational angler how their catch rates have changed over the years and the majority would say that they have decreased. Ask them why this has happened and most would say something about commercial trawlers or subsistence fishermen; very few would acknowledge that recreational fishing in general could be having a negative impact. In fact less than 2% of the 260 anglers interviewed in the Garden Route thought that recreational anglers’ catches could have an impact on fish populations. For most, it seems inconceivable that their catches could be having an influence on fish populations. “How could I be having an impact? I haven’t caught a fish for the last month. It can’t be recreational anglers, we don’t catch enough [fish], it must be the big commercial fishermen. They are the ones raping our seas,” explains one angler we interviewed on Knysna estuary.

If one looks superficially at individual catch rates (the number of fish caught per angler hour) for coastal and estuarine anglers in the Garden Route, the first impression may be the anglers are correct. Over a two year period (2010 to 2012) anglers along the Wilderness/Sedgefield coastline caught on average only one fish for every 10 hours of angling effort. The catch rates of their compatriots fishing along Natures Valley (adjacent to the Tsitsikamma Marine Protected Area), even though considerably better, on average one fish every five hours spent fishing, were similarly not very good.

However, it’s not an individual’s catch today that causes the problem; it is the cumulative catch of all anglers over the last few decades. For instance, aerial surveys conducted by SANParks during 2009 between Tstisikamma and Wilderness indicate an annual fishing pressure of around 50 000 angler outings (Smith et al. In press). That represents a great deal of individual fishing trips in just one year, and along only a small section of the coastline.

But this is only part of the story. Contrary to what one might expect (in particular with the increasing awareness and promotion around catch and release), we are also finding that even though most anglers are recreational, retention rates are high, with over 70% of all fish caught being kept (sometimes as much as 85% within our estuaries). Furthermore, a high proportion of the retained catches measured have been undersized (below the species-specific minimum legal size limit). By retaining undersized fish anglers are effectively undermining the usefulness of our fishery regulations. A possible reason for this non-compliance could be that roughly half the anglers interviewed did not know the correct regulations for the fish species they were trying to catch.

Coastal and estuarine resources are under pressure in part due to angler behaviour. Increasing our knowledge of underlying behavioural drivers and taking cognisance of the social and economic incentives of anglers is essential in determining effective management strategies that will ensure park objectives are met and fish stocks remain sustainable.
Although ignorance of the laws is not a valid excuse, lack of access to the regulations was raised as a concern by some anglers. To increase the availability of information, SANParks developed a set of pictorial fishery regulations signboards that were erected at popular fishing spots in 2011. The signboard designs were made freely available and a number of municipalities and conservancies have since utilised them. Although it is difficult to evaluate the impact of these information boards it is always gratifying to see someone taking an interest in them and on one occasion I witnessed a son correct his father on the size limits of a fish stating “I saw it on the signboard at the mouth”. During 2011 and 2012 Garden Route NP also held a number of workshops with park rangers and Working for the Coast teams to create awareness around our marine environment and in particular our local fish. The next step would be to take the awareness programme outside of SANParks to the anglers.

It is quite clear that there are problems within our estuarine and coastal fisheries and we need to gain a better understanding of the factors driving angler behaviour and anglers’ fishing expectations. Questions being looked at include: what are angler motivations for going fishing (i.e. what do they want), what factors influence site selection choices (i.e. why do anglers fish where they do), and what influences fishing trip duration?

Recreational fishing is still a very popular pass time along the Garden Route with some people specifically visiting this area to go fishing. As explained by one angler “We started fishing here about 15 years ago and have been coming back for our annual holiday ever since. It’s a beautiful area and every year we catch a couple of grunter and white steenbras”. Within this one statement there are already clues as to why anglers go fishing. There are most certainly those anglers who have catch-related motives, for example the desire to catch a large or trophy fish. But there is also a range of social and setting-type motivations such as the desire to be in a beautiful area and share it with friends and family. For these anglers catching a fish may be seen as a bonus rather than the desired outcome and may partly explain why recreational fishing is still popular despite a national decline in fish populations and corresponding decrease in catch rates.

A second possible reason for why recreational fishing remains so popular could revolve around the concept of shifting baselines, which basically describes an intergenerational change in reference points (in this case the number and size of fish caught). For example, the baseline for the anglers interviewed above was 15 years ago, when they first started fishing in this area, whereas the reference point for someone who starts fishing today would be the current size and number of fish caught.

However, anglers’ expectations may be raised through the reporting of catches within local newspapers. In analysing 70 years of trophy fish catches reported in a local Garden Route newspaper, a recent study showed that apart from poenskop, which showed a size and catch rate reduction (Fig. 1), there was low variation in the average biggest catches...
of other top species caught along the Garden Route (Barendse et al. 2014). The reporting of large specimens being caught may in fact contribute to artificially maintaining a size baseline, raising anglers’ expectations of landing “the big one”, and thus keep them coming back for more, despite populations and average size actually declining.

Figure 1: Average weight ± standard error (kg) (blue) and total number of poenskop with weights (red) reported within a local Garden Route newspaper over seven decades. By the mid-1980s this species had all but disappeared from shore anglers’ catches. Inset: Poenskop are endemic to South Africa, and grow very slowly with a maximum recorded age of over 45 years.

There is clearly a need not only to increase our understanding around social dynamics within coastal and estuarine fisheries but for increased communication and engagement between conservation management, scientists and anglers to reduce conflicts, increase awareness of fishing regulations, and ultimately improve the sustainability and value of these fisheries. So if a fisherman could catch fish how many would he catch? Well, the short answer is it depends on the fisherman.

References
Knowledge Consolidation

State of Knowledge reporting in Garden Route National Park
Jessica Hayes & Ian Russell

A State of Knowledge (SOK) report has been compiled for Garden Route NP. State of Knowledge reports are a mechanism for documenting and summarising existing scientific information relevant to national parks. The need for such reports arose as a result of the difficulty experienced by many people working in certain national parks in becoming familiar with the body of past scientific work, and accessing available scientific information. The SOK report does not provide extensive summaries of all the available literature, but rather provides introductions to topics covered in published papers and reports relevant to the particular park. All information is referenced so that further reading can thus be undertaken if required. As such it helps to improve awareness of the information relevant to park management, planning and research that is available from various published sources. Although initially developed primarily for SANParks personnel, it has become apparent that SOK reports have much wider appeal and use, particularly by the general public and overseas-based scientists who have difficulty in accessing local grey literature and reports.

There is no specific approach to or method for compiling SOK reports. However it should be recognised that there are certainly associated challenges with doing justice to the literature and capturing all relevant material during the process.
Scientific Services in the Garden Route had previously compiled SOK reports for six parks in the Western Cape, including the previously autonomous Tsitsikamma and Wilderness NPs, and the Knysna National Lake Area. In earlier drafts the summarised information dealt largely with aquatic ecosystems, predominant in these areas. The proclamation of Garden Route NP in 2009, which includes extensive fynbos and forest areas, along with the inclusion of the Tsitsikamma, Wilderness and Knysna conservation areas into Garden Route NP in 2011, prompted the consolidation and revision of several existing SOK reports. The updated SOK for Garden Route NP was completed and made available during 2014. It is important to bear in mind that due to historical differences in administration, the research focus of the Garden Route NP SOK report varies accordingly, with greater focus on certain ecosystems and in certain areas of the park compared with others.

The emphasis of the current Garden Route NP SOK report is on biophysical and ecological characteristics of the area, and environmental processes, which reflect the competencies of the authors. However, we hope to widen the scope of this report in the future by providing better cover of other aspects, such as history and social ecology. To succeed in this task, Scientific Services will depend on input by specialists in these fields.
The Garden Route NP SOK report can be found on the SANParks website (http://www.sanparks.org/conservation/scientific_new/garden_route/state_of_knowledge). The report will be updated annually. Readers who are aware of omissions or inaccuracies or who wish to make comments on or contributions to the SOK report are encouraged to contact Garden Route Scientific Services.

CRC’s Knowledge Collation Project

Vuyelwa Olayi, Carly Cowell & Nicola van Wilgen

Until the CRC establishment in 2008, science support to parks within the Cape Cluster was provided by other research nodes, which also administered the parks’ external research. As a result, information relating to the Cape Cluster parks, namely: Agulhas; Bontebok; Tankwa Karoo; Table Mountain; West Coast; and Namaqua NPs, has been dispersed and not readily accessible. Following recommendations emanating from the SANParks Global Environmental Change project, and in response to data needs by scientists and researchers within and outside of the organisation, the Knowledge Collation Project was initiated in 2012. The project aims to consolidate data of scientific and management importance that is available for each park in one central location, the CRC, with duplicates in the individual parks.
All the Cape Cluster parks have been visited and many hours have already been spent retrieving and sorting data. Thus far over 1 000 records have been captured on an Endnote database. These include peer-reviewed journal articles, theses, management and field reports, books, popular articles, correspondence, maps, grey literature, audio visual materials and raw data. Once all existing data from the Cape Cluster parks have been captured, they will be uploaded to the SANParks Data Repository for storage and wider access. Original hardcopies of records will be available to view at the CRC Library or the respective park on request. A further goal of this project is an annotated bibliography of all research conducted within the Cape Cluster parks. This will be updated annually and incorporated in the State of Knowledge report for each park.

An unforeseen outcome of this project has been connecting with former research and management staff. Old park records, such as rangers’ reports, minutes of meetings, scientific publications not available electronically or the oral recollections of previous park staff, were often obtainable only from retired park staff. This project provided the opportunity to engage with former staff, interview them, and discuss their experiences of the parks they worked in, thereby preventing this invaluable knowledge from being lost.

The Knowledge Collation Project has grown beyond what was originally a small research project to collate park data to inform research within the parks, to something that has served as a catalyst for linking data with people and experiences, and has been embraced by scientists, managers, rangers and administration staff with great enthusiasm.

Example of an old article, published in 1945, with information regarding cave systems in Table Mountain NP.
A titbit of history

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930</td>
<td>Botanical specimen collection in Kruger NP began before the establishment of a formal herbarium. The oldest specimen, <em>Grewia occidentalis</em> (cross-berry), was collected in 1931 by Anna Amelia Obermeyer, curator of the former Transvaal Museum Herbarium from 1929-1938.</td>
</tr>
<tr>
<td>1940</td>
<td>From 1941-1952 Lesley Edward Wostall Codd collected 1122 specimens in Kruger NP.</td>
</tr>
<tr>
<td>1950</td>
<td>In 1951, assistant biologist Hermanus Phillipus van der Schijff, made the first formal collection for the Kruger NP herbarium. Between 1951 and 1955 van der Schijff collected 6277 specimens. Shown here is <em>Gymnosporia senegalensis</em> (red spikethorn).</td>
</tr>
<tr>
<td>1980</td>
<td>In 1988 the herbarium was moved to its current location, the Skukuza Biological Reference Collection, which features a laboratory, a zoological reference museum, and a darkroom.</td>
</tr>
</tbody>
</table>

Since 1955 many collectors have supplemented the herbarium. Interestingly, herbarium labels have changed over the years from those containing basic information to recent labels with more bio-ecological information and a photo of the plant. The advent of computers has greatly improved the ability to use the herbarium data for various conservation-related issues, such as the generation of plant checklists and quarter degree plant lists, the provision of information on species richness or underrepresentation in different landscapes, and the effortless delivery of distribution data.

References

*Photo of Lang published courtesy of Ditsong National Museum of Natural History.*
**Photos of Obermeyer, Codd, and van der Schijff published courtesy of SANBI Publishing.*
The second oldest specimen, *Ximenia caffra* (sour plum), was collected in 1932 by Herbert Lang, a naturalist who led museum collection expeditions into Africa. Lang was also the first collector who, in 1931, made a substantial herbarium collection in northern Kruger NP which was transferred to the Transvaal Museum (Glen & Germishuizen 2010).

In 1937 the first official checklist of the plants of Kruger NP was compiled by Obermeyer and published in the *Annals of the Transvaal Museum*.

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Between 1951 and 1956, a research programme for Kruger NP, which included a herbarium, was initiated to serve as a guideline.

In 1957 herbarium was moved from Pretorius Kop to Skukuza.

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In 1957 herbarium was moved from Pretorius Kop to Skukuza.
Monitoring and Evaluation

12 years of exclusion: What have we learnt and where to from here?

Judith Botha & Frances Siebert

Background

In their basic form, exclosures are fenced areas designed to keep out animals for the purpose of testing certain ecological theories. In 2002 herbivore exclosures were erected along the Sabie and Letaba Rivers in Kruger NP. Each locality was divided into two herbivory treatments: (1) a “total/full” (electrified) exclosure of approximately 50 ha, designed to exclude all herbivores from a hare upwards in size, and (2) a “partial exclosure” of approximately 40 ha, consisting only of two cables and electric wiring at 1.8 m and 2.2 m above ground. The purpose of the partial exclosure was to exclude elephant and, by virtue of their size, giraffe, but allow access to all other herbivores. Each exclosure was divided in half, with one half allowed to burn should fire pass through, and the other kept unburnt. These exclosures extended from within the river channel to the crest, in order to enclose the full sequence of catenal landscape features and their associated soils, vegetation and smaller fauna, thereby allowing for the study of the relationships of habitats along the topographic gradient. Part of the river channel was included in “sacrificial” exclosures, so-called because they may have sustained damage and were designed to be reconstructed when the river floods (bankfull events with a 5-10 year recurrence interval). The open area between the two exclosures served as a no burn reference area, and the unfenced reference area at the outside ends of the exclosures served as a natural fire regime treatment; both the open area and unfenced reference area allowed herbivory (Fig. 1). To detect vegetation change, two permanent transects extending from the riverbank to the crest were established in each of these six treatments. Transects were all marked with permanent markers. Vegetation plots of 10 m x 20 m, with the long side parallel to the river channel were set up along these transects.

To date, the diversity and structure of woody and herbaceous vegetation have been monitored on six sampling occasions at the two sites. Results include the effects of herbivores, with or without elephant, on woody plant structure, density, diversity, regeneration and chemical defence responses. Herbaceous vegetation patterns, such as their diversity across herbivore treatments in

3-SECOND BRIEF

Notwithstanding the associated challenges, exclosures provide unique opportunities to study many different ecological processes. Although some effects are visible soon after a project’s inception, others require longer periods of time before changes can be detected.
Exclosure sites, are receiving increasing attention. In addition, annual sampling of peak standing biomass is being conducted at the drier Letaba site, and browsing intensities of forb species, herbaceous flowering plants that are neither a grass nor sedge, are being investigated at the Sabie exclosure. Automated weather stations have been in operation at both sites since 2002 together with soil moisture sensors which record matric potential (potential energy of the water due to forces between the water and the soil) at 12 minute intervals at each representative hillslope element. A full soil hydraulic characterisation and hydro-pedological classification of the hillslopes at both sites has been completed, along with sapflow characterisation of water use of selected tree species. Detailed species lists and vegetation maps have been compiled for both sites, and the tree layer was mapped with airborne LiDAR (Light Detection and Ranging) in 2008 and again in 2010. Since 2002 data on approximately 140,000 plant individuals have been accumulated. At the Letaba site, camera traps have provided an indication of elephant visitation and seasonal movements over the past two years.

Figure 1: Schematic layout of the exclosures showing the various treatments.
In addition to the above, research has been conducted at the Sabie exclosure on the effects of fire and herbivory on: (1) ant and beetle diversity, (2) soil nutrient concentrations, (3) catenal hydrology with special emphasis on the sodic sites, and (4) the population structure of some key species, such as Marula.

**Interesting Findings**

After only three years of herbivore exclusion at the wetter Sabie site, substantial increases in herbaceous biomass and a decline in species richness were recorded in the absence of large herbivores, especially in the bottomland riparian zone. After another five years of herbivore exclusion, herbaceous biomass in the Nkhulu sodic zone accumulated further at the expense of species diversity.
Woody vegetation dynamics, diversity and structure responded much slower to herbivore exclusion than the herbaceous vegetation, although increases in woody density and species richness in the absence of all herbivores, and not elephant alone, have been recorded after five years of herbivore exclusion at the Sabie site. Noticeable changes in the woody vegetation layer can be seen after 10 years at both the wetter Sabie and the drier Letaba sites.

To date, research at these exclosures has revealed minor effects of elephant on both herbaceous and woody species diversity. However, other research involving high-tech 3D LiDAR campaigns, comparing woody vegetation structure inside and outside of these exclosures, indicates how the structure is significantly influenced by herbivory (Asner & Levick 2012). As such, vegetation composition and structure respond differently to herbivory over space and time.

**Challenges**

As these exclosures extend into the riparian zone, their fences become severely damaged or completely washed away during periods of higher than average rainfall. This has occurred several times at both exclosure sites over the years. In addition to the damage caused to fences, these high flow events lead to a delay in the repair of damaged fences due to inaccessibility as a result of high water levels. During the drier periods of the year animals such as buffalo, giraffe, kudu and elephant break the fences to gain access to the vegetation. Once they are inside, it is extremely difficult and costly to remove animals, often requiring a helicopter to chase them out. In addition to expensive fence repairs, the periodical entry of herbivores into the exclosures is undesirable for some of the exclosure experiments. Visiting the exclosures on a regular basis is the only way to ensure that these types of problems are picked up and addressed timeously.

Vegetation monitoring offers its own unique challenges in that these surveys are very time consuming and need to be done by a team that can identify woody and all herbaceous plants, which include forbs. The surveys also have to be timed correctly so as to miss the rainy season but still early enough in the year to ensure correct identification.
**Future research**

Thus far a great deal has been accomplished and the intensive vegetation surveys will be repeated every five years, as long-term changes may differ from the shorter term responses already detected. The LIDAR-based observations provide an unique opportunity to compare the intensive surveys with the LIDAR methodology and streamline the intensive monitoring process. They also provide context for interpreting wider landscape-level vegetation changes, by defining changes with and without herbivory. As the plant species lists and vegetation maps have been completed, other areas such as hydrology and herbivore movement and visitation can now be focused on. Future projects will include detailed plant functional trait analyses and linking vegetation patterns to hydrological sequences and animal movement.

**References**


Flood damage to the Sabie exclosure. Once this magnitude of damage has occurred it can take up to six months to repair fully.

Layout of the transects in the Sabie exclosure (generated by Chenay Simms)
In the 1900s the eastern lower slopes of the Cape Peninsula Mountains were planted with pine trees for timber production. Alien pines have transformed the ecosystem, and changed the fire regime, nutrient and water cycles of the natural veld. Cape Flats Sand Fynbos (CFSF), nationally categorised as a Critically Endangered vegetation type, was previously abundant on the flats and foot hills of the peninsula. Rapid urbanisation was responsible for the eradication of most of the remaining CFSF following World War II, when suburbs such as Tokai, Meadowridge and Bergvliet were developed for returning servicemen.

In 2007, ownership of the land in Tokai was transferred from Cape Pine to SANParks. It was agreed that all pines would be phased out over a 20 year-period and the land restored to CFSF. When the first pine compartments were cleared, the lower section of Tokai was identified by horticulturists and scientists from both South African National Biodiversity Institute (SANBI) and SANParks as the ideal site to implement research on the return of threatened fynbos species lost from the area.

Various methods of reintroduction are currently being tested. These include planting seedlings rather than vegetatively propagated plants, growing the plants/seeding in small propagation plugs and 1 kg plant bags, and planting directly into the veld from these. Measurements being taken include mortalities, plant growth (height and canopy cover), time to first flowering, number of flowers, seed set and root biomass. Preliminary results indicate that when planted from 1 kg bags plants have a better chance of survival than when planted from plugs. Two extinct-in-the-wild species have since also been returned to the Tokai area – *Erica verticillata* (whorled or marsh heath) and *Erica turgida* (Kenilworth heath). These ericas were grown from plants in The Kirstenbosch Gardens Erica Collection and donated to SANParks by Kirstenbosch. Both species require three generations in the wild to no longer be classified as extinct.
In late 2013 parts of the upper section in Tokai were harvested for timber, followed by a controlled fire. The CRC took this opportunity to collaborate with the Centre for Invasion Biology (CIB) at Stellenbosch University and the City of Cape Town to study the long-term effects of pines in the fynbos ecosystem. The CRC is co-ordinating the monitoring at Upper and Lower Tokai. Monitoring forms an integral part of SANParks’ strategic adaptive management approach to assess successes and failures in field, and the data in the long-term will help SANParks determine the best methods for improved success in plant reintroduction following alien clearing. This information also feeds into the state of biodiversity reports and policy development both at national and international levels.

Additional compartments continue to be harvested in Table Mountain NP, as the pines mature, recreating important biodiversity corridors and providing more opportunities for collaborations and research. In general monitoring and field observations show an increase in diversity of plants, reptiles, small mammals and amphibians in the cleared area. This suggests that active restoration can not only return targeted plants but also other biodiversity components.

*Erica verticillata*, currently listed as Extinct in the Wild, returned to the lowlands of Tokai. This fynbos species flowers late summer when little else is in flower.
Water chemistry of twelve rivers of Table Mountain National Park, the ancient home of a critically endangered Ghost Frog

Zishan Ebrahim

Table Mountain NP, a world heritage site, is the source of more than 12 rivers. These rivers form part of the history of the founding of the City of Cape Town and have flowed over Table Mountain for eons, cutting channels into its surface. Of these, only 12 have channels which clearly flow from the plateaux, 700 m above sea level (Fig. 1):

- Platteklip Gorge, flowing north into the city bowl, is the famous hiking trail up to the Table Top;
- south toward Hout Bay, the Disa River and the Original Disa Stream flow;
- falling off Table Mountain’s easterly slopes are Fernwood Gully, Skeleton and Window Gorges, as well as Cecilia, Newlands, Nursery, and Hiddingh Ravines;
- while on the westerly slopes the waters in the Kasteelpoort and Bilkwaterskloof are rapidly channelled into the Atlantic.

SANParks and SANBI working together to plant 3000 Erica verticillata along the banks of the Prinskasteelvlei in Tokai Park.

Effective monitoring need not include the monitoring of a species directly, but should include the monitoring of threats to its habitat – especially during vulnerable stages of the life cycle – and the conservation thereof.
Figure 1: Map of the study area. The water samples are taken at two points, 300 m and 400 m above sea level, in 12 rivers. The ‘Table Top’ is considered to be the mountain-scape which lies higher than 700 m above sea level.

The Table Mountain ghost frog, Heleophryne rosei, (Fig. 2), a Critically Endangered species and of conservation concern, is endemic to these gorges and rivers in the Northern Section of Table Mountain NP. However, it does not breed in all of these rivers as tadpoles are observed in only five rivers. Two rivers have records of a recent sub-population of this species, implying either its irregular use as a spawning site or that they are no longer suitable habitat for tadpoles. There is no evidence of Table Mountain ghost frogs having ever occurred in the remaining rivers.
According to the IUCN the Table Mountain ghost frog is Critically Endangered for these reasons:

- The species has an extent of occurrence less than 100 km². [Extent of occurrence is 9 km²]
- The species is endemic to this one location [the northern section of Table Mountain NP]
- Continuing decline (observed and projected) of its area of occupancy
- Continuing decline (observed and projected) of its habitat area, its habitat extent and/or its habitat quality

http://www.iucnredlist.org/details/9773/0

Figure 2: The habitat, the adult, and the tadpole of the Table Mountain ghost frog (*Heleophryne rosei*).

CapeNature’s tadpole-monitoring has highlighted several threats in certain river habitats, including erosion and fire concerns, water abstraction, and invasive alien plant species. It also reveals differing trends in the number of Table Mountain ghost frogs tadpoles in adjacent meta-populations. A further threat to tadpoles could be changes in water chemistry – from that typical of rivers in which tadpoles are present, to that typical of rivers in which they are absent.

The CRC is undertaking a water chemistry monitoring project to record several variables including pH (Fig. 3), electro-conductivity, temperature, and dissolved oxygen at two sites in each of the 12 rivers. The aim of this project is to better understand the habitat of *H. rosei* tadpoles, and to discern if any of the monitored variables can explain the absence of tadpoles from particular rivers. The results of this study will have bearing on other threatened species and rehabilitation plans.

Several other threatened and endemic species are also associated with these 12 rivers. The floodplains of the Disa and Liesbeek Rivers are home to the Endangered western leopard toad (*Amietophrynus pantherinus*). The Cape Peninsula moss frog (*Arthroleptella lightfooti*) is endemic to the Cape Peninsula, and may be found in stream-side...
vegetation and seepages. The Pride of Table Mountain, the red disa (*Disa uniflora*), Western Cape’s provincial flower, grows in several of these streams. Some rare and endemic invertebrate species of special concern, such as dragonflies and beetles also occur in these rivers.

In addition to sustaining biodiversity, water chemistry is relevant to citizens, as these ecosystem services deliver water to society. The water sampling sites in this study are all within Table Mountain NP in places where people easily access the waters for both drinking on-the-day, as well for collecting to use for drinking and cooking at home. It is for these reasons, biodiversity conservation and sustainable resource use, that monitoring the health of the 12 rivers and threats to them is important.

![Figure 3: Preliminary data: The relationship between the habitat suitability of the Table Mountain ghost frog (as determined by the number of tadpoles present) and the river pH. Tadpoles are present in five rivers and absent from five rivers, records show evidence of a past sub-population in two rivers.](image)

**Long-term groundwater level monitoring in Kruger and Mapungubwe National Parks**

Robin Petersen

Groundwater is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers. Groundwater forms a critical component of the hydrological cycle and plays an important role in the environment. Groundwater sustains river flows (referred to as base flow) and supports refuge pools in the dry season. Refuge pools are critical in seasonal rivers, as they support water-dependent ecosystems, such as wetlands and springs, that would otherwise not be sustained when the rivers dry up.
Groundwater resources are under increasing pressure through intensification of human activities including climate change. In many regions, groundwater abstraction rates exceed the rate at which groundwater resources are replenished. Once resources are modified or contaminated, groundwater can be very costly and difficult to restore. Thus, the monitoring and protection of our groundwater resources are critical.

In South Africa’s flagship conservation area, Kruger NP, groundwater systems are relatively un-impacted and provide an excellent opportunity to study the natural behaviour of aquifers in relation to rainfall, drought, river flow and other relevant influences. On the other hand, in the arid environment of Mapungubwe NP there are key groundwater concerns related to abstraction of water from the Greefswald and Shroda alluvial aquifers along the Limpopo River for mining and agricultural purposes. Abstraction from these aquifers may not only affect base flow contributions to the Limpopo River during dry seasons, but may also stress aquifer-dependent ecosystems such as the Kalopi wetland and the Greefswald gallery forest.

In 2007 and 2009, SANParks, in collaboration with the Department of Water and Sanitation (DWS) Limpopo Geohydrology Directorate office in Polokwane, initiated long-term groundwater monitoring projects in Kruger and Mapungubwe NPs. The aim is to gain an understanding of the groundwater systems by investigating:

- seasonal and long-term trends of groundwater level behaviour in relation to rainfall;
- interactions between surface-water and groundwater, with particular reference to streams and rivers;
- how the system reacts to climate variability; and
- appropriate management and protection of the groundwater resources.

Currently 43 boreholes are actively monitored across Kruger NP and seven in Mapungubwe NP. Groundwater levels are measured at unused boreholes using “Solinst” automated level loggers. The loggers are programmed to readings that are corrected to atmospheric pressure from barometer-loggers installed congruently at hourly intervals to provide high resolution data essential for working with highly complex systems that respond quickly to events (e.g. flooding of the river or over-abstraction). The data are downloaded twice a year, i.e. at the end of the dry season and after the wet season. Rainfall data are collected in the parks on a daily basis by field rangers in their respective sections using standard rain gauges, or in some cases at weather stations and consolidated centrally at Skukuza on a monthly basis.
**Kruger National Park**

Groundwater recharge in Kruger NP occurs during the wet summer months (December to March) and very little to none occurs during the dry winter season (Fig. 1). Water will only reach the aquifers during rainfall events of 100 mm or more. There are low and high recharge periods that seem to vary in duration from 6-14 years. These periods are characterised by seasonal fluctuations resulting in gains and losses during consecutive hydrological years. Depending on whether the hydrological period has above or below average rainfall, water levels show either a declining or a rising trend, i.e. during below average rainfall years the overall water level trend drastically declines as the system experiences higher natural losses than gains due to discharge of groundwater to streams and rivers. This is particularly apparent in the perennial rivers where groundwater maintains base flow.

**Mapungubwe National Park**

Analysis of the Mapungubwe NP data indicates that groundwater/surface-water interactions play a vital role in groundwater recharge processes (Fig. 2). The aquifer is recharged almost immediately during surplus flow conditions then gradually declines over the dry winter periods maintaining base flow conditions in the Limpopo River.
The general trend in the water levels indicates that groundwater abstraction, particularly along the Greefswald section, appears to be well managed as the water levels have not declined below the static water level since the installation of the loggers. The construction of dams or impoundments on the Limpopo and Shashe Rivers potentially poses the greatest threat to the sustainability of the primary aquifer by disrupting the recharge/flow processes of the system.

Figure 2: A comparison between groundwater level fluctuations along the eastern riparian Greefswald section and river flow downstream of the Sashe/Limpopo confluence in Mapungubwe NP.

Continuous monitoring of the groundwater levels will be critical for analysing long-term water level trends. This will allow us to assess the potential impacts of groundwater abstraction especially during years of below-average rainfall, and climate change, as well as the impact that river flow may have on aquifer-dependent ecosystems which are vulnerable to changes in the water regime.

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References
Freshwater

Ga-Selati and Olifants pollution events: Are we ready for future uncertainties?

Eddie Riddell, Stefanie Freitag-Ronaldson, Danny Govender & Robin Petersen

Rivers are vital contributors to humanity’s livelihood, well-being and economic productivity and this is particularly so in the case of the Olifants River within South Africa. It is well known that the Olifants River while being a significant contributor to South Africa’s economy, is also one of its most stressed rivers systems in terms of over and poorly-allocated supply and deteriorating water quality. This leads to a concomitant impact on the ecosystem goods and services that the basin can provide to society. While the water management problems in the headwaters of the basin, such as acid mine drainage and stressed municipal waste water treatment systems, are relatively well understood, in the lower part of the basin, within the lowveld region, these issues, while present, have historically received less attention.

In addition to the Olifants mainstem, the lowveld region includes the relatively pristine contributions of the Blyde, Klaserie and Timbavati tributaries which ameliorate some of these upstream effects, as well as the severely degraded Ga-Selati River which passes close to Phalaborwa town. Over the past few decades the Ga-Selati River has suffered from the compounded effects of severe water quality decline due to poorly treated effluent leaving waste water treatment works (WWTW) in the large peri-urban areas of that catchment, as well as from the impacts of the large mining operations (copper and phosphate) and associated industries. Until the early 2000s frequent spikes in acidity, phosphates, sulphates and salinity, among other effects, were common; this impacted on the viability of the aquatic ecosystems in the downstream Olifants River system.

While the Ga-Selati River continued to suffer the effects of deteriorating WWTWs since the early 2000s, there were some significant improvements in water quality due to the zero-effluent discharge policies of the mining operations. Thus, new measures were adopted by the major Phalaborwa industries to use water more efficiently and recycle water within these mining plants. However, the recent wet period of 2011-2014, which included the effects of 2012’s Cyclone Dando, introduced an unforeseen water management challenge of containment of storm water. This issue came to the fore between late December 2013 and March 2014 with a series of large and uncontrolled discharges into the Ga-Selati River from Phalaborwa’s phosphate industry. This led to a series of acute toxic acid spills resulting in mass fish die-off in a 20 km stretch of the Ga-Selati-Olifants River confluence area.

While these spills were of variable duration and impacted on the surface water resources during high flow conditions, questions arise around the long-term low-level impacts of this type of spill through groundwater seepage. The expected effect during
low flow periods would be a super concentration of contaminants. Furthermore, these pollution events are of serious concern for managing the ecological integrity of aquatic ecosystems within Kruger NP and for human health for the many people dependent on the system for their basic food and water needs. Importantly such events must not be allowed to occur in the future since the lower Olifants in Kruger NP is classified as a National Freshwater Ecosystem Priority Area (NFEPA).

Meanwhile, a broader question arises and relates to the adaptability of those many actors who utilise multiple-use landscapes such as the Ga-Selati catchment. We know that private sector companies are able to adapt somewhat to market forces and fiscal mechanisms, but how adaptable are they to a changing climate? Moreover, to a variable climate within a changing regulatory framework? And how likely are they to invest in disaster risk reduction when dealing with changing commodity prices?

A philosophical standpoint is required here – ecologists are quite comfortable working within an uncertainty paradigm, but what of other sectors? The pollution events in the Ga-Selati River demonstrated two main issues to SANParks: first, conservation science must stand firm in its resolve to use the regulatory mechanisms at national policy level (such as the National Water Act and National Environmental Management Act) so that polluters are held accountable, and to furthermore ensure that multiple land-use activities do not adversely affect the aquatic environment; second, mining and industry must become more proactive in adapting their operations to the increasing climatic variability. Conservation science has a role to play in informing these adaptation strategies. We should therefore endeavour to develop resilient co-operation across sectors, so that unforeseen changes and impacts can be acknowledged and resolved collectively.
To this end SANParks has begun to engage in action-focused research collaborations during 2014 with partners including both the government and non-governmental sector to develop and update water management situation assessments in the Ga-Selati-Olifants region. Moreover, this research agenda includes the development of decision support systems that can accommodate the water demands and water management constraints across multiple-use systems. It is hoped that this will foster better systemic integration, and thereby provide scenario-based information so that short- to medium-term planning is possible in a holistic and preventative manner. By harnessing new information technology such as decision support modelling systems it is believed that progress can be made towards achieving integrated solutions to water management problems in our rivers.
Operationalising Strategic Adaptive Management in river management

Eddie Riddell & Jacques Venter

The Kruger NP has been at the forefront of river ecosystems research for over 30 years. Recognising that rivers, in terms of their flow regime, water quality and the status of their flora and fauna, are variable and dynamic systems has allowed river scientists to articulate the conservation learning-by-doing philosophy known as SAM. This management approach allows the natural resources manager to be cognisant of uncertainty while ensuring effective and rational decision making. This has also influenced water resources management policy in South Africa and become the modus operandi of SANParks’ conservation strategy.

While SAM has been widely applied to various aspects of savanna ecosystem management within Kruger NP, for example in veld burning or disease control over the past two decades, the application of SAM to river management has required significant nurturing over time as it is put into practice. This is not because SAM in river management is a furtive exercise but rather the contrary – it is dependent on significant consensus building as required within the modern day Integrated Water Resources Management (IWRM) paradigm. Water is a resource whose use is often strongly contested. This means that the building blocks to give effect to IWRM can take considerable time to cultivate. First, one has to quantify the management benchmarks such as the minimum amount of water that should flow along a river to maintain its ecosystem function (known locally as the ecological reserve). In South Africa this reserve is determined on a monthly basis. Second, it requires a correct policy setting and an institutional environment in order to facilitate a mutual allocation of the water resource. This is to both the reserve and other avenues of benefit to society.

It has taken some time to get the ecological reserve flow rules written into legislation since they were mandated in the National Water Act (1998), as these differ on a catchment by catchment basis, requiring comprehensive reserve flows to be determined and then each to undergo a public participatory selection process. These are then gazetted before becoming a binding management class specific to each catchment. Despite some delays in this regard there have been significant strides made in the past five years to get the operational procedures developed. Within the context of the Kruger NP’s rivers the implementation of the ecological reserve has to a large extent been dependent on co-ordinated management of upstream dams with upstream stakeholders. This has necessitated development of information management, dissemination and decision-making frameworks required by the different stakeholder groups within each of the five major rivers that flow through Kruger NP – the Crocodile, Sabie, Olifants, Letaba, Luvuvhu Rivers.

Ongoing applied research and collaboration have demonstrated that adaptive river management practices can achieve ecological sustainability provided that multi-institutional mechanisms are in place and are based on credible and salient information. The next step will be to evaluate these frameworks when the catchments are more stressed in terms of their water availability. Further research is necessary to directly link aquatic ecosystem response to these short- to medium-term river management actions.
Major role players include the national regulator (Department of Water & Sanitation), the Catchment Management Agency and other water authorities, water users (represented by irrigation boards and municipalities), technical operators of dams, and Kruger NP. The process to get the reserve implemented has typically followed the information feedback depicted in Figure 1 by establishing an information communication system used by these role players (Fig. 2). This is done to ensure that storage dams can be used to augment supply to users as well as to keep the rivers flowing for the purpose of ecological preservation.

**Figure 1:** Typical communication feedback between water resource management institutions in the catchments of the lowveld, where arrows represent lines of direct communication. KNP = Kruger National Park

**Figure 2:** Framework of an operational water resources management decision support system.
All this interaction is predicated on a sound information system using a hydrological model with accurate climate and water use data, and importantly, a practical information dissemination system to all stakeholders (email, sms, website). However, in order to give effect to the decision support system there is no substitute for one-on-one dialogue to foster trust and mutual co-operation among the various stakeholders. Thus it is crucial to have regular meetings where all parties discuss active and emerging issues, such as long-term climate forecasts and technical issues.

All five major rivers entering Kruger NP now have these systems in place made possible through Water Research Commission funding, and are showing positive signs that the reserve can be implemented. The Crocodile River in particular is the shining example as historically this catchment had the most contested water use, primarily between commercial agriculture and conservation areas. Now in its fifth year the Crocodile River Operations Committee (CROCO), facilitated by the Inkomati-Usuthu Catchment Management Agency (IUCMA) is showcasing that SAM can be used as a principle to manage releases from the Kwena dam, in order to satisfy the needs of both the water users and the aquatic environment.

An example of how this information flow works in practice is shown in Figure 3, through a rapid-response feedback system using ‘worry levels’ where Kruger NP staff monitor the Crocodile River flow at the Tenbosch gauging weir near Crocodile Bridge gate. The staff inform the water management authority, the IUCMA, that observed flows are moving close to the reserve requirements (low worry); if however the reserve flows are compromised then the situation is in a medium to high worry level. In these latter cases the Kruger NP river bio-technician or river manager would inform the authority, who authorises mitigating action, such as a release from the dam, while at the same time alerting users (irrigators) who would then begin to restrict their water use.

Figure 3: An example of the rapid-response feedback system used in river management between Kruger NP and upstream stakeholders.
Work published by the Association for Water & Rural Development and University of KwaZulu-Natal (UKZN) demonstrated the major negative alterations to the hydrology of the Crocodile River catchment (Riddell et al. 2014). This assessment was in relation to its ecological water requirement as a response to significant catchment management actions over the past 50 years. Further research by UKZN during 2014 also demonstrated the positive responses in the catchment’s hydrology as a result of the formation of the CROCOC, with measurable increases in river flows that are compliant with the reserve (Jackson 2015).

Fortunately this good example of how SAM plays out in practice in a multi-sectorial environment has been developed during a period of relative calm in water resources management, as the lowveld region has over the past few years had good rains. Testing the efficacy of operationalising SAM will come of course when the Kruger NP catchments become increasingly water stressed during periods of lower than average rainfall.

References


Engelhard fishladder: Effective migration route?

Fish undertake migrations for a number of reasons including to spawn, feed and seek refuge. These migrations are also essential to ensure the dispersal of species and maintain genetic fitness within fish communities. Fishladders, also known as fishways or fish passes, are structures placed on or around constructed barriers (such as dams or weirs) to re-establish connectivity between critical habitats for migratory fish species, thus mitigating the impacts of the blockage of migration routes. If this management tool is to be meaningful for conserving fish species, it must provide a fully permeable connection and ensure both up- and downstream movements. Additionally, fishladders must be able to operate effectively over a wide range of river flows, and cater for a broad range of fish sizes, varying swimming abilities and behavioural preferences.

In 2011 a fishladder was constructed in the Letaba River at Engelhard Dam in Kruger NP. The following year a study was initiated to: (1) determine whether migratory fish and their offspring are able to swim upstream to the dam, and (2) evaluate the selectivity of the fishladder in attracting different fish. The top part of the ladder was closed, thereby restricting movement downstream through the ladder and only allowing upward movement. Samples of ichthyofauna were collected from the 21 buckets along the ladder using electronarcosis. The fish were identified to species level and released. Two days later the survey was repeated to determine if fish are able to swim up the ladder. The occurrence (species number) and relative abundance of fish in the buckets along the fishladder as well as at various sites along the Letaba River were recorded. The study was carried out during low flows in winter of 2012, 2013 and 2014.

Preliminary results indicate that fish are able to use the ladder as a migratory route, that they are able to ascend the ladder at different times of the year, and that the ladder caters for fish of various sizes. Both the abundance and diversity of fish species occurring in the fishladder increased over the three-year period (Fig. 1). Various hypotheses for the observed increase in abundance and species diversity have been proposed including seasonal effect and time of sampling.
Figure 1: Total fish species and number of fish caught in the Engelhard fishladder in three successive winter sampling periods (2012-2014).

This study has the potential to provide means by which ongoing monitoring can be successfully implemented to detect critical changes in fish community structure as a result of construction of dams and fishladders. Such awareness is essential for effective planning and management of rivers within protected areas as well as for the improvement of strategic adaptation responses to climate change impacts.

References


Changing Paradigms

Thought Piece: Parks Connecting Society

Wendy Annecke

SANParks’ vision, “a sustainable National Parks System connecting society” has profound implications for realising both the inherent connectedness of people as part of ecological systems, and the potential for people to connect through being part of the national parks. Most scientists focus on how to achieve the ‘sustainable’ part of the vision, few of us see ourselves and all other South Africans as embedded in the parks and thus connected to each other. As scientists we relate to others through our research: other scientists, park managers, all types of rangers, some of the Biodiversity Social Projects staff, and occasionally with People and Conservation staff. Historically Scientific Services has been separated from the worlds of tourism, stakeholders and the general public. We are different – ecological systems are the object of our study and a specific audience receives the information emanating from our discipline-based research. Working in this silo we have become distant from society. Although we are being encouraged to make an effort to connect, I suggest that a more radical shift is required – we need a different way of understanding, a different lens and perhaps a different language in order to engage the practice of being one in a connected biosphere.

Scientific research in SANParks initially encompassed the fauna then the flora. In 1994 the shift from apartheid-style national parks to a more inclusive concept of conservation helped raise the profile of people in conservation and a social ecology unit was established. However while biodiversity entered the vocabulary of scientists in the 1980s and ecological systems have become mainstream in the past ten years, social ecology sat more uncomfortably on the tongue and as a concept did not find traction in the patriarchal institution. Its demise was swift. The failure to integrate people in conservation is a symptom of the lack of recognition of the integral role of people in the biosphere, and reflects a deep reluctance to incorporate complex social elements in the pursuit of
understanding how ecological systems work. The point was brought home to me by a scientist who asked: "Isn't there a more attractive word than social or human that could be used?". We need a step-change in the mindset that locates scientists outside of people and people outside of the environment. To do good science we need to recognise that scientists are part of society and that people are embedded in the biosphere and shape it, as Folke points out, from global to local and from past to present.

What difference could it make to conservation if we were to share such an integrated concept? Is there an example of when we all felt immersed in South Africa, part of the ecosystems, rooted in our environment? The elections of 1994 may have been such a time, but closer to all of us was the World Cup Soccer tournament of 2010. Just about everyone in South Africa was involved when it happened. Despite the criticisms we loved the stadiums, we celebrated the fan walks and we flooded the open-air parks. We rejoiced in Bafana Bafana's success and when our team went out we easily supported other international teams and embraced their supporters in our land. We were one: good humoured and secure in the knowledge of our country. We were rooted in our land, in action, in common purpose. Not every South African could attend a football match, but everyone understood their importance. So it should be all the time in terms of our national parks as a component of our biosphere. Not every South African can or wants to go to a national park, but everyone should understand the rootedness of our beings in the biosphere and as a fundamental part of all of us. Just as we know the streets we live in, the water we drink and the taxis that we catch as systems we are part of, so we should have the system of parks imprinted in our souls. We are embedded in these systems and them in us. We are in and of the biosphere, we shape it but we are also utterly dependent on it. We are embedded as much in the waste we carelessly discard as we are in the rivers and the mountains.

The historical process that separated people from the environment is deeply imprinted on own culture and consciousness, but its time is past. We are fortunate in South Africa that we had an example of a people who understand their oneness with the biosphere
and whose language does not divide people from the rest of the earth. Too bad the bushmen communities have been decimated, their wisdom marginalised and their languages lost – an understanding of their deep insight could guide us now. We need a new vocabulary to disrupt the old binaries and find ways to speak more easily about a philosophically profound and different concept to the one we currently embrace. We know that change is happening in our biosphere and it is likely we will need insight, intelligence, resilience and Ubuntu to survive. We are fortunate in Scientific Services to have leaders who provide space to learn, trust to co-learn, flexibility to initiate and create, the willingness to move from traditional discipline-specific research to multi-disciplinary and more recently to trans-disciplinary research, as we seek to resolve complex problems. But simultaneously we need to uncover the elements that link us and make us whole. We cannot wait for others to create the recognition and reverence for us, we have to imagine and know our own embeddedness and act from the premise that a National System of Parks Connecting Society embraces us all in a powerful and holistic biosphere.
Emerging diseases frighten agricultural authorities and human health practitioners. Agricultural approaches, from which conservation management evolved, seek to achieve zero-prevalence of controlled or regulated diseases. So, when authorities detected bovine tuberculosis (BTb) in lions during 1995 in Kruger NP, it generated concern, and fuelled several hypotheses about an imminent collapse of the lion population.

The discovery of bovine tuberculosis (BTb) in Kruger NP lions during 1995 sparked concerns regarding an imminent collapse of the lion population. Nevertheless, data gathered from a series of studies over a number of years did not support initial predictions of how the Kruger NP lion population may be decimated by the disease. Contrary to the typical zero-tolerance approach of agriculturists to disease, the presence of BTb in lions may represent more of a perceived rather than a real threat.

Exactly how is BTb likely to affect lions and their role in Kruger NP’s complex system? The problem for lions starts with their diet. Many of their main prey items, such as buffalo, are BTb maintenance hosts. Once infected, lions can also infect one another. Infection by BTb imposes metabolic constraints on lions. Metabolic constraints affect fertility – age at first birth, birth rates and litter size in BTb-infected lions should thus decline. These same mechanisms of BTb also predict increased deaths. Increased male deaths are likely to result in more male take-overs of prides and thus more cubs dying.

Metabolic constraints also induce physiological limits. Reduced energy would likely result in changes in lion hunting behaviour, leading to changes in diet and range use. Overall, these mechanisms predict lion numbers would decrease with BTb prevalence, supporting the concern raised in 1995.

Figure 1: Diagram explaining how BTb influences lions, the predicted consequences and how data support those predictions.
**Making a diagnosis**

During 2009 SANParks set out to explicitly test predictions regarding how BTb is likely to affect lions. Their first challenge was to diagnose BTb in a free-ranging lion. State and SANParks veterinarians typically diagnose BTb in lions from necropsies of diseased lions. A TB skin test is performed, thereafter the lion is euthanised and its BTb status confirmed on bacterial cultures of tissue samples. However, the disease is easily detected only in lions with advanced symptoms such as emaciated bodies and by selecting only these lions, bias is inevitably introduced into the samples.

At the same time as the lion demographic studies were taking place, researchers at the University of Pretoria, Stellenbosch University, Onderstepoort Veterinary Institute, State Veterinary Department and SANParks sought to develop blood-based diagnostic tests for BTb in free-ranging lions as part of independent studies. Even after the verified development of the intradermal tuberculin skin test, diagnostic tests remained problematic for logistical reasons. For this test, researchers are required to catch a lion twice, at a three-day interval, test inoculate on a patch of skin in the neck of a lion, and measure the inflammatory response against a control.

The ongoing development of blood-based BTb diagnostics received a boost when SANParks’ Veterinary Wildlife Services built a mobile lion boma. This allowed lions to be contained for the three days and for the skin test to be read without requiring multiple captures of the same individual. Even so, defining prevalence at low disease incidence remained a statistical challenge. Despite the statistical challenges, the samples reflected that 82%, 52% and 7% of the lions in southern, central and northern Kruger respectively tested positive for BTb based on the skin test.

**Testing the predictions**

In addition to disease, prey biomass and lion sociality are key drivers of lion populations. SANParks thus needed to separate out the various factors and split Kruger NP into zones of: (1) prey biomass, (2) BTb lion disease prevalence, using known BTb prevalence in buffalo as a proxy, and (3) lion density, based on previous lion studies during 2005 and 2006 (Fig. 2).
SANParks, the Tshwane University of Technology, the Ajubatus Foundation, the Honorary Rangers, Jock Safari Lodge and Lukimbi Safari Lodge collaborated and collated information from 33 prides between 2005 and 2013. Veterinarians fitted one female per pride with a satellite transmitter. Researchers tracked the prides and noted behaviour, hunting, prey composition, mating and the individual histories of lions in a pride.

**Figure 2:** Kruger NP zonation used for the study on how BTb influences lions. The circles are places where SANParks conducted a lion population size survey 2005 and 2006 using call-up stations. The filled circles represent places where lions responded to the call-ups. A call-up comprises an hour-long recording of a buffalo calf in distress over large speakers. Researchers then note how many lions turn up and from that can estimate the total number of lions in Kruger NP.

In northern Kruger, 0-4% of buffalo prey was BTb infected, much lower than the 30-46% in southern Kruger. Lion exposure to BTb is thus much higher in the southern parts of Kruger. Even with such differences in exposure to BTb across Kruger, researchers could not find support that known BTb prevalence in buffalo influenced lion diet, home range use, age at which a female has her first litter, litter size and survival.
Lion diet changed when rainfall did – in above average rainfall periods, lions ate more species potentially infected with BTB. The home ranges of prides with two to five lionesses varied from 24 km² to 512 km² defined by prey biomass. Lionesses had their first litter when they were between 2.6 and 4.1 years old and litters ranged from one to five cubs. Female annual survival (70-85%) was higher than male survival (45-75%). Lionesses had litters every 2.4 to 3.3 years, while male pride tenures lasted 1.5 to 3.5 years. These values are similar to the range of values for lion populations elsewhere in Africa. Most importantly, values were also the same between the zones with different BTb prevalence in buffalo most likely because BTb does not influence lions at a population level.

SANParks could also not find conclusive impacts of BTb on lion abundance after researchers accounted for the effects of prey biomass already in studies during 2005 and 2006. Despite BTb presence in Kruger, the park has approximately 400 lionesses, the most stable component of the lion population.

**Rethinking disease**

The data did not support most of the initial predictions and fears associated with BTb effects on lions, and illustrate that threats may often only be perceived ones and not real. Dynamics of emerging diseases, including alien varieties, form part of ecological processes that maintain biodiversity. The traditional zero-tolerance approach to disease thus contradicts conservation mandates.

For conservationists, disease seldom matters – only when populations are small and accentuating factors, such as external disease sources close to parks, exist. The study also implies that policies which enable people to obtain benefits from wildlife and livestock may need to replace traditional disease regulatory approaches. For instance, certifying wildlife and livestock products as disease-free rather than having disease-free zones may be much easier and ecologically realistic to implement. Such innovative disease management approaches are important initiatives that will assist SANParks in sharing ecological benefits from protected areas that span the spectrum of human needs.

**References**

Publications

Papers in peer-reviewed journals

During 2014 SANParks research staff authored or co-authored 38 peer-reviewed journal articles (see Appendix A for full reference list). Forty two staff members contributed as authors, with a total of 66 SANParks authorships across the papers. Twelve SANParks staff members were principle authors on 14 (32%) of the publications. Twenty eight staff members authored/co-authored a single paper, 12 authored/co-authored two to four papers, while two staff members published five or more papers in 2014. The 38 publications were spread across 31 journals, covering a range of impact factors (Fig. 1). Staff members were also involved in the publication of various internal and external reports, which are available from the respective research node offices.

Figure 1: Number of peer-reviewed papers published by SANParks research staff during 2014 according to impact factor of journals (NA = not accredited by Thomson Reuters). Impact factors are defined and determined by Thomson Reuters; 2013 impact factors used as 2014 impact factors only appear in the second half of 2015.

The most frequently used journal for research dissemination was the in-house journal *Koedoe* (four papers). Four journals have two papers each published with SANParks-affiliated authorship, with the remaining 26 journals having a single paper (Table 1).
Table 1: Journals in which SANParks research staff published in 2014. Papers are ordered by number of papers, followed by Impact Factor. (NA = not accredited by Thomson Reuters; full reference list in Appendix A).

<table>
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<tr>
<th>JOURNAL</th>
<th>TOTAL NUMBER OF PAPERS</th>
<th>NUMBER OF PAPERS (Principle Author)</th>
<th>NUMBER OF PAPERS (Co-Author)</th>
<th>IMPACT FACTOR</th>
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External peer-reviewed research emanating from/related to national parks

SANParks leverages enormous intellectual capital and research funding through registered projects by external collaborators. During 2014, 153 papers relating to 14 of the 19 national parks were published in peer-reviewed journals by external collaborators without SANParks affiliates (Table 2; full reference list in Appendix B).

When considering papers published by external and SANParks authors, Kruger NP (n=82), Garden Route NP (n=17), Addo Elephant NP (n=17) and Table Mountain NP (n=13) were the parks that featured the most in the peer-reviewed literature during 2014, but encouragingly many papers appeared that considered more than one national park (n=11). Some of the smaller parks also had multiple papers published, typically based on some of their unique attributes (e.g. cultural and archaeological studies in Mapungubwe NP).

Table 2: Articles related to specific South African national parks appearing in peer-reviewed journals during 2014 (full reference lists in Appendices A and B).

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<tr>
<th>NATIONAL PARK</th>
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<td><strong>38</strong></td>
<td><strong>191</strong></td>
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Books and book chapters

Three SANParks staff members were involved in five chapters appearing in two books that were published in 2014 (Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region, edited by N. Allsop, J. F. Colville, and G. A. Verboom, and Fowler’s Zoo and Wild Animal Medicine, edited by R. E. Miller and M. E. Fowler) (Appendix C).

In-house Research Journal, Koedoe

Koedoe, the peer-reviewed in-house journal of SANParks, promotes biodiversity conservation science and protected area management in Africa, by publishing research that will enhance the body of knowledge required to support effective conservation and sustainable management of our natural resources. This knowledge is generated within the context of complex ecological and social systems in which protected area networks are embedded. As a result, Koedoe highlights fundamental practices that contribute to the conservation of natural resources, which are increasingly faced with pressures from a growing human population and the effects of global environmental change. Koedoe also publishes scientific advancements in field studies, in-depth reviews of complex topics, as well as evidence-based policy and management approaches to assist with context-specific management challenges.

One of the greatest achievements for Koedoe during 2014 was being awarded its first Impact Factor of 1.486, in the 2014 Release of Journal Citation Reports (Source: 2013 Web of Science data), placing Koedoe 21st out of 42 in the biodiversity conservation category, and highest in the natural sciences in South Africa.

There has continued to be a substantial increase in visitors to the Koedoe website (www.koedoe.co.za) and in the number of papers that have been downloaded, since the journal moved to an online publishing platform in 2008 (Fig. 2). In 2014, about 301 400 visits were made to the website. This represents an increase of 84% on the number of visits to the site in 2013. Approximately 156 100 (51.8%) were first-time visitors to the website. The visitors originate from 180 countries. Papers were downloaded about 267 500 times, (data collated using COUNTER-Counting Online Usage of Networked Electronic Resources). Similarly, direct counts from the Koedoe server indicate that papers from the entire collection (1954-2014) had been downloaded a total of 1 722 063
times by 2014, reflecting a 47.6% increase from 1 166 200 in 2013. The special issue on Adaptive Management in SANParks (2011, Vol 53:2) was downloaded a total of about 111 000 times between 2011 and 2014. In the past year alone, the number of downloads doubled from approximately 54 000 (for the period 2011 to 2013) to 111 000. Collectively these results demonstrate that awareness of *Koedoe* and its value are both increasing.

![Figure 2](image_url)  
*Figure 2: Numbers of visitors and articles downloaded between 2008 and 2014 (data from *Koedoe* server on the journal's AOSIS hosting platform, as determined using COUNTER-Counting Online Usage of Networked Electronic Resources).*

In June 2014 a special issue titled “Tourism and protected areas: A growing nexus of challenge and opportunity” was published by guest editors Stephen McCool and Anna Spenceley (2014, Vol 56:2). The special issue, which contains 10 papers originating from protected areas around the world, was launched at the IUCN World Parks Congress, Sydney Australia, in November. The special issue has already gained widespread attention, and has been downloaded approximately 15 337 times.

In 2014 a total of 34 manuscripts were submitted and a total of 21 papers published (Table 3). Of the 276 manuscripts (all categories) submitted since 2008, 134 have been published, representing an overall rejection rate of 48.5%.
**Table 3:** Status of manuscripts submitted to *Koedoe* between 2008 and 2014.

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<td>42</td>
<td>48</td>
<td>34</td>
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<td>Average articles in Review per month</td>
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<td>20</td>
<td>12</td>
<td>10</td>
<td>32#</td>
<td>17</td>
<td>22</td>
<td>21$</td>
</tr>
</tbody>
</table>

# Includes special issue on Adaptive Management Vol. 53:2.

$ Includes special issue on Tourism and Protected Areas Vol. 56:2.
Conference Presentations (national and international)

SANParks staff presented 17 papers (and nine posters) at national and 25 papers (and one poster) at international conferences during 2014, representing SANParks at a total of nine national and eight international conferences and forums (note, only reflecting principle authorships; Tables 4 and 5; full reference list in Appendix D). Twelve of the conferences were hosted in South Africa, while five were hosted abroad. Four staff members were invited to give keynote presentations at three national and two international conferences. One staff member received an award for ‘Best Poster’ (at 36th Fynbos Forum), and another for ‘Best Student Presentation’ (17th SANCAHS National Hydrology Symposium).
Table 4: National conferences where SANParks authors gave presentations (only first authorships included; ordered by number of presentations).

<table>
<thead>
<tr>
<th>Conference</th>
<th>NUMBER OF PRESENTATIONS (Number of Posters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern African Wildlife Management Association Symposium, Port Elizabeth</td>
<td>5 (+ 1 poster)</td>
</tr>
<tr>
<td>36th Annual Fynbos Forum, Knysna <em>(Includes two Invited Keynotes and a Best Poster award)</em></td>
<td>4 (+ 3 posters)</td>
</tr>
<tr>
<td>Symposium of Contemporary Conservation Practice, Howick</td>
<td>2</td>
</tr>
<tr>
<td>15th Annual Southern African Marine Science Symposium, Stellenbosch</td>
<td>1 (+ 5 posters)</td>
</tr>
<tr>
<td>17th Indigenous Plant Use Forum Symposium, Phuthaditjhaba</td>
<td>1</td>
</tr>
<tr>
<td>17th SANCIAHS National Hydrology Symposium, Cape Town <em>(Best Student Presentation)</em></td>
<td>1</td>
</tr>
<tr>
<td>49th Annual Grassland Society of Southern Africa Congress, Bloemfontein</td>
<td>1</td>
</tr>
<tr>
<td>Southern African Society of Aquatic Scientists Conference, Thaba Nchu</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>17 (+ 9 Posters)</strong></td>
</tr>
</tbody>
</table>

Table 5: International conferences where SANParks authors gave presentations (only first authorships included; ordered by number of presentations).

<table>
<thead>
<tr>
<th>Conference</th>
<th>NUMBER OF PRESENTATIONS (Number of Posters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th Annual Savanna Science Network Meeting, Skukuza, South Africa</td>
<td>11 (+ 1 poster)</td>
</tr>
<tr>
<td>6th IUCN World Parks Congress, Sydney, Australia <em>(Includes Invited Keynote and Pre-workshop Presentation)</em></td>
<td>7</td>
</tr>
<tr>
<td>3rd International Science and Policy Conference of the Resilience Alliance, Montpellier, France</td>
<td>2</td>
</tr>
<tr>
<td>13th MEDECOS International Conference, Olmue, Chile</td>
<td>1</td>
</tr>
<tr>
<td>8th European Conference on Ecological Modelling, Marrakech, Morocco</td>
<td>1</td>
</tr>
<tr>
<td>Botswana Wildlife Research Symposium, Maun, Botswana <em>(Invited Keynote)</em></td>
<td>1</td>
</tr>
<tr>
<td>INSAKA, Cape Town, South Africa</td>
<td>1</td>
</tr>
<tr>
<td>International Congress on Parasites of Wildlife and the 43rd Annual PARSA Conference, Skukuza, South Africa</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>25 (+1 POSTER)</strong></td>
</tr>
</tbody>
</table>
SANParks staff contributed both to biome-specific conferences (e.g. Fynbos Forum, Southern African Marine Science Symposium, Savanna Science Network Meeting) discipline-specific conferences (e.g. South African Wildlife Management Association Symposium; International Congress on Parasites of Wildlife, etc.) as well as broader-themed conservation and management conferences (IUCN World Parks Congress; International Science and Policy Conference; Symposium of Contemporary Conservation Practice). SANParks was well represented on the programmes of the Savanna Science Network Meeting (11 presentations and one poster), IUCN World Parks Congress (seven presentations), South African Wildlife Management Association Symposium (five presentations and one poster), Fynbos Forum (four presentations and three posters) and Southern African Marine Science Symposium (one presentation and five posters). SANParks hosted the 12th Savanna Science Network Meeting in Skukuza, Kruger National Park.
Achieving effective conservation in the complex and dynamic conservation milieu of today requires ongoing learning and adaptive capacity. An in-house research function is pivotal in facilitating these capabilities. While the organisation’s research capital does not reside entirely within one department, Scientific Services has taken the lead in driving the research agenda for SANParks. SANParks’ science function steers, partly populates and chronicles the organisation’s learning journey, acknowledging the history, experience and dedication of many individuals and the combined heterogeneous group, upon which the research and monitoring function rests within the organisation.

SANParks’ scientists devote time and energy to achieving reliability through peer-reviewed research output, and relevance as well as legitimacy through purposeful and respectful engagement with managers, policy makers and other stakeholders. Reliability is also critical for engagement and there is inevitable tension in the relative amount of time devoted to these facets of their work, both as individual researchers and as the science group. These facets are reflected on in the diversity of articles, stories and experiences captured here.

2014 has been an exciting and productive year for the SANParks research team and its diversity of collaborators and stakeholders. The intersection of people, parks and research have facilitated a deepened understanding of roles, responsibilities and the multiplicity of knowledge needs and forms required to make wise choices on the certain path of change and trade-offs for sustainable national parks.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>BTb</td>
<td>Bovine Tuberculosis</td>
</tr>
<tr>
<td>CFSF</td>
<td>Cape Flats Sand Fynbos</td>
</tr>
<tr>
<td>CIB</td>
<td>Centre for Invasion Biology</td>
</tr>
<tr>
<td>CRC</td>
<td>Cape Research Centre</td>
</tr>
<tr>
<td>CROCOC</td>
<td>Crocodile River Operations Committee</td>
</tr>
<tr>
<td>DAFF</td>
<td>Department of Agriculture, Forestry and Fisheries</td>
</tr>
<tr>
<td>DWS</td>
<td>Department of Water and Sanitation</td>
</tr>
<tr>
<td>IUCMA</td>
<td>Inkomati-Usuthu Catchment Management Agency</td>
</tr>
<tr>
<td>IUCN</td>
<td>International Union for Conservation of Nature</td>
</tr>
<tr>
<td>IWRM</td>
<td>Integrated Water Resources Management</td>
</tr>
<tr>
<td>LiDAR</td>
<td>Light Detection and Ranging</td>
</tr>
<tr>
<td>NFEPA</td>
<td>National Freshwater Ecosystem Priority Area</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
</tr>
<tr>
<td>NMMU</td>
<td>Nelson Mandela Metropolitan University</td>
</tr>
<tr>
<td>NP</td>
<td>National Park</td>
</tr>
<tr>
<td>NSF</td>
<td>National Science Foundation</td>
</tr>
<tr>
<td>OTS</td>
<td>Organization for Tropical Studies</td>
</tr>
<tr>
<td>SAEON</td>
<td>South African Environmental Observation Network</td>
</tr>
<tr>
<td>SAM</td>
<td>Strategic Adaptive Management</td>
</tr>
<tr>
<td>SANBI</td>
<td>South African National Biodiversity Institute</td>
</tr>
<tr>
<td>SOK</td>
<td>State of Knowledge</td>
</tr>
<tr>
<td>UCT</td>
<td>University of Cape Town</td>
</tr>
<tr>
<td>UKZN</td>
<td>University of KwaZulu-Natal</td>
</tr>
<tr>
<td>WWTW</td>
<td>Waste Water Treatment Works</td>
</tr>
</tbody>
</table>
Carly Cowell has an interest in the effective management of protected areas by linking scientific theory with best management practices. To achieve this she works at the interface between science and management, facilitating knowledge exchange through communication.

Diba Rikhotso is a biotechnician working in the Garden Route (Knysna office) and focuses on vegetation monitoring and research.

Dirk Roux is a freshwater conservation scientist working at the interface between science, policy and management.

According to Eddie Riddell, water resources manager for Kruger NP, river management pressures in 2014 have demonstrated that new information tools and pioneering research techniques remain critical for collaborative management and governance of natural resources including freshwater.

Frances Siebert is with the Unit of Environmental Sciences and Management, North West University. Her research focuses on the response of different vegetation layers to herbivory, but also to the exclusion of herbivores in a herbivore-driven savanna ecosystem.

George Sass is a biotechnician in Garden Route NP (Knysna office). His work focuses on forest ecosystems and he has a specific interest in forest disturbance, forest dynamics and resource use (both timber and non-timber forest products).

Guin Zambatis is the curator of the Skukuza Biological Reference Collection. Collecting plants in Pafuri, Punda Maria sections and Ship Mountain was her highlight for 2014.

Hendrik Sithole is the invertebrate research manager of the Savanna and Arid Research Unit. He is primarily interested in understanding the role of macroinvertebrates in sustaining our ecosystems.
Hugo Bezuidenhout is a specialist scientist with Scientific Services in Kimberley. In December 2015 he will have been with SANParks for 25 years. Although he is a vegetation ecologist, his interests extend to soil science and geology. Nature conservation is his passion, and he is particularly enthusiastic about sharing the interesting plant communities and species that exist in different habitats with people. He is also passionate about carrot cake, which is fitting for a vegetation ecologist.

Ian Russell is the manager of the Rondevlei office of Garden Route NP, and conducts monitoring and research primarily on water quality, aquatic plants, fish and waterbirds in estuaries.

After completing an MSc in whale reproductive biology, Inês Ferreira worked in academic journal publishing for several years. She joined SANParks in 2012 as their science awareness officer and is responsible for facilitating scientifically generated knowledge transfer to a variety of audiences. Of particular interest to her is the production and visual representation of content in a manner which is engaging and enhances understanding, yet retains scientific integrity.

Izak Smit is the systems ecology, GIS and Remote Sensing manager for the Savanna and Arid Research Unit. His research focuses mainly on understanding drivers of spatio-temporal landscape-scale patterns and whether these are or can be influenced by management actions such as artificial water provision, planned fires and herbivore management.

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

Jessica Hayes is the regional ecologist in Garden Route NP, working at the interface between science and management. During 2014 she was busy with the compilation of the Garden Route State of Knowledge Report and delved into wetland ecology in the latter half of the year.

During 2014, Judith Botha, program integrator, focused on analysing long-term datasets to detect environmental change and identify causal agents.

Karen Vickers has been a lecturer for OTS since 2007. Living and working in Kruger NP has allowed her to pursue a broad range of research related to understanding biodiversity pattern and process, with a particular focus on the relationship between vegetation structure and faunal community dynamics.
When not out running on the trails Kyle Smith, marine ecologist and generally just fishy person, spends a fair amount of time talking to anglers trying to figure what makes them tick (or fish, in this instance).

Laurence Kruger has been involved with OTS South Africa since its inception in 2003 and has been director of the programme since 2007. His primary interests lie in functional ecology, particularly species response to disturbance. Currently Laurence conducts a great deal of research on the effects of elephants and fire on savanna woodlands and how plants respond to this disturbance.

Laurence Kruger

Lizette van der Vyver (Moolman) is a fauna ecologist working in Garden Route NP, based at the Knysna office.

Llewellyn Foxcroft has an interest in all aspects of invasion ecology, linking basic ecological theory to applied, management-orientated problem solving. His work broadly focuses on examining patterns of invasive alien plants across SANParks and beyond. He has served as editor of Koedoe since 2008.

Llewellyn Foxcroft

Lizette van der Vyver (Moolman)

Louise Swemmer is a social scientist who promotes and facilitates research that aims to support the implementation of fair benefit sharing and effective constituency building for SANParks. Louise has a keen interest in applied research, and does most of her work in and around Kruger NP.

Markus Hofmeyr started at SANParks in 1999 as a veterinary biologist. Since 2003 he has served as head of the Veterinary Wildlife Services Department. Among other things he is responsible for SANParks and regional wildlife capture and translocations and veterinary support to research programs requiring handling of wildlife. Markus is currently also an extraordinary lecturer with the Department of Production Animal Studies at the University of Pretoria, from where he obtained his BVSc.

Markus Hofmeyr

Mbulelo Dopolo is the marine research programme manager at the CRC. In 2003 he obtained an MSc in Zoology at UCT, specialising in reproductive ecology of small pelagic fish. He joined SANParks in 2008. His research interests include: marine ecology and conservation, fisheries science and management, and social-ecology. Prior to joining SANParks he worked as a biological oceanographer at DAFF (formerly Marine and Coastal Management), and at the Department of Environmental Affairs and Development Planning.

Mbulelo Dopolo

Nicola van Wilgen conducts research on global change and its trends and impacts in national parks. Her interests include sustainable biodiversity conservation, with a particular focus on alien species, land-use change, resource use, data analysis and management, climate change and communication of research results to relevant stakeholders.

Nicola van Wilgen

Louise Swemmer
Nosipho Tyagana is a junior restoration scientist based at the CRC. Her current research includes determining the soil-stored seed bank of indigenous plant species following pine harvesting in Table Mountain NP and the restoration of Overberg Sandstone Fynbos in Agulhas NP. She is also interested in restoration work in Namaqua NP as well as in determining the distribution and patterns of grazing lawns in Bontebok NP.

Ntombizodwa Ngubeni is a forest ecologist working in forest ecosystems in Garden Route NP. Her research focuses on forest fire ecology, forest gap dynamics and resource use, particularly the non-timber forest products.

Peter Novellie has 31 years' service in SANParks, initially in research and later in research management and corporate governance.

As freshwater ecologist and geohydrology scientist, Robin Petersen's main focus is developing an effective and efficient river bio-monitoring programme.

Rod Randall is the general manager of Scientific Services, Garden Route. He continues to work on his long-term interest in seabirds and waterbirds, and the reasons for their (generally) declining populations.

Sam Ferreira is an ecologist with an interest in solving ecological problems. He conducts and facilitates research on factors influencing tempo-spatial dynamics and how ecological restoration can overcome the influences of human disturbances on ecosystems. His role in SANParks is to ensure that management of large mammals is underpinned by robust scientific information.

Samantha Mabuza first became acquainted with OTS as a student in 2011. Since joining SANParks as a junior scientist, she has been involved in compiling a report on work conducted by OTS in Kruger NP. She is currently undertaking an MSc looking at recruitment bottlenecks on some large trees in the park. Outside of the serious science, she is keen on getting fellow researchers to build a social media presence and connect with people outside their field.

Sandra MacFadyen is a PhD student with the Department of Botany and Zoology, Stellenbosch University. Her research focuses on understanding landscape dynamics in protected areas and biodiversity mapping. Prior to this, she was employed with SANParks for over 15 years, culminating with her position as the geospatial analyst for Scientific Services based in Kruger NP. Sandra continues to collaborate with SANParks friends and colleagues as she pursues her PhD studies fulltime.
For much of the year under review, **Stefanie Freitag-Ronaldson** has been the acting head of Scientific Services. In both this and her regular role as general manager of the Savanna & Arid Research Unit, she strives to ensure that SANParks’ science function evolves and remains relevant to the organisation, conservation and society. This is critical to guarantee that new and diverse forms of knowledge and understanding are used to make sense of and inform decisions around the challenging and pressing social-ecological conservation issues of today.

**Thabo Mohlala** is a biotechnician for SAEN specialising in aquatic ecology. He has an extensive background in freshwater ecology, ecotoxicology and impacts of climate change processes and a keen interest in studying temporal and spatial changes of aquatic ecosystems over time.

**Trevor Adams** is a terrestrial biotechnician at the CRC and provides scientific services for the Cape Cluster parks. He is responsible for the Species of Special Concern - Plants Monitoring programme and wetland ground truthing in the Agulhas plain.

**Vuyelwa Olayi** is a Groen Sebenza intern, with a background in environmental management and geohydrology. Her areas of interest include freshwater conservation, environmental resources management and environmental impact assessment. Current research includes data collection and archiving of scientific information pertaining to SANParks’ Cape Cluster parks, and freshwater monitoring that aims to assess the current levels of pollution and other impacts on rivers in Table Mountain NP.

**Wendy Annecke** is the general manager of Scientific Services, Cape Research Centre. She maintains research interests in social ecological systems, and in particular in participant observation of the role of fellow scientists in their natural environments.

**Wessel Vermeulen** is a forest ecologist and the manager of the Knysna office of Scientific Services in Garden Route NP. He has as specific interest in sustainable resources, fire in fynbos and forest ecosystems.

**Zishan Ebrahim** is an ecological geographer and GIS technician at the CRC. Since joining SANParks he has been involved with the monitoring of animal species of special concern, particularly those of freshwater habitats. He is currently doing his MSc in Zoology, focusing on the spatial distribution of amphibians (particularly their breeding sites) and the spatial extent of threats to threatened frogs and toads.
PHOTOGRAPH CREDITS

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Skukuza +27 (0)13 735 4325
A. Peer-reviewed journal articles by SANParks staff

(SANParks research staff indicated in bold)

Addo Elephant National Park


Garden Route National Park


Kruger National Park


West Coast National Park


Multiple Parks

General


Published by SANParks author, but conducted outside SANParks estate


B. Peer-reviewed journal articles related to South African national parks

(Not authored by SANParks staff)

Addo Elephant National Park


Agulhas National Park


Augrabies Falls National Park


Garden Route National Park


**Golden Gate Highlands National Park**


**Karoo National Park**


Kalahari Gemsbok National Park


Kruger National Park


Mapungubwe National Park


Namaqua National Park


Table Mountain National Park


**Tankwa Karoo National Park**


**West Coast National Park**


**Transfrontier Conservation Areas (of which SANParks is part)**


Multiple Parks


General


C. Books and book chapters by SANParks staff

(SANParks research staff indicated in bold)


D. Conference/forum presentations by SANParks staff

(first author; SANParks research staff indicated in bold)

National


Barendse, J., K. Smith, S. Oosthuizen, and D. Roberts. Every angler’s dream: Do 70 years of trophy fish catches reported in a Garden Route newspaper reflect known trends in linefish stocks or indicate baseline shifts? 15th Annual Southern African Marine Science Symposium, Stellenbosch University, South Africa, 15-18 July 2014. (Poster)

Baliwe, N. and M. T. Dopolo. Land-based boat monitoring of commercial and recreational fishing effort and catches in Table Mountain National Park marina protected area. 15th Annual Southern African Marine Science Symposium, Stellenbosch University, South Africa, 15-18 July 2014. (Poster)


Kraaij, T. and B. W. van Wilgen. Existing knowledge of fire ecology and past and current approaches to fire management in fynbos. 36th Annual Fynbos Forum, Knysna, South Africa, 4-7 August 2014. (Invited Keynote)


Moolman, L. and D. Rikhotso. Australian Blackwood windfall patterns in the forest interior of the southern Cape afrotemperate forests, South Africa. 36th Annual Fynbos Forum, Knysna, South Africa, 4-7 August 2014. (Poster)


Strydom, T., T. Rowe, E. Riddell, N. Govender, S. Lorentz, and P. le Roux. Pyrohydrology: Effects of fire treatments on soil hydrology in African savannas. 17th SANCIAHS National Hydrology Symposium, Cape Town, South Africa, 1-3 September 2014. (Best Student Presentation)


International


Bacela, W. Growing tourism revenue while ensuring equitable access for citizens. 6th IUCN World Parks Congress, Sydney, Australia, 12-19 November 2014.

Daemane, M. E. Understanding and strengthening the role of protected areas for disaster risk reduction and climate change adaptation: Factors that enable or hinder our ability to bring PA management, disaster risk reduction and climate change adaptation together. World Parks Congress Pre-workshop, Sydney, Australia, 9-19 November 2014.

De Goede, N. Cross border conservation in the /Ai/Ais-Richtersveld Transfrontier Park. 6th IUCN World Parks Congress, Sydney, Australia, 12-19 November 2014.

De Goede, N. Income generation of the /Ai/Ais-Richtersveld Transfrontier Park. 6th IUCN World Parks Congress, Sydney, Australia, 12-19 November 2014.


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Swemmer, L. K. Benefit sharing in SANParks, who wins, who loses and who cares? The 5th International INSASKA Symposium on Benefit Sharing, Cape Town, 14-17 April 2014.