Erratum to 2018 Annual Progress Report:

The following paper was published in a predatory journal and should be removed from the list of outputs of the Centre.

Nxele, B.J. and Shivambu, C.T. (2018). House Crow (*Corvus splendens*) eradication measures from eThekwini municipality, KwaZulu-Natal, South Africa. *Journal of Biodiversity Management & Forestry* **7**4 pages. DOI: 10.4172/2327-4417.1000200.

Issued by Sarah Davies
29 November 2019.

DST-NRF Centre of Excellence for Invasion Biology

DST-NRF Centre of Excellence for Invasion Biology

Annual Report

2018

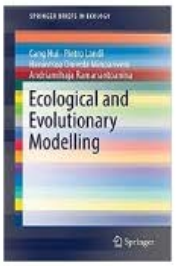
C·I·B performance in 2018

DST-NRF Centre of Excellence for Invasion Biology

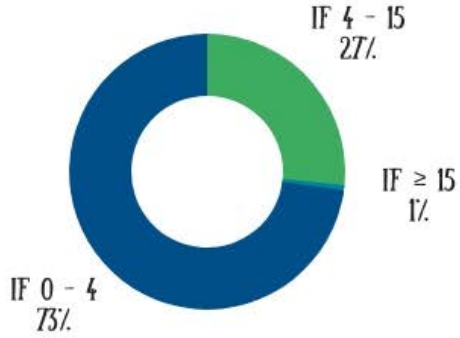
Research

Peer-reviewed products and authorship:

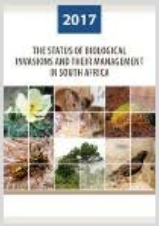
161 journal papers *
4 book chapters
1 book
33% student-led papers
*TARGET: 85



Peer-reviewed papers by impact factor:



Service provision



SANBI Biodiversity for Life
South African National Biodiversity Institute

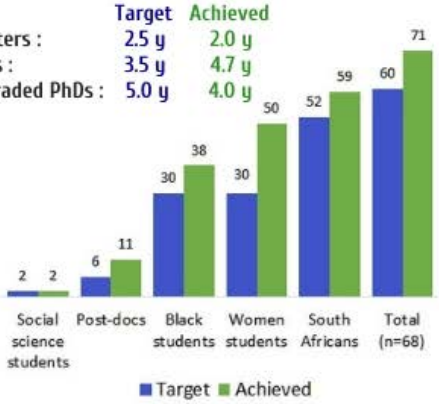
With SANBI, produced the first National Status Report on Biological Invasions

- Compliance:
- Core team members undertook 29 voluntary reviews on behalf of the NRF
- Submitted quarterly cash flow statements to the NRF
- Steering Committee meetings were held on 29 March & 14 November

Education & training

Average duration of degrees:

	Target	Achieved
Masters :	2.5 y	2.0 y
PhDs :	3.5 y	4.7 y
Upgraded PhDs :	5.0 y	4.0 y



Networking and Information brokerage

1 international conference organized
1 local conference organized
1 full team activity, ARM

38 international conference presentations
56 national conference presentations
115 joint venture student training initiatives

In partnership with WCED, limbovane worked with 23 schools, reaching 838 learners and 58 educators

Education Department

Centre for Invasion Biology · Stellenbosch University · Facebook: centreforinvasionbiology · Twitter: @InvasionScience · www.sun.ac.za/cib

Executive summary

Reporting period	:	1 January 2018 - 31 December 2018
Name of Director	:	Prof. David M. Richardson
Name of CoE	:	DST-NRF Centre of Excellence for Invasion Biology
Abbreviated CoE Name	:	Centre for Invasion Biology
Host institution	:	Stellenbosch University

Progress against Key Performance Areas

Research

The C·I·B's research in 2018 addressed a wide range of disciplines, scientific approaches, issues, spatial and temporal scales, and taxa. We published ~~162~~ 161 peer-reviewed papers in ~~109~~ 108 different journals (91% ISI-accredited), including contributions in the high-impact journals *Biological Reviews*, *BioScience*, *Ecology*, *Global Change Biology*, *Journal of Applied Ecology*, *Methods in Ecology and Evolution*, *Nature Communications*, *Nature Climate Change*, and *Proceedings of the National Academy of Sciences of the United States of America* (all with Impact Factors greater than 5). Our publications covered many of the most pressing issues in invasion ecology internationally and in a South African context, and the full spectrum of focal areas identified in the C·I·B's Strategic Plan for 2015-2019. Our research addresses fundamental issues related to the biology of invasive species, aspects of invaded ecosystems, invasion processes, and many facets of the human dimensions of invasions.

Education and Training

Sixty student registrations (90% South African) and 11 post-docs (45% South African) were supported by the Centre during 2018. Eight of our PhD students graduated and all are employed with partner organizations or are continuing their academic careers. Many of our alumni occupy important positions in a range of sectors including businesses, consultancies, government agencies and NGOs and CBOs. We continued the 3rd-year undergraduate module on Invasion Ecology at Stellenbosch University; in 2018, fifty students completed the module.

Networking

The C·I·B again co-ordinated productive interactions with partner organizations and assisted our key partners with important interactions. The main networking activity in 2018 was the co-ordination of a workshop to explore the feasibility and desirability of establishing an invasion science network for BRICS countries. The workshop was attended by invasive species researchers from Brazil, India, China and South Africa. The C·I·B Fellows programme again brought a range of new insights to our initiatives and we hosted fellows from Australia, France and Sweden.

Information Brokerage

The C·I·B's information brokerage KPA continued to be very diverse and productive. Two workshops were held, on 'Biological invasions in South Africa: trends and implications for management', and

'The importance of international networks in invasion science', and will lead to published products and new international collaborations. The Annual Research Meeting was highly successful, with a strong emphasis on science communication by students and post-doctoral associates. The Iimbovane Outreach Project diversified its engagement partners, working with disable people and holding intensive learner workshops on the Stellenbosch University campus. The C·I·B continued to engage with its partners and audience via social media, articles and interviews in the popular media.

Service Provision

Our headline contribution to service provision in 2018 was the formal publication of the first National Status Report on Biological Invasion in South Africa by the Department of Environmental Affairs. This report, the first of its kind worldwide, was produced in collaboration with South African National Biodiversity Institute in terms of the 2014 regulations under the National Environmental Management: Biodiversity Act (NEM:BA; Act 10 of 2004). C·I·B core team members Brian van Wilgen and John Wilson were the lead editors, and many other C·I·B team members were co-authors of chapters. The National Status Report has attracted much publicity nationally and internationally.

Many of the Centre's members provide regular inputs to policy and management initiatives. Our crucial collaboration with SANBI, especially in the area of risk assessment, is a major contribution in this regard. Sabrina Kumschick (C·I·B), John Wilson (SANBI) and Llewellyn Foxcroft (SANParks) worked on developing best-practice methods of risk assessment for invasive species.

C·I·B-affiliated researchers hold prominent positions as Editors-in-Chief, Editors, Associate Editors, and serve on Editorial Advisory Boards of many top journals. Importantly, the C·I·B is well represented on the editorial boards of the two main specialist journals in the field of invasion science: *Biological Invasions* and *NeoBiota*.

What was the gender impact of the C·I·B's work?

Women form 24 % of the C·I·B's core team and 41% of our research associate network. All of the hub staff are women, and importantly, the all-woman Iimbovane team is a strong role model for inspiring secondary science learners to take up scientific careers. Our student body is 70% female, and 73% of our post-doctoral associates are female. The C·I·B makes every effort to provide an inclusive and friendly yet professional environment where all genders and cultural groups feel welcome and are given opportunities able to be productive and grow. These efforts include a range of training events and academic meetings where training takes place, as well as science communication and personal development training opportunities and coaching. Women consistently perform well in our annual awards for writing (80% of the finalists in the C·I·B/The Conversation Africa Science Communication Awards were women) and oral presentation (70% of the Fame Lab finalists were women).

Red Flags

The overriding red flag issue for 2018 was sustainability; C·I·B management and staff devoted much of their time to discussion and writing of submissions to the Department of Environmental Affairs

(DEA), the Department of Science and Technology (DST) and the National Research Foundation (NRF). We held meetings with key stakeholders to discuss potential future directions for the Centre. The C·I·B management team, SU management and delegations from the DST and NRF met in the latter part of the year to discuss future scenarios and funding of the C·I·B. Prof. Yonah Seleti, Ms Rose Msiza and Mr Leluma Matooane represented DST and Mr Nathan Sassman represented NRF. The two productive meetings led to some important agreements:

- DST is generally happy with the C·I·B work as a multi-disciplinary research entity delivering 'Invasion Science for Society'. The shape and size of the C·I·B is appropriate and the current KPAs should be retained;
- Data management is an area that could be scaled up in the future C·I·B;
- Funding for the core costs of the CoE are likely to be forthcoming from DST;
- DST will give thought to how to help the C·I·B engage with DAFF and other government departments to ensure that the C·I·B's activities are effectively integrated within the larger global change initiative of government;
- DST expressed satisfaction with the range of partner support obtained by the Centre;
- The financing from partner organisations other than DST needs to grow, and DST agreed to broker in-depth discussions with relevant government departments, particularly DEA and DAFF.

Below is a list of the key interventions made over the past two years to secure the future of the C·I·B. Several of the interventions are still awaiting responses from government agencies.

Date	**Communication**	**Recipients/attendees and response**
6 June 2017	Sustainability plan submitted to NRF (document)	DG Pillay; M Khati
26 October 2017	Revised sustainability plan presented to Steering Committee (document)	F Mazibuko
13 July 2017	Request for meeting with DG (email and attached document)	N Ngcaba; P Lukey *Awaiting response*
29 August 2017	Follow-up request for meeting with DG (email and attached document)	P Lukey; G Preston; N Ngcaba *Awaiting response*
12 December 2017	DEA pitch for support/value proposition (document)	J Donaldson; G Preston *Awaiting response*
9 October 2018	Discussions with DST and NRF (meeting)	Y Seleti; L Matooane; N Sassman
15 November 2018	Follow-up discussions with DST (meeting)	Y Seleti; L Matooane; R Msiza
29 November 2018	High level vision for future directions (document)	Y Seleti; L Matooane; R Msiza *Awaiting response*

Natural Resources Management Programme

A second major red flag in 2018 related to ongoing problems experienced in collaborations with our primary 'industry partner' the Department of Environmental Affairs Natural Resources Management

Programme (DEA NRM). Since 2008 the C·I·B has worked with DEA NRM to meet its research, capacity building and demographic goals, and in our view, we have been successful, training 80 students and producing 103 research papers from our collaborations.

The C·I·B responded to a DEA tender for further collaborative research in September 2017. To date, no appointment has been made, despite protracted contract negotiations. This period is critical because the sustainability of the CoE is in question, and the Centre faces the possibility of losing research, support staff and promising students because we are unable to provide viable solutions and a way forward for our team members. We are concerned at the inability of the C·I·B to interact productively with DEA NRM at this critical time in the Centre's development, and that this will have long-term impacts on invasive species management in South Africa.

General Comments

The C·I·B is going from strength to strength. Its place as a global leader in Invasion Science for Society was highlighted at several international forums during 2018. At a workshop on interdisciplinary research in invasion science in Florida, USA, in January 2018, the C·I·B was repeatedly hailed as a useful model for effective invasion science institutes globally. C·I·B Director Dave Richardson gave a plenary talk at the NeoBiota conference in Dublin, Ireland, on the C·I·B model. Again, there was general agreement that the Centre has done exceptionally well on multiple fronts. Similar levels of enthusiasm are generally aired in meetings with South African stakeholders, but the question of whether we can broaden the funding base to support the Centre's activities remains the biggest unresolved issue in such discussions.

Contents

1 RESEARCH

1.1 Objectives

The C·I·B's research aims to reduce the rates and biodiversity impacts of biological invasions by understanding how these can be reduced and remediated through appropriate policy interventions, and how interactions among global change drivers, especially climate change and biological invasions, might further influence the impacts of biological invasions and alter policy advice.

Our projects and integrated programmes of research target all aspects of the phenomenon of biological invasions, all taxonomic groups and all ecosystems. A better understanding of invasion patterns and processes is required, and options for management and remediation need to be explored in multiple ways. Each stage in the invasion process (pre-introduction; initial incursion; expansion; and dominance) demands special tools, insights and types of study.

Besides the aspects attached specifically to the aforementioned compartments, the C·I·B undertakes work under several overarching themes: Biological foundations, model systems, human dimensions, basic inventories, modelling capacities, policy formulation and risk assessment. This suite of themes provides the scope for cutting-edge work in invasion science, while providing opportunities to draw in students from diverse biological fields (from fundamental to applied) and many other disciplines.

1.2 Progress

Short-term strategic research priorities are grouped under the following major headings: biodiversity foundations; acacias as model systems for understanding invasions and impacts; detection, demonstration, responses and remediation; global environmental change and ecosystem services; and human dimensions. Molecular methods as a tool in invasion science are a cross-cutting theme, as they are becoming increasingly widely used to identify the provenance of introduced species and for uncovering many aspects of the invasion process. The ability to distinguish apparently similar species at the cellular level is a fundamental component of the C·I·B's research tool box, and contributes substantially to many of the research projects detailed below. Further details of many research projects are available on the C·I·B's web site (http://academic.sun.ac.za/cib/). The projects summarized below give a flavour of the wide range of disciplines, taxa, spatial and temporal scales, and scientific approaches in the C·I·B's research during 2018.

Research focussed on many of the most pressing issues in invasion ecology and the full spectrum of focus areas identified in the C·I·B's strategic plan. Our research is addressing fundamental issues related to the biology of invasive species, aspects of invaded ecosystems, invasion processes, and many facets of the human dimensions of invasions.

1.2.1 Long-term collaborative research - Long-term change in arthropod assemblages

The C·I·B manages three long-term monitoring transects which gather data on invertebrate communities in relation to altitude, aspect, climate, vegetation and other biological variables. The system is summarised in Table 1. The plan is to analyse long-term data from the three transects separately and together to advance our understanding of the relationship between biodiversity and climate using hyper-diverse insect groups such as ants. As the long-term data sets reach maturity, the analysis and publication of this work will be an ongoing collaboration between C·I·B core team members and the Universities of Monash (Australia) and Oxford (UK). Data from the transects are increasingly being used in global analyses such as the one discussed below.

Table 1: Summary of the C·I·B's long-term monitoring of insect assemblages.

Dates	Sites	Replicates per site	Traps per replicate	Aspect	Sampling periods	Elevation range (m amsl)	Arthropod groups sampled
Cederberg							
2002-2014	17	4	10	W	Mar, Sep	0-1926	Ants, carabid beetles and spiders*, climate
2015 onwards	17	4	10	W	Mar, Sep	0-1926	Climate only
Sani Pass							
2006 onwards	8	4	10	E	Jan, Sep	900-3000	Ants, climate
Soutpansberg							
2009 onwards	11	4	10	N, S	Jan, Sep	800-1700	Ants, beetles and spiders*, climate

***spider by-catch is donated to the South African National Survey of Arachnida**

THE DOMINANCE-DIVERSITY RELATIONSHIP IN ANTS

A study by a team of international researchers, including former C·I·B post-doctoral associate Tom Bishop, showed that invasive dominant ant species have different effects on the diversity of the wider ant community than native dominant species (Arnan *et al*. 2018; *Global Change Biol*. 24: 4614–4625). It has long been recognised that a subset of ant species can be classed as 'behaviourally dominant'. These dominant species exert a strong influence on other ants through their highly aggressive and territorial behaviour. Understanding the impact that these species have on the rest of the ant community is central to understanding how invertebrate biodiversity is shaped and maintained across the globe. As a result, an important research theme in ant ecology has been the dominance-diversity relationship. This describes the relationship between the number of ant species found in an area and the presence or abundance of dominant species. Often, this relationship appears as a hump shape: species richness is high at intermediate levels of dominant ant abundance. Typically, it is assumed that this effect is caused by dominant ants competitively excluding other, non-dominant ant species.

Using a global dataset of over 1 000 local communities, including data from the C·I·B transects, Bishop and colleagues tested whether the dominance-diversity rule held across a wide range of habitats and conditions. They found the classic dominance-diversity hump shaped relationship (Fig. 1). This was not the case, however, in sites that had invasive dominant species. When dominant invasive ants were present, increases in the abundance of dominant ants nearly always led to a decline in species richness. Indeed, species richness in uninvaded communities was consistently higher than in invaded communities. This study is correlative in nature, but shows the global impact that invasive ant species can have on natural communities. The researchers conclude that there is in fact a diversity of dominance-diversity relationships! There appears to be one rule for natural systems and another for invaded ones.

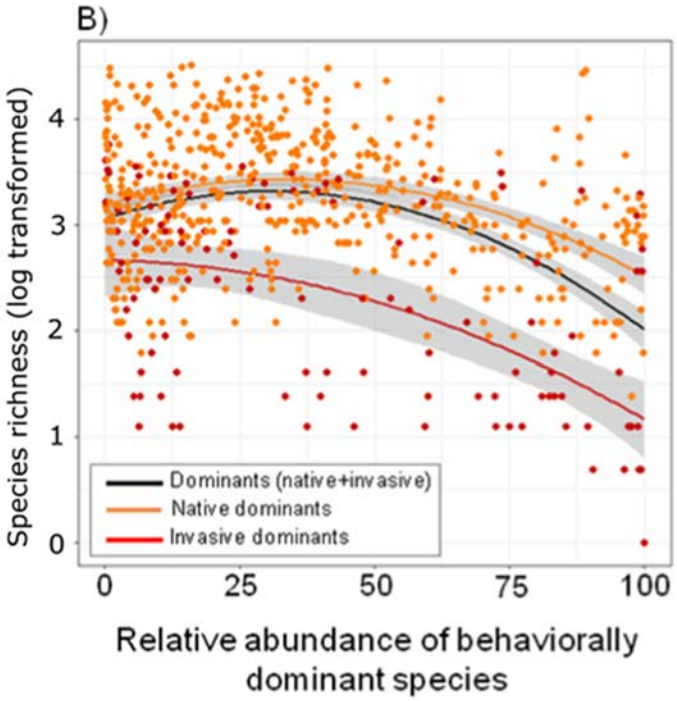


Fig. 1. The relationship between species richness and the abundance of dominant ants. The red line shows the decline in local species richness when invasive dominants are present, the orange line shows the pattern when only native dominants are present.

1.2.2 Biodiversity foundations

Recognizing the significance of the foundational aspects of biology and the social sciences within the context of invasion biology, and the fact that human activities can often not be clearly separated from natural processes, the C·I·B has undertaken much foundational work over its lifespan. Such work has also been essential to draw in students and collaborators who are particularly interested in 'the workings of nature' rather than on particular framings of biological invasions. The examples chosen to discuss in this report focus on emerging insights on 'redistribution ecology', the effects of

climate change on native species assemblages, and the complex links between native tree density and termite activity.

AN INTERDISCIPLINARY AGENDA TO ADVANCE SPECIES REDISTRIBUTION RESEARCH

Climate change is leading to the redistribution of species across the Earth, with important socio-economic and governance consequences, but research in this field is still not sufficiently interdisciplinary. A group of international scientists from across the physical, biological and social sciences set out to review how species redistribution research can best advance by working across disciplinary boundaries. The work was led by University of Hong Kong Ass. Prof. Timothy Bonebrake and included C·I·B post-doctoral fellow Raquel A. Garcia.

As temperature and precipitation patterns change in the Anthropocene, some areas become unsuitable for resident species whereas other areas become attractive to newcomers. The end result is a redistribution of biodiversity, with both losses and gains of species. Over the last 30 years, researchers have been documenting the patterns of shifting species, investigating the mechanisms underlying the shifts and trying to predict future patterns. But only more recently has the debate turned more actively to the challenges that species redistribution brings to our society and economy.

Challenges arise particularly when dependence on natural resources is high. Communities whose livelihoods rely on species that are disappearing because of climatic changes or competition by invasive newcomers are potential losers. By contrast, those that are able to adapt to using newly arrived species are potential winners. As disease vectors move to newly suitable areas, so does the incidence of infectious diseases. For both winners and losers, challenges also emerge when species distributions shift across jurisdictional or ownership boundaries.

Biodiversity redistribution defies conservation and natural resource management paradigms that are static in time and space, encouraging innovation. The review outlines key needs and directions in ecological, conservation and socio-economic research on species redistribution. The authors highlight emerging solutions such as real-time management systems for resource use, partnerships with landowners and indigenous communities to maintain landscape connectivity, and managed species relocation.

But creativity is also needed in research (Fig. 2). Understanding the implications of species range shifts for ecosystem services and disservices delivered to society, such as food provision and diseases, requires interdisciplinary efforts. Researchers are increasingly harnessing citizen science and engaging indigenous communities and the agriculture and fishing industries in species monitoring programmes. As climate changes continue and the inter-connectedness of the natural and human systems becomes more apparent, these new ways of doing research are bound to become mainstream.

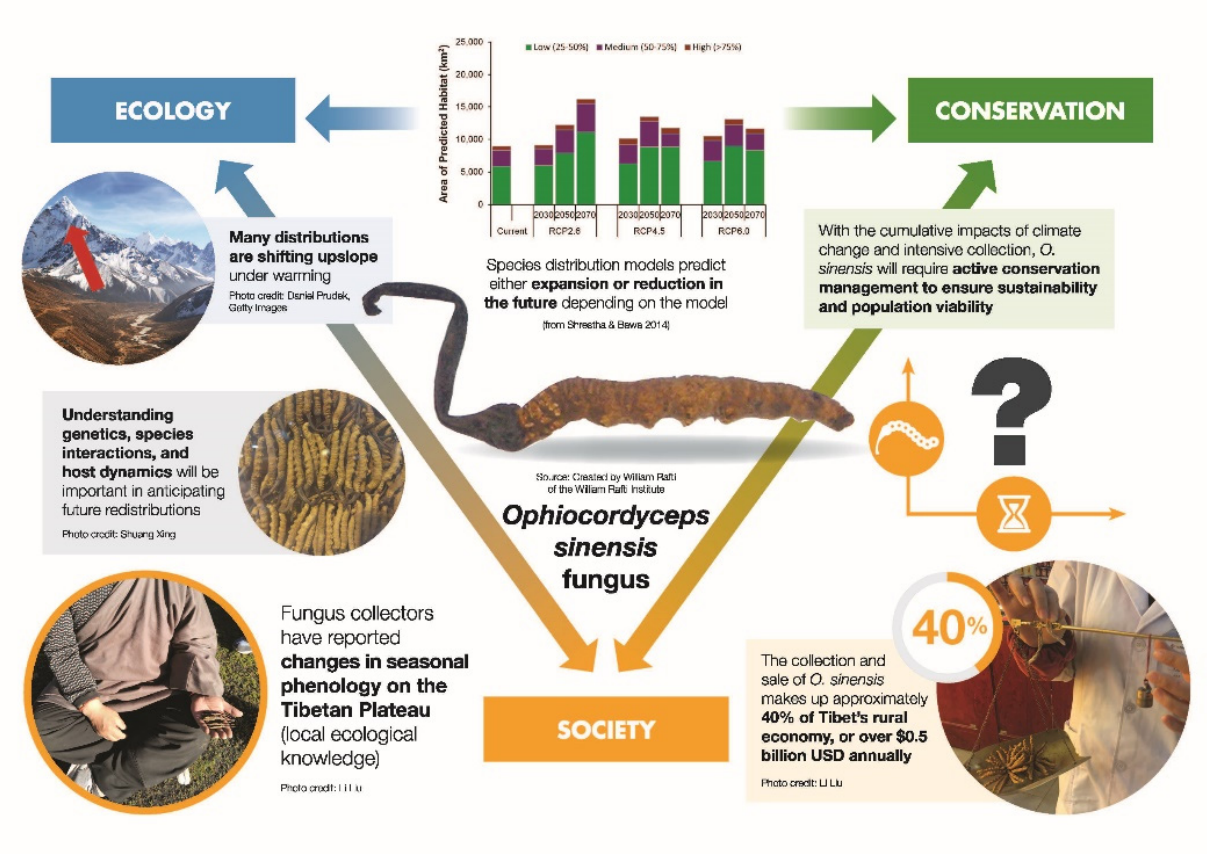


Fig. 2. Understanding and preparing for species redistributions requires interdisciplinary research into the biogeography and ecology of species, their economic and social value, and the conservation options available. An example showing this interconnectedness is the caterpillar-feeding fungus of the Tibetan plateau (*Ophiocordyceps sinensis*). Researchers have detected upslope shifts of the species' distribution and fungus collectors have reported phenological changes, but reliable predictions hinge on improved knowledge of the physiology of the species and the dynamics of its interaction with the host caterpillar species. Shifts in the fungus distribution affect the indigenous communities whose livelihoods depend on this species for income. Conservation actions should thus be informed by the scientific and indigenous knowledge about existing threats to the fungus, including climate change and intensive collection, as well as the economic opportunities the species brings for local communities.

HOW VULNERABLE ARE FYNBOS FISH TO CLIMATE CHANGE?

The Western Cape at the south-western tip of Africa is a global hotspot of biological diversity. Although best known for its diverse and unique vegetation, the fynbos, less well known is that the rivers flowing through the fynbos-covered mountains also support an unusually high number of unique aquatic species. In particular, the freshwater fishes living in our fynbos rivers are typically found nowhere else on the planet – a staggering 20 of the 23 known species are endemic to the Fynbos region (Fig. 3).

Instead of celebrating these unique and charismatic fishes, biologists are growing increasingly concerned about their conservation status; at present 14 of the 20 endemics are listed as either Vulnerable, Endangered or Critically Endangered in the IUCN Red Data Book. Key factors responsible

for this high threat rate include impacts of invasive animals and plants, and declines in habitat quality and quantity resulting from human impacts stemming from agriculture and urbanisation.

More recently, an additional human-linked pressure, global climate change, has been earmarked as an additional pressure that may compound other impacts and could drive already fragile populations off the map. However, climate change impacts on our fynbos fishes had not been studied until recently.

C·I·B-funded post-doc Jeremy Shelton and colleagues undertook a vulnerability assessment to determine how the added threat of climate change might alter the conservation status of these already-stressed fishes. They adapted an approach developed by Peter Moyle of the University of California Davis for assessing stream fish vulnerability in US streams, and applied it to 20 native and 17 non-native freshwater fishes in the Western Cape.

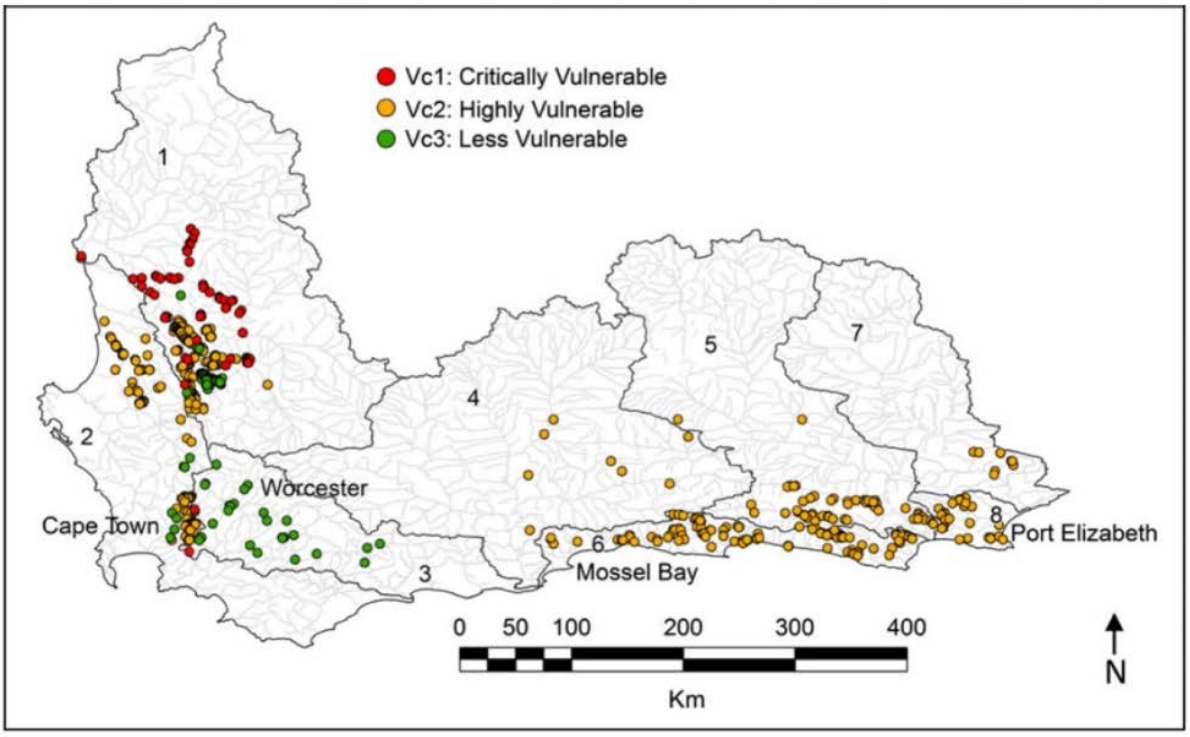


Fig. 3. Native fish vulnerability hotspots (shown as red dots) in the upper Berg, Breede and Olifants River catchments of the Western Cape. These are areas of especially high conservation value based on available data and expert opinion. Catchments are: 1 = Olifants- Doring, 2 = Berg, 3 = Breede, 4 = Gouritz, 5 = Gamtoos, 6 = coastal, 7 = Sundays and 8 = Swartkops.

The analysis, which draws on expert opinion where empirical data are lacking, revealed (1) that native species were generally more vulnerable to extinction than were non-native species under climate change scenarios, (2) that the climate change impacts are expected to increase the vulnerability of most native, and some non-native, species, and (3) that vulnerability hotspots

requiring urgent conservation attention occur in the Olifants-Doring, upper Berg and upper Breede River catchments in the south west of the region.

“In a country where capacity for freshwater conservation is scarce, it’s vital we focus limited resources on the areas that need them most – places where species extinctions can be prevented with strategic conservation interventions” adds Shelton.

Besides providing guidance for prioritizing management interventions, the study highlights the need for reliable data on the biology and distribution of many fynbos fishes, and argues that identification of priority rivers for protection should be based on multiple sources of data ranging from expert opinion through to field surveys.

WOODY ENCROACHMENT SLOWS DECOMPOSITION AND TERMITE ACTIVITY IN AN AFRICAN SAVANNA

A recent study found that encroachment by *Dichrostachys cinerea*, a native woody plant, slows decomposition and reduces termite activity in savannas. This was the surprising finding of a study by Monica Leitner, MSc candidate, and a team of researchers. The team included Mark Robertson, a C·I·B core team member from University of Pretoria, Andrew Davies from the Carnegie Institution for Science, Kate Parr from University of Liverpool and Paul Eggleton from the Natural History Museum in London. The study investigated the impact of woody encroachment on decomposition and termite activity in African savannas (Leitner *et al*. 2018; *Glob. Change Biol*. 24, 2597-2606).

Savannas comprise grass and trees, but the cover of woody plants making up the tree layer is increasing in savannas around the world. These open grassy savannas are being converted to dense thickets by a process known as woody encroachment or bush encroachment. An increase in woody plant cover in savannas reduces grazing capacity for herbivores, and alters processes that can lead to changes in ecosystem function. Plant litter decomposition is an important process that influences nutrient cycling and carbon storage. To date very few studies have investigated how encroachment influences plant litter decomposition through its effect on the decomposer community.

Leitner and colleagues investigated plant litter decomposition in a semi-arid African savanna with high levels of encroachment by *Dichrostachys cinerea*. They measured grass litter decomposition in ten encroached areas and ten open savanna areas. They found that grass litter decomposed twice as fast in open savanna than in encroached areas. Furthermore, termite activity and abundance was significantly lower in encroached savannas than in open savannas. The authors suggest that a decline in fungus growing termites in these encroached areas is the likely explanation for the reduced rate of decomposition in encroached areas.

Fig. 4. Open savanna (left) and bush encroached area (right) of Madikwe Game Reserve. (Photos: M. Leitner)

Termites are known to influence soil properties, hydrology, vegetation communities and herbivory in savannas. Evidence to support the idea that changes in the termite community are responsible for changes in decomposition rate is supported by both the reduced number of termites that they sampled in encroached areas, and by the slower decomposition rates they recorded when they experimentally suppressed invertebrates in this study.

"The results of our study suggest that woody encroachment has the potential to substantially alter aboveground litter decomposition and termite activity in African savannas", says Leitner. "These findings have important implications for ecosystem functioning given the vast expanse of savannas across Africa, which covers more than 13 million square kilometres".

1.2.3 Model systems for understanding invasions and their impacts

Several key groups of organisms and settings (including Australian acacias, the harlequin ladybird, *Xenopus laevis* and environments such as urban areas and agricultural contexts) were, for various reasons, selected as model groups or systems for gaining important insights on the full range of challenges and management options associated with introduced species in South Africa.

Acacias as model systems for understanding invasions and impacts

Invasive acacias have commercial and other benefits in certain contexts, but increasing negative impacts in others. They also have substantial influence (positive and negative, depending on geographical and socio-political context) on ecosystem services. Introductions and plantings of acacias in South Africa and other parts of the world has created a valuable natural experiment for elucidating many key aspects of invasions science. Australian acacias have featured prominently in research undertaken at the C·I·B over the past decade.

UNRAVELLING THE GENETIC STRUCTURE ACROSS THE NATIVE RANGE OF THE GLOBALLY INVASIVE TREE SILVER WATTLE

C·I·B post-doctoral associate Heidi Hirsch and co-authors, including C·I·B core team members, Jaco Le Roux and Dave Richardson, investigated the genetic structure among the native populations of the Australian tree *Acacia dealbata*, commonly known as silver wattle.

The study links to a previous paper (Hirsch *et al*. 2017; *Biol. Invasions* 19: 1715–1722) which highlighted how taxonomic uncertainties can complicate inferences in invasion biology. Silver wattle is native to the eastern and south-eastern parts of mainland Australia and Tasmania, and is an important invasive species globally, including in South Africa. The species was previously thought to comprise two subspecies, which differ in their environmental requirements and morphological traits.

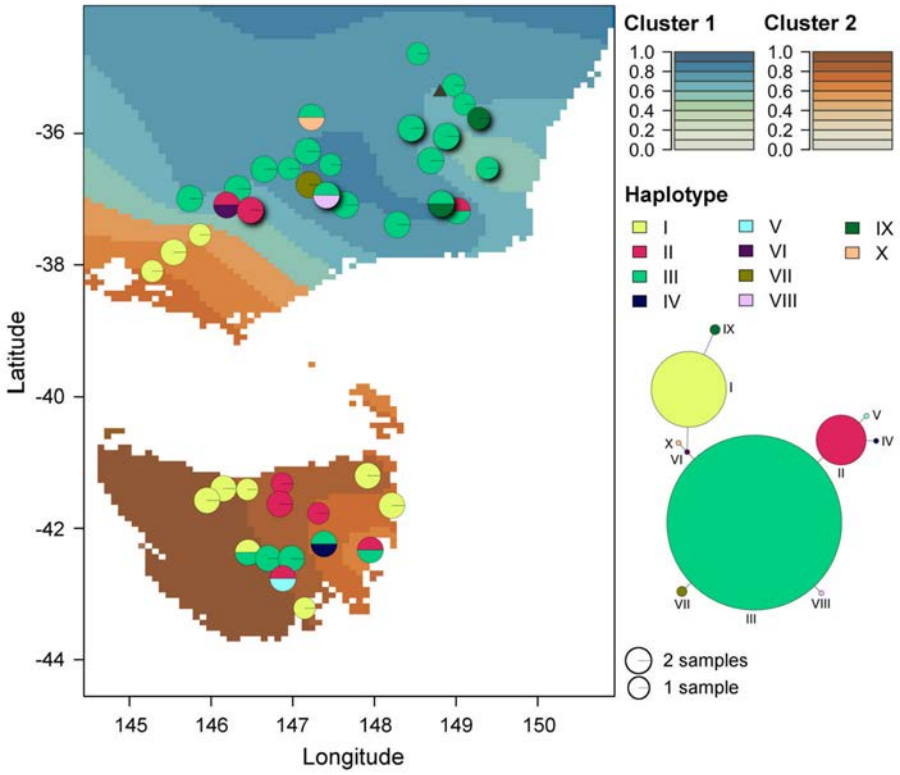


Fig. 5. Spatial interpolation of the ancestry coefficients estimated by STRUCTURE for the optimal number of genetic clusters (K = 2) among native population of Acacia dealbata in southeastern Australia.

The 2017 study used niche modelling and DNA sequencing approaches and could not detect any signs of a taxonomical differentiation within silver wattle in its native range. It is, however, likely that such a differentiation happened only relatively recently and is therefore not detectable in the conservative DNA regions that were sequenced. Consequently, the 2018 study applied a fine-scale population genetic analysis based on hypervariable microsatellite markers to investigate the genetic

structure of native silver wattle populations in more detail. Even using this approach it was not possible to differentiate the two putative subspecies of silver wattle in Australia. Rather, the work showed that there are two geographically distinct genetic clusters, corresponding to populations in the Australian mainland and in Tasmania (Fig. 5). Formal subspecies descriptions of silver wattle are therefore not valid and the work suggests that morphological differences within the species' native range are more likely to be explained by high levels of phenotypic plasticity.

Hirsch explains, "Again, we were not able to find genetic evidence for a taxonomic subdivision of silver wattle and, based on these results, I think a taxonomic revision for *Acacia dealbata* is called for. The identified genetic structure among the native populations, however, provides information that can be of importance for conservation managers in Australia where the species is used for local restoration plantings. The results are important for investigations on the invasion history of the species in South Africa; this is the focus of ongoing work at the C·I·B."

THE IMPORTANCE OF SOIL LEGACY EFFECTS AND SUCCESSFUL MUTUALISTIC INTERACTIONS DURING INVASIONS OF AUSTRALIAN WATTLES IN NUTRIENT- POOR ENVIRONMENTS

Non-native plants often alter environments they invade, favouring their own performance through positive feedbacks. Plant–soil interactions represent one such mechanism, but their complexity (e.g. invader-induced changes in soil nutrients, microbial communities, etc.) makes inferences of the precise mechanisms that benefit invaders difficult. Invasions of woody plants in fynbos ecosystems provide excellent opportunities to explore such mechanisms.

C·I·B core team member Jaco Le Roux and co-workers set out to determine: (1) whether invasion by wattles changes the diversity and structure nitrogen-fixing soil rhizobial community, and (2) the importance of available rhizobia and overall invader-induced soil changes as mediators of the performance of invasive wattles.

They sampled soils from invaded and nearby uninvaded areas in the fynbos biome and, using next-generation sequencing, compared rhizobial communities between invaded and uninvaded soils. They then determined the relative importance of invasion status (invaded vs. uninvaded), in conjunction with rhizobial addition, in explaining the performance of invasive acacias under common garden conditions.

The next-generation sequencing revealed that invaded soils generally had lower rhizobial diversity and were more homogenous in species composition than uninvaded soils. Bradyrhizobium strains, the most common known rhizobia associated with wattles, were more abundant in invaded than uninvaded sites (Fig. 6). The greenhouse experiment found significantly reduced growth performances of wattles in uninvaded relative to invaded soils for most species by site comparisons, and almost no influence of additional rhizobial inoculum. However, the overall relationship between nodulation and growth kinetics was much steeper for plants grown in uninvaded compared to invaded soils.

Although invasive wattles clearly homogenize the composition of nitrogen-fixing rhizobia and reduce diversity, it appears that mutualist availability poses no significant barrier to wattle establishment. Although acacia-induced changes to soil conditions enhance plant performance, successful nodulation seems important for early-growth performance when encountering novel soil conditions.

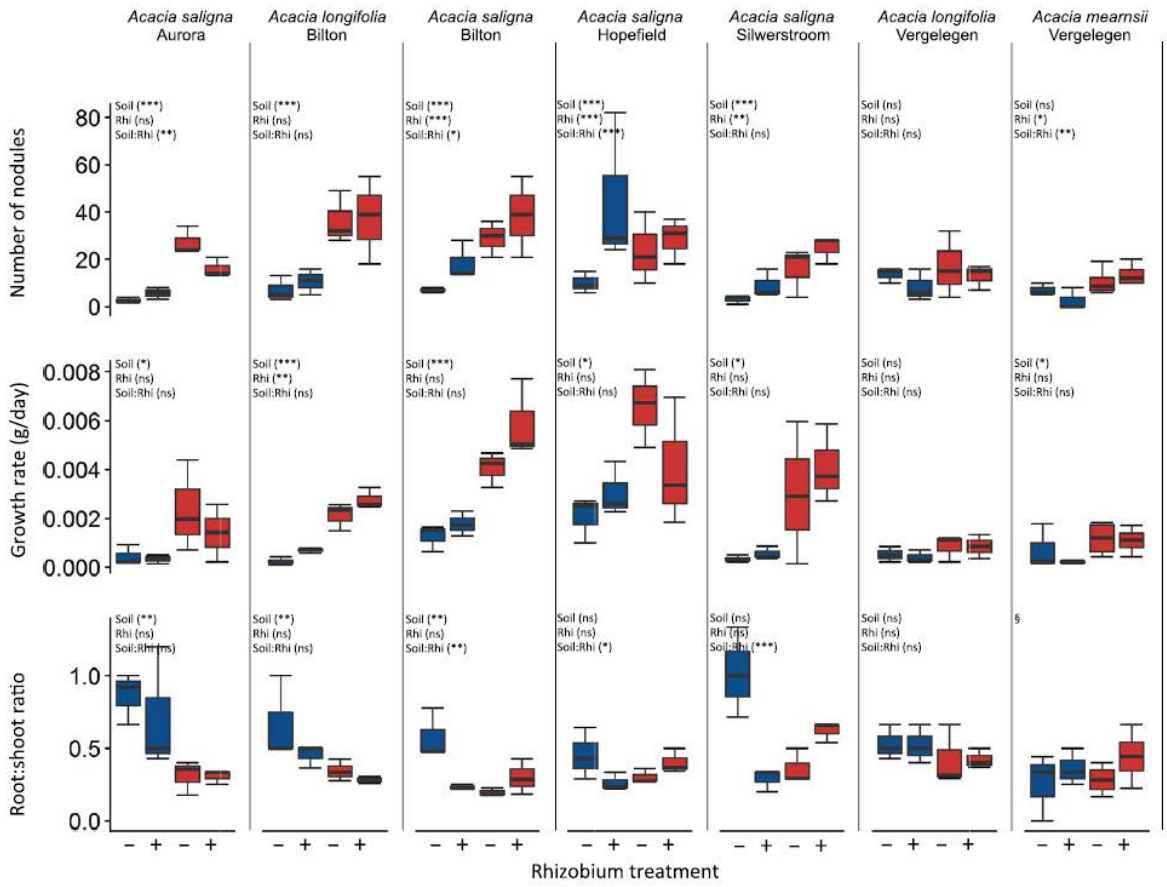


Fig. 6. Boxplots illustrating the effects of soil conditions (invaded and uninvaded) and rhizobial inoculum treatment on the nodulation and growth kinetics of three invasive Australian wattle species in the Western Cape.

BARRIERS TO RESTORATION PRESENTED BY SOIL LEGACY EFFECTS

The soil legacy effects of invasive nitrogen-fixing woody species such as Australian wattles can create fundamental barriers to the restoration of native plant communities. This was the finding of a recent review paper by C·I·B PhD student, Mlungele Nsikani who worked with C·I·B core team members Brian van Wilgen and research associate Mirijam Gaertner (Nsikani *et al*. 2018; *Rest. Ecol*. 26: 235–244).

Legacy effects are those where changes in biological, chemical or physical conditions remain evident even long after removal of the invader. For example, changes in the soil microbial composition can

be a legacy effect after clearing invasive nitrogen-fixing woody species, such as wattles. These changes become a barrier to restoration by limiting the germination and/or growth of native plant species.

Numerous studies have described individual legacy effects of nitrogen fixing invasive woody species, how they can present barriers to restoration of native plant species, and how these barriers can be managed. However, restoration ecologists still lacked a broad review of all these aspects despite their consideration being crucial to improving restoration efforts. To address this, Nsikani and colleagues reviewed 440 scientific papers to identify barriers to restoration presented by soil legacy effects and potential management actions to improve restoration.

The literature review highlighted the need for restoration ecologists to investigate all potential barriers to restoration during restoration programs. Furthermore, given that they are appropriate in context, restoration ecologists would benefit by applying the management actions included in this review. For example, restoration ecologists could apply soil microbial treatments to manage changes in the soil microbial composition (Fig. 7).

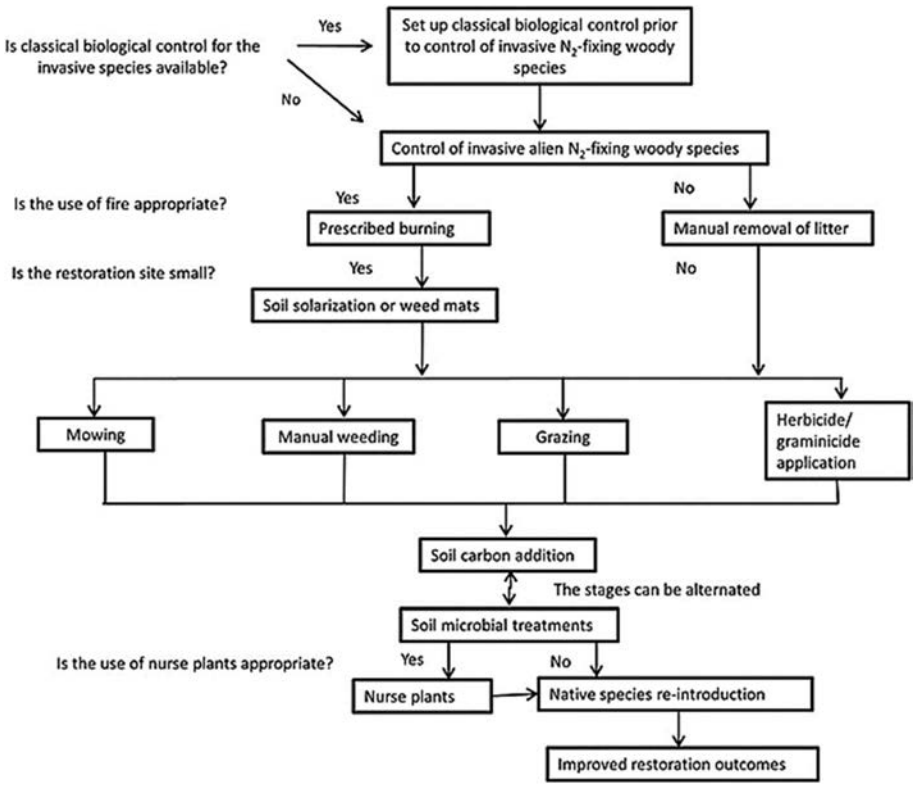


Fig. 7. How to combine potential management actions to address barriers to restoration presented by soil legacy effects of invasive alien N2-fixing woody species into an integrated management effort to improve restoration outcomes.

The paper encouraged restoration ecologists to write-up and publish their results (even if no legacy effects are found) after investigating potential barriers and/or applying management actions

identified in this review. To improve restoration efforts, management actions should be combined into an integrated management effort instead of being applied individually.

“Barriers to restoration arising from soil legacy effects will most likely have to be tackled during restoration programs,” said Nsikani, “if we are to have any hope of success in restoring native plant communities in previously invaded areas”.

FIXING THE RONDEGAT RIVER AFTER INVASIONS

For some vegetation restoration projects, simply removing invasive alien plants might not be sufficient to restore the native flora. C·I·B post-doc Jennifer Fill, C·I·B Chief Technical Officer Suzaan Kritzinger-Klopper, and C·I·B core team member Brian van Wilgen documented some unexpected outcomes of alien plant removal along the Rondegat River, an ecologically important river system in the Western Cape Province, South Africa. The researchers set out to assess native fynbos vegetation recovery in the riparian zone, three years after alien invasive plants had been removed (Fill *et al*. 2018, *Rest. Ecol*. 26: 434-438).

Periodic surveys of restoration outcomes are necessary for monitoring progress towards project goals. The Rondegat river restoration project was initiated to remove invasive alien plants and fish from the middle and lower reaches of the river. In 2012, government agencies treated the river with the piscicide rotenone to eradicate alien North American smallmouth bass (*Micropterus dolomieu*). Between 2010 and 2012, invasive alien trees (e.g., black wattle, *Acacia mearnsii*) were also removed from the riparian zone. Follow-up treatments were carried out between 2013 and 2016 to remove emergent seedlings of invasive alien plants. Although several assessments of aquatic fauna recovery had been conducted during this period, the success of the project in restoring native riparian vegetation had not been reported.

In 2014 and 2015, the researchers compared riparian vegetation composition among four land use types along the Rondegat River. These included fynbos that had not been invaded by alien trees and shrubs; areas that were still invaded by alien trees and shrubs; areas that had been cleared as part of the restoration project; and cleared areas subsequently used as cattle pastures. It was expected that in cleared areas, from which alien vegetation had been removed, native fynbos vegetation would be recovering and should appear similar to uninvaded fynbos. Fill and colleagues found that clearing did allow remnant native shrubs to recover (Fig. 8) and native species richness was much higher in cleared sites and in pastures than in invaded sites. However, there had been unexpected rapid secondary invasion of cleared sites by alien and native weedy grasses, such as Bermuda grass (*Cynodon dactylon*), perennial veldtgrass (*Ehrharta calycina*), and Vaseygrass (*Paspalum urvillei*). These species increased in cleared plots and maintained high cover in pasture plots despite the recovery of native shrubs after clearing. Secondary dominance by such species could alter the trajectory of vegetation recovery and require additional active management, such as removal of secondary species and planting of native species.

Fill and colleagues advocate that regular, long-term monitoring should be implemented in restoration projects. “Monitoring is an absolutely essential part of project planning, in terms of scheduling and funding allocation,” Fill stated. “It helps us track progress and make appropriate and effective management decisions.”

Fig. 8. The Rondegat River in the Cederberg, Western Cape, before (left) and after (right) clearing the dense stands of *Acacia mearnsii*. (Photos: D. Impson [left]; J. Fill [right])

Xenopus laevis: a globally significant invader

THE ROLE OF XENOPUS AS A PREDATOR UNDER THE SPOTLIGHT

Predators can play an important role in regulating prey abundance and diversity, determining food web structure and function, and contributing to important ecosystem services such as regulation of agricultural pests and disease vectors. Thus, the ability to predict predator impact on prey is an important goal in ecology. Often, predators of the same species are assumed to be functionally equivalent, despite considerable individual variation in predator traits known to be important for shaping predator–prey interactions, like body size. This assumption may greatly oversimplify our understanding of within-species functional diversity and undermine our ability to predict predator effects on prey.

To explore these assumptions, C·I·B Masters candidate Corey Thorp and co-workers examined the degree to which predator-prey interactions are functionally homogenous across a natural range of predator body sizes. Specifically, they quantified the size-dependence of the functional response of African clawed frogs (*Xenopus laevis*) preying on mosquito larvae (*Culex pipiens*). Three size classes of predators, small (15–30 mm snout-vent length), medium (50–60 mm) and large (105–120 mm), were presented with five densities of prey to determine functional response type and to estimate search efficiency and handling time parameters generated from the models.

Results of the mesocosm experiments showed that the functional response of *X. laevis* changed with size: small predators exhibited a Type II response, while medium and large predators exhibited Type

III responses (Thorp *et al*. 2018; *PeerJ* 6:e5813 https://doi.org/10.7717/peerj.5813). Functional response data showed an inversely proportional relationship between predator attack rate and predator size. Small and medium predators had highest and lowest handling time, respectively. The change in functional response with the size of predator suggests that predators with overlapping cohorts may have a dynamic impact on prey populations. Therefore, predicting the functional response of a single size-matched predator in an experiment may misrepresent the predator's potential impact on a prey population.

Study leader and co-author of the paper, C·I·B core team member John Measey expands on the implications of this research: "Our results suggest that studies in which predators are size matched may be misleading when trying to predict the effects of native vs invasive species. Ecological interactions are notoriously complex and variation in size of predators and prey likely lead to different outcomes."

Invasions in urban areas

A 'CITY OF CHOICE' FOR URBAN FERAL CATS?

The feral cat, *Felis catus*, is considered as one of the 100 world's worst invasive alien species and has the potential to colonize a wide range of habitats with its high fecundity rate and its ability to obtain resources from its surroundings. Feral cats are mostly active at twilight and during the night and are described as domestic or stray cats that have returned to a 'wild' state, which allows them to survive for many generations without the help of humans.

A study by C·I·B masters candidate Kerushka Pillay at the University of KwaZulu-Natal, revealed that home range, habitat use and movement of urban feral cats were generally centred around supplemental resources such as food, in the town of Pietermaritzburg, also referred to as the 'City of Choice' (Pillay *et al*. 2018; *Urban Ecosys*. 21:999–1009). This study is the first in South Africa to use Global Positioning System trackers on feral cats (Fig. 9) to determine their home range and how they use their habitat in an urban area.

Results showed that feral cat home ranges in Pietermaritzburg were relatively small and centred around anthropogenic supplementary food resources, with considerable overlapping of individual home ranges in the same vicinity. Cats favoured human-made surfaces e.g. infrastructure and housing, over gardens and green habitat types with natural surfaces. Night-time home ranges were larger than day-time home ranges, suggesting that feral cats moved further when human activity was low.

"It is unclear which mechanisms drive feral cat populations to exploit anthropogenic supplementary food resources. However, the consequences of feeding feral cats can increase survival and reduce home ranges and movement," explains Pillay.

She adds, “Feral cats in the study used urban habitats where food resources were more available and accessible at feeding and garbage disposal sites which influenced their home ranges sizes. If cat populations are unmanaged and cats not sterilised, the increased population can heavily impact the local environment. Impacts such as increased cat fights, spraying and defecating on public property can result in health risks to humans and other wildlife. Diseases are more likely to spread between individual cats when populations are larger and can even spread to domestic cats.”

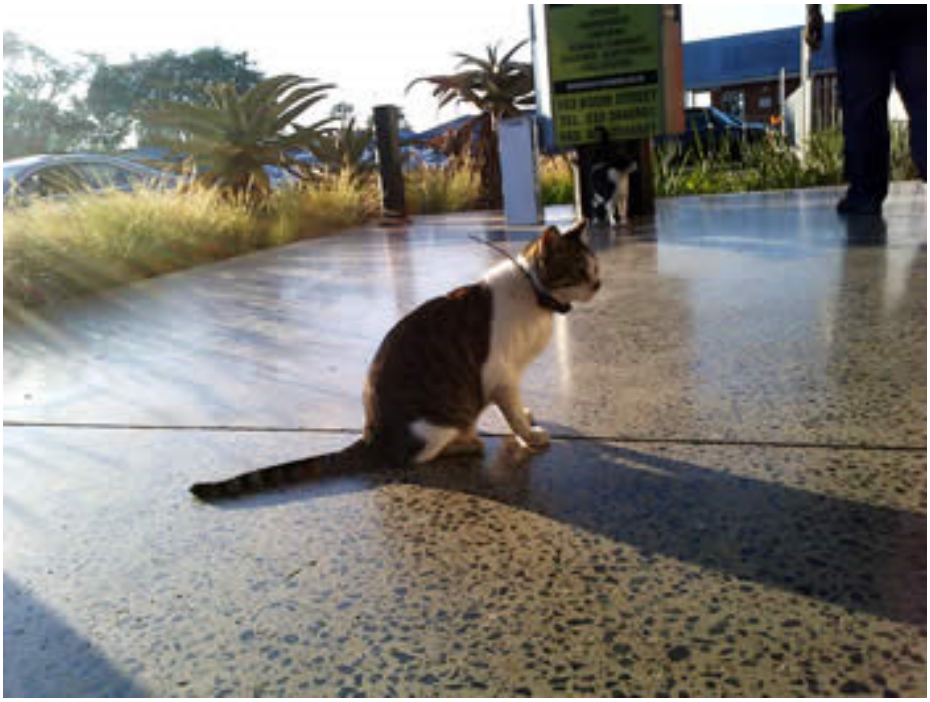


Fig. 9. A female feral cat fitted with a GPS tracking collar to monitor its movements at the Pietermaritzburg Airport. (Photo: K. Pillay)

Agricultural pest insects as models for invasion science

EXPORING THE SENSITIVITY OF FRUIT FLIES TO CLIMATE CHANGE

Agricultural pest insects constitute a major socio-economic challenge to sustainable agriculture and food security in Africa, and there are concerns about increased threats from climate change. As vectors of plant and animal diseases (e.g. direct damage caused by pest feeding and subsequent loss of market value, or indirect economic damage resulting from new or existing trade barriers), insects post a multitude of threats to agricultural productivity in South Africa. They also serve as an excellent model system for understanding terrestrial insect invasions as they typically occur in well-monitored areas with strong infrastructural and logistic support (e.g. farm managers and grower networks already in place). They are therefore particularly useful for testing theories of niche shift during invasions, either involving host plant switching or adaptation of climatic tolerances.

A study by C·I·B core team member John Terblanche and collaborators at the University of Pretoria and Monash University (Australia) examined multiple climate stress resistance traits, and the plasticity thereof, for a globally invasive agricultural pest insect, the Mediterranean fruit fly, *Ceratitis capitata* (Weldon *et al*. 2018; *Sci. Rep*. 8:9849). Traits that were examined included desiccation and starvation resistance, critical thermal minimum (CT_{min}) and maximum (CT_{max}). The study also accounted for life history variation (e.g. body size) and population genetic connectivity among distinct populations from diverse bioclimatic regions across southern Africa.

Desiccation resistance, starvation resistance, and CT_{min} and CT_{max} of *C. capitata* varied between populations. For thermal tolerance traits, patterns of flexibility in response to thermal acclimation were suggestive of beneficial acclimation, but this was not the case for desiccation or starvation resistance. In all cases, population differences in measured traits were larger than those associated with acclimation despite relatively high gene flow among populations. Population differences in mean desiccation resistance were weakly but positively affected by growing degree-days. There was also a weak positive relationship between CT_{min} and temperature seasonality, but CT_{max} was weakly but negatively affected by the same bioclimatic variable. No measured tolerance trait variation was explained by the addition of among-population phylogenetic signal.

“The results of this work show that trait associations with climate depend on the trait in question” said John Terblanche, “but it remains complex since the plasticity, or ability to change, of the traits we scored was not linked with environmental variability or among-population genetic relatedness”. This study suggests that the invasive potential of *C. capitata* may be supported by adaptation of diverse stress traits to local bioclimatic conditions among populations. With regard to both water and thermal relations, the magnitude of phenotypic plasticity is far less than that attributable to differences between populations. The team concluded that local climatic trait adaptations via multiple small trait shifts likely provide a significant fitness advantage in diverse climate conditions, and further promote the invasiveness of this agricultural pest.

1.2.4 Detection, demonstration, responses and remediation

DEVELOPMENT OF A SET OF INDICATORS FOR MONITORING BIOLOGICAL INVASIONS AT A NATIONAL LEVEL

As part of South Africa's national legislation on biological invasions the C·I·B and SANBI were tasked with producing the first National Status Report on Biological Invasions. The obvious first step was to look at what other countries had done. However, while there are many strategies, and a few assessments of economic impact, no other countries have produced comprehensive reports on the current status of biological invasions. Invasions are typically included as one aspect in general biodiversity assessments, but then only as one of several interacting drivers of global change.
It was decided that the National Status Report should provide information on where alien species were coming from (and how they were introduced), which species are problematic, where the impacts are, and assess the success of efforts to reduce the size of the problem.

A major task was to compile a set of indicators that could be used to quantify aspects of invasions now and at regular intervals in the future. This will accurately record changes in the status of invasions due to arrival of new species, further spread and increased impact of already present invaders, and the influence of various management efforts in mediating these factors.
There have been several initiatives to develop indicators to track biological invasions at a global scale, including work on Essential Variables for Invasion Monitoring & Reporting, http://invasionevs.com/, which comprise a set of three core variables on alien species. The earlier work provided useful insights but was not adequate because the Status Report also had to report on the efficacy of interventions and look explicitly at pathways of invasions.

A team lead by C·I·B core team member John Wilson settled on a group of 20 indicators which together provide an indication of the size of the different elements of the invasion problem and the degree to which they were been addressed. Using the guidelines of the Biodiversity Information Partnership (https://www.bipindicators.net/) the team developed a factsheet for each indicator.

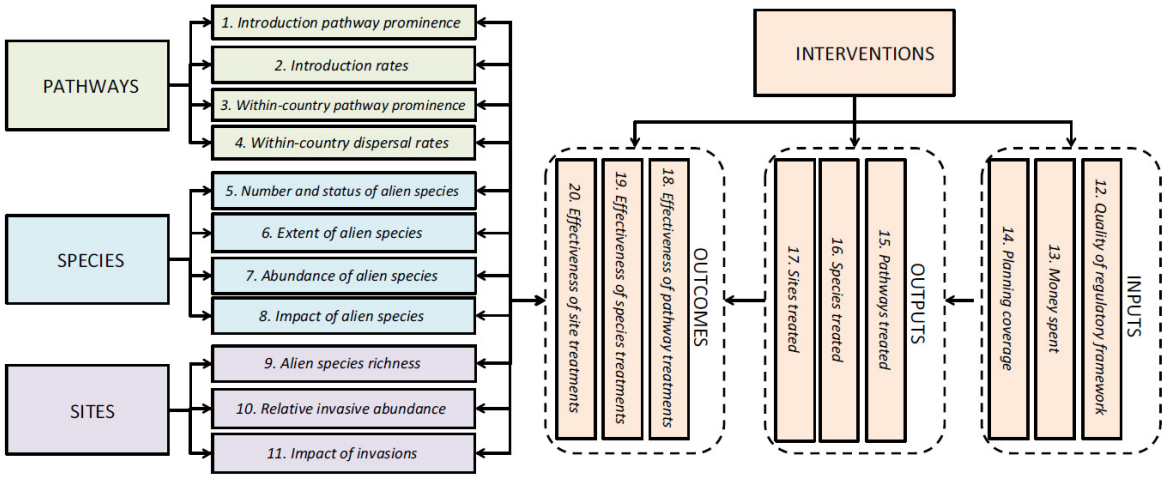


Fig. 10. A proposed indicator framework for a national status report on biological invasions and their management. There are four main sections (in capital letters)—pathways, species, sites, and interventions—with proposed indicators in italics.

In presenting these indicators to governmental colleagues the team noted that 20 was simply too many for general reporting on the state of biodiversity. There was clearly a need for a smaller number of high-level indicators. The team combined the indicators into four 'head-line indicators': the rate of introduction of new unregulated species; the number of invasive species that have major impacts; the extent of area that suffers major impacts from invasions; and the level of success in managing invasions. These four indicators align both with the Pathway-Species-Site-Intervention framework and the Pressure-State-Response framework.

The indicators were developed using South Africa as a test case. Can the framework of indicators be used for other countries? There will clearly need to be adjustments for location (e.g. to reflect the

most important ecosystem services threatened by invasions – for South Africa these were biodiversity, pastoralism, and water availability). However, the indicator framework (Fig. 10) (Wilson *et al*. 2018; *J. Appl. Ecol*. 55:2612–2620) has potential to be applied in other countries.

Protected areas face on-going challenges associated with long-term management of alien plants, and their management inevitably requires prioritization. Successful prioritization relies on accurate data. To assess the impact of data accuracy on the realisation of alien control outcomes, PhD student Chad Cheney and his C.I.B supervisor associates Karen Esler and Nicola van Wilgen quantified the adequacy of two data sets used in alien plant management (Cheney *et al*. 2018: *Biol. Invasions* 20:3227-3243). A systematic plot-based survey method provided fine-scale baseline data on alien plants in Table Mountain National Park (n = 10 057 plots, across 25 000 ha). These fine-scale data were compared to data historically used to inform management decisions, and collated from both collective observations of park managers (Manager's data set) and Working for Water project data. Significantly more alien plants were recorded during systematic sampling compared to management data [101 versus 23 (WfW) and 12 (managers dataset)], and systematic sampling estimated species' hectare coverage at orders of magnitude less than management data (e.g. condensed areas of 1.36 vs. 12.85 km2 for Acacia saligna). The inaccuracy of management data impacts negatively on funding allocations, as these data appear to overestimate what is required (Fig. 11). Contrary to popular belief, fine-scale surveys are a cost-effective way to inform long-term invasion management decisions through improving programme effectiveness.

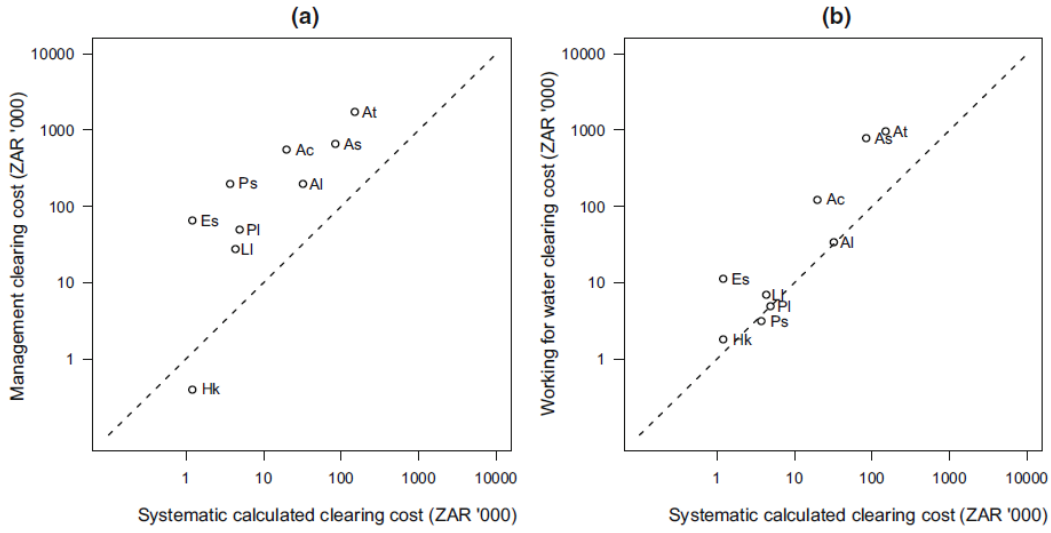


Fig. 11. The over-estimated budgets required to control all invasive plants in Table Mountain National Park, relative to the calculated clearing cost using systematically collected data (these data exclude additional travel and treatment costs). Estimates are from (a) manager's data, and (b) WfW data, for all selected taxa (combined); Ac-*Acacia cyclops*; Al-*Acacia longifolia*; As-*Acacia saligna*; Es-*Eucalyptus* spp.; Hs-*Hakea* spp.; Ll-*Leptospermum laevigatum*; Pl-*Paraserianthes lophantha*; Ps-*Pinus* spp.cators in italics.

A NOVEL APPROACH TO QUANTIFYING THE SOCIOECONOMIC IMPACT OF INVASIVE SPECIES

Some species of plants and animals can cause harm when introduced to areas where they do not occur naturally, affecting biodiversity, ecosystems, health and livelihoods. On the other hand, many alien species are harmless, and have no obvious negative impacts. The number of introduced species is growing fast worldwide and there are now too many to control. To decide which ones to focus on, scientists and managers need to compare their impacts.

Traditionally, the most common approach has been to look at economic impact. This could include, for example, yield losses in agriculture and other forms of monetary impact. Other scoring systems measure environmental impact. For example the IUCN, the largest global nature conservation agency, uses the Environmental Impact Classification for Alien Taxa (EICAT) to classify introduced species according to the severity of their impacts on native species. This creates something like a blacklist of the most environmentally damaging invaders.

But species also affect other aspects of human well-being, like health, material assets, safety, and social relationships. For example, some plants produce allergenic pollen that prevent sensitive persons from participating in outdoor activities. Others are vectors of diseases, such as the tiger mosquito that can transmit the pathogen that causes Dengue fever. Not only the people that get infected are concerned, but many more that change their activities to avoid getting exposed to the intruder.

C·I·B visiting fellow Sven Bacher and C·I·B core team member Sabrina Kumschick, working with a large team including several C·I·B-affiliated researchers sought a more objective way of measuring the socio-economic impact of introduced species. The team borrowed a Nobel Prize-winning approach from welfare economics in compiling a new assessment tool called the Socio-Economic Impact Classification of Alien Taxa or SEICAT (Bacher *et al*. 2018; *Meth. Ecol. Evol*. 9: 159-168).

Changes in people's activities were used as a measure of how much their lives are affected by introduced species. This approach is different to previous measurement tools in that it looks at how species affect the everyday lives of people – and not just from a monetary perspective. This new tool can help to guide decisions on where to spend management resources. It assesses the changes that an introduced species makes to the activities that people are involved in. It looks at how the species affects people's opportunities to achieve what they value doing (Table 2). SEICAT uses a five-point scale, from no real change in activity to massive, irreversible disappearance of an activity from a region.

For example, the cane toad (*Rhinella marina*)was introduced to Australia in 1935 as a way to control insects that were a pest on sugar cane crops and went on to spread over large areas. It has had a devastating impact on animals that indigenous people hunt for food and use as totems, causing irreversible change to cultural practices of certain communities in Australia. In contrast, most introduced agricultural pests in developed countries are well controlled by pesticides. Although the

annual costs of pesticides in countries like the United States reach several billion US dollars, most pests just make the crops a bit more expensive, but customers will still buy them. Thus these pests do not change people's activities very much – despite the impressive monetary costs.

The Socio-Economic Impact Classification of Alien Taxa measures different impacts on the same scale, enabling users to compare and classify the impact of different species. The new tool helps to flag the cases where people's lives are most affected by introduced species and thus to allocate resources to help mitigating such impacts where it is really needed.

Table 2. Description of Socio-Economic Impact Classification of Alien Taxa (SEICAT) according to observed changes in peoples' activities.

Impact classification	Description
Minimal concern (MC)	No deleterious impacts reported despite availability of relevant studies with regard to its impact on human well-being. Taxa that have been evaluated under the SEICAT process but for which impacts have not been assessed in any study should not be classified in this category, but rather should be classified as data deficient
Minor (MN)	Negative effect on peoples' well-being, such that the alien taxon makes it difficult for people to participate in their normal activities. Individual people in an activity suffer in at least one constituent of well-being (i.e. security; material and non-material assets; health; social, spiritual and cultural relations). Reductions of well-being can be detected through e.g. income loss, health problems, higher effort or expenses to participate in activities, increased difficulty in accessing goods, disruption of social activities, induction of fear, but no change in activity size is reported, i.e. the number of people participating in that activity remains the same
Moderate (MO)	Negative effects on well-being leading to changes in activity size, fewer people participating in an activity, but the activity is still carried out. Reductions in activity size can be due to various reasons, e.g. moving the activity to regions without the alien taxon or to other parts of the area less invaded by the alien taxon; partial abandonment of an activity without replacement by other activities; or switch to other activities while staying in the same area invaded by the alien taxon. Also, spatial displacement, abandonment or switch of activities does not increase human well-being compared to levels before the alien taxon invaded the region (no increase in opportunities due to the alien taxon)
Major (MR)	Local disappearance of an activity from all or part of the area invaded by the alien taxon. Collapse of the specific social activity, switch to other activities, or abandonment of activity without replacement, or emigration from region. Change is likely to be reversible within a decade after removal or control of the alien taxon. "Local disappearance" does not necessarily imply the disappearance of activities from the entire region assessed, but refers to the typical spatial scale over which social communities in the region are characterised (e.g. a human settlement)
Massive (MV)	Local disappearance of an activity from all or part of the area invaded by the alien taxon. Change is likely to be permanent and irreversible for at least a decade after removal of the alien taxon, due to fundamental structural changes of socio-economic community or environmental conditions ("regime shift")
Data deficient (DD)	There is no information to classify the taxon with respect to its impact, or insufficient time has elapsed since introduction for impacts to have become apparent

PRIORITISING AREAS FOR INVASIVE ALIEN PLANT MANAGEMENT IN AN URBAN SETTING

Factors related to human safety and security are most important when prioritising land parcels for invasive alien plant management across the Cape Town metro. This was the surprising finding of a study by C·I·B PhD student, Luke Potgieter, and a multi-disciplinary team including C·I·B core team member Dave Richardson and research associate Mirijam Gaertner, CSIR researcher Patrick O'Farrell, and project managers at the City of Cape Town's Green Jobs Unit. The study identified high-priority land parcels for invasive alien plant management at landscape and local scales (Potgieter *et al*. 2018; *Environm. Manage*. 62: 1168-1185).

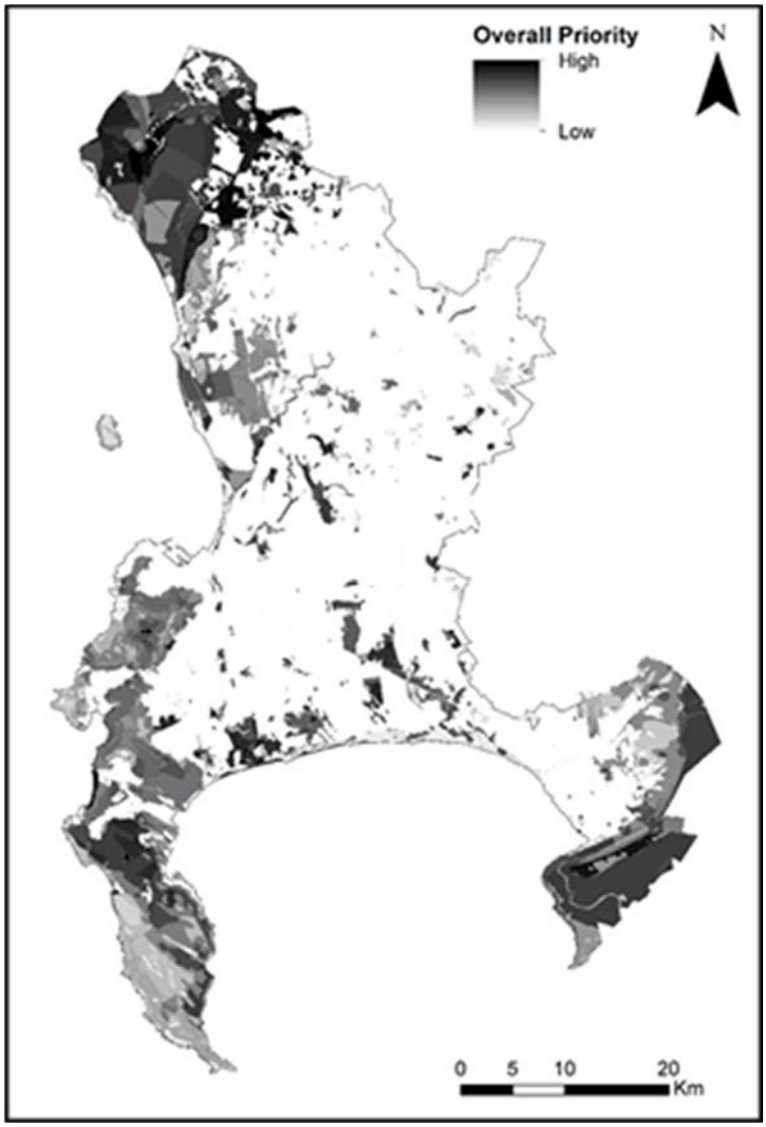


Fig. 12. Overall priority areas for the management of invasive alien plants across the City of Cape Town.

Alien plant invasions in urban areas have considerable impacts on biodiversity, ecosystem services, and human well-being. However, management is particularly challenging given the complex interactions between ecological, economic and social elements that exist in urban areas. Managing urban plant invasions therefore requires a strategic approach to guide management across the urban landscape, and a tactical approach to plan and coordinate control efforts on the ground. Prioritising land parcels for invasive species control assists with funds being appropriately allocated and utilised, resulting in the highest return on investment being achieved.

Potgieter and colleagues used multi-criteria decision tools to develop a prioritisation framework for managing invasive alien plants in urban areas at landscape and local scales. A stakeholder workshop was held to develop and rank criteria for prioritising land parcels for invasive alien plant management in the City of Cape Town. By matching spatial data with selected criteria and applying their multi-criteria decision analysis in a Geographic Information System, they developed a strategic

landscape scale prioritisation map. They also modified an existing invasive alien plant management framework to develop a tactical (site level) prioritisation scheme for guiding on-the-ground control operations.

Their study identified high priority land parcels for invasive alien plant management at landscape and local scales across the City of Cape Town (Fig. 12). Factors related to human safety and security (such as fire risk to infrastructure, risk of flooding, and areas at risk of being illegally occupied) emerged as key features for setting spatially explicit priorities for IAP management. The overall approach resulted in an intuitive framework for dealing with the complexities involved in decision-making processes in urban environments.

“The process followed here has established a set of clear, transparent and agreed priorities which can be used to guide the allocation of limited funds” says Potgieter. “Our dual prioritisation approach can be tailored to address different IAP management objectives specific to other urban centres around the world.”

TWO MARINE INVERTEBRATES REPORTED AS ALIEN FOR THE FIRST TIME

Despite extensive surveys of South Africa’s marine ecosystems, new alien and invasive species are regularly reported. A study by C·I·B post-doctoral associate Koebraa Peters and C·I·B core team member Tammy Robinson found an unusual looking seastar and crab in Saldanha Bay along the west coast – these were identified as *Heliaster helianthus* and *Homalaspis plana*.

The South American multiradiate sunstar (*Heliaster helianthus*) and the Chilean stone crab (*Homalaspis plana*) are invertebrate species native to the west coast of South America (Fig. 13). Both species were detected, on separate occasions, during maintenance of a pier in Saldanha Bay, in 2015 and 2017. Only one adult of each species was detected. Intertidal and subtidal surveys were undertaken in surrounding natural habitats to search for further individuals, but none were detected.

Native to intertidal and shallow subtidal waters of northern and central Chile and southern Peru, the seastar feeds on mussels, including the Pacific mussel (*Semimytilus algosus*), a species from Chile that is already invasive along the South African coastline. The predatory sunstar is a keystone species in its native range, where it plays a role in community structure of rocky shores.

“The seastar has the potential to become invasive along our coastline, should it become established. It could pose a threat to native biota in these habitats, as there are currently no predators regulating community structure in these habitats”, explains Peters.

The Chilean stone crab is widespread along the Chilean coastline where it forms part of an important artisanal fishery. This crustacean lives in sheltered habitats and feeds on other crabs, barnacles, mussels and sea snails. As with the sunstar, it consumes the already present Pacific mussel. It is less

likely to survive along the wave exposed shores of South Africa but sheltered habitats would still be at risk if the crab becomes established in the region.

The arrival of these three Chilean species along the west coast of South Africa over the last 14 years is important when considering the management of marine invasive species. All three species are likely to have been introduced through shipping, either as larvae in ballast water or as fouling on vessels. The Pacific mussel could also have been introduced with the importation of oyster spat from Chile.

Peters explains: “there are strong links between the west coasts of South America and South Africa; we can therefore expect additional species transfer between the two regions. There is even potential for reintroduction of the sunstar and crab now that we know they can be successfully introduced into Saldanha Bay”.

She adds “both shipping and the importation of oysters are important pathways that link these two regions and the similarities in environmental conditions also play a crucial role in the successful introductions.”

Fig. 13. The South American multiradiate sunstar Heliaster helianthus (left; photo: T. Robinson) and the Chilean stone crab *Homalaspis plana* (right; photo: K. Peters) photographed on the west coast of South America.

South America and South Africa both have cool temperate waters and experience coastal upwelling. Together, matching environmental conditions and the presence of two pathways makes Saldanha Bay particularly susceptible to invasions from the west coast of South America. It is therefore, essential for management authorities to consider this link and for both the sunstar and the stone crab to be added to species watch lists, not only in South Africa, but also other regions that experience similar environmental conditions and those that have pathways and vectors associated with Chile and South Africa.

FIRST RECORD OF BLUE TILAPIA IN THE EERSTE RIVER CATCHMENT, WESTERN CAPE

Biological invasions affect native biodiversity and the stability of invaded ecosystems. Genetic impacts through hybridisation are one of the more insidious impacts because they could lead to replacement or local extinction of native species by introgressive hybridisation (genomic extinction). Genomic extinction is currently threatening one of Southern Africa's more charismatic freshwater fishes, Mozambique tilapia *Oreochromis mossambicus*, through hybridisation with Nile Tilapia *Oreochromis niloticus*, a species globally introduced for aquaculture. There are strong lobbies for the establishment of Nile Tilapia aquaculture in South Africa but nature conservation authorities are resisting these lobbies to conserve the remaining pure populations of Mozambique tilapia.

A study to evaluated the putative establishment of a second introduced *Oreochromis* species in South Africa was conducted by C·I·B post-doc Sean Marr and an international team including C·I·B core team member Olaf Weyl and CapeNature researchers Dean Impson and Martinus van der Westhuizen. The study confirmed the presence of another, Blue tilapia *O. aureus*, and modelled the potential area of South Africa suitable for the species (Marr *et al*. 2018; *Afr. J. Aquat. Sci*. 43: 187-193).

Oreochromis aureus was imported into the Western Cape from Israel for experimental purposes in 1959. Offspring of these fish were released into farm dams in the greater Cape Town area to evaluate their potential to survive the Western Cape winter. Survival was reported in 73% of the dams. As is the case with many introductions, subsequent introduction and distribution information on this species is largely anecdotal. Accounts of persistence in farm dams in the Eerste River catchment and introductions in KwaZulu-Natal have been reported. Because the persistence of these populations was never evaluated, and because the species had not been formally reported in South Africa in almost 30 years, prominent researchers evaluated its introduction as failed. In response to anecdotal reports that *O. aureus* populations may have persisted in some dams near Stellenbosch, a survey was completed to determine the status of *O. aureus* in these dams using DNA barcoding and morphological attributes to positively confirm the identity of the species and species distribution model to predict the potential distribution range of *O. aureus* in southern Africa.

Marr and colleagues used a machine learning maximum entropy modelling programme, MaxEnt, to map the areas of southern Africa suitable for the establishment of *O. aureus* using global distribution data and WorldClim rainfall and temperature data. The MaxEnt model predicted that Western Cape rivers from the Olifants-Doring to the Breede River, the central Orange-Vaal catchment, coastal rivers from Mossel Bay to Port Elizabeth and eastern rivers from the Gamtoos through to Mozambique and the Mpumalanga and Limpopo Lowveld, were climatically suitable for this species, indicating a considerable invasion debt in southern Africa (Fig. 14). Surveys to assess for the establishment of *O. aureus* in South Africa, especially the KwaZulu-Natal localities, and eradication of existing populations, if feasible, are recommended immediate management actions. Hybridisation of *O. aureus* with Mozambique tilapia is common in aquaculture and the potential for hybridisation in

nature could compromise the genetic integrity of the remaining pure populations of Mozambique tilapia.

Co-author of the paper Olaf Weyl commented on the results: “It is important to determine the extent of spread of this and other invasive tilapias in South Africa to determine current risks to native species. Knowledge on distributions are also important to guide decisions on the most appropriate areas for the use of non-native tilapias in economic activities such as aquaculture”.

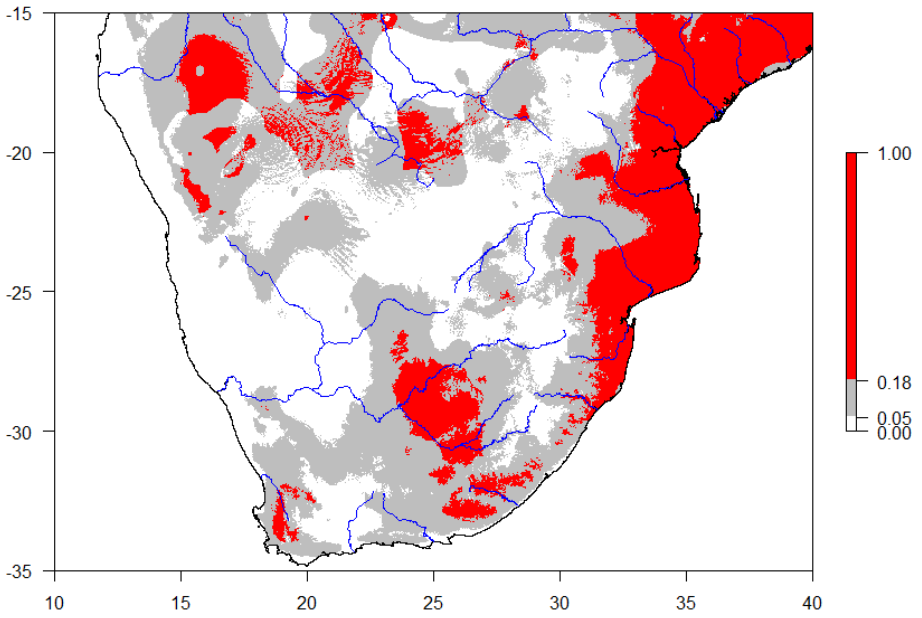


Fig 14: MaxEnt predictions for the potential southern Africa distribution of Blue tilapia Oreochromis aureus based on its current global distribution. White represents regions with habitat suitability scores for O. aureus less than 0.5, grey regions depict 0.5 to 0.9 habitat suitability scores; red shading depict greater than 0.9 habitat suitability scores.

1.2.5 Global environmental change and ecosystem services

ALIEN PINE INVASIONS INCREASE THE SEVERITY OF LARGE WILDFIRES

Large wildfires in the Knysna region in 2017 caused widespread damage to infrastructure and plantations. The area is heavily invaded by alien trees, especially pines (Fig. 15). A study was undertaken to determine how dense stands of invasive trees affected the severity of the fire. The fires burnt an area of 15 000 ha over four days, claimed the lives of seven people, and destroyed more than 5000 ha of commercial pine plantation and more than 800 buildings.

The study, involving researchers from Nelson Mandela University, South African National Parks, the CSIR and the C·I·B, used remote sensing to show that fire severity was significantly higher in plantations of invasive alien trees, and in fynbos invaded by alien trees, than in uninvaded fynbos.

The severity of the fire was also exacerbated by a prolonged drought and extremely dangerous weather conditions.

Fig. 15. Orderly plantations of pine trees (background) and invasive pines on the Garcia Pass in the Western Cape. These invasions can substantially increase fuel loads leading to higher and more damaging wildfires. (Photo: B.W. van Wilgen)

Invasion of fynbos by alien pines substantially increases the mass of combustible plant material, thereby increasing the amount of fuel available to burn, and making fires more intense and more difficult to control. While this is understood in broad terms, the phenomenon has never been documented in any detail. These increases in vegetation fuel loads have been accompanied by development in rural areas, and an increase in the interface between housing developments and vegetation, increasing the risks that people face from wildfires. The accepted response to this is to reduce risk by constantly clearing flammable vegetation around houses that are at risk.

“As conditions in the Western Cape become hotter and drier, and as the extent of invasions increases, we can expect events of this nature and magnitude to become more frequent” says Brian van Wilgen, a co-author of the paper. He adds that “Events like the 2017 Knysna fires are infrequent, and people can quickly lose interest in implementing fire-wise practices, and become increasingly willing to place developments in high-risk areas in the long inter-fire periods. Our study underscores the need to implement effective programs to control the spread of invasive alien plants, and to re-examine the economic and ecological sustainability of commercial planting of invasive alien trees in fire-prone areas”.

1.2.6 Human dimensions

A ROADMAP FOR CLIMATE CHANGE BIOLOGISTS AND CONSERVATION PRACTITIONERS

Predicting the future is hard. A recent review on climate change vulnerability assessments of species attempts to make this task easier for climate change biologists and conservation practitioners. Led by Wendy Foden at Stellenbosch University, this review is the work of a group of 18 international scientists including C·I·B post-doctoral fellow Raquel A. Garcia.

Protecting the earth's biodiversity means designing conservation plans that take into account future as well as current threats. Climate change has joined the long list of threats to terrestrial, aquatic and marine species, and quantifying this threat has become a necessity. Scientists have promptly responded to this call, generating thousands of studies assessing the vulnerability to climate change of species of plants, animals and (not so many) microorganisms. These studies use many different modelling approaches, each with their own purpose, data requirements and methodological considerations, and all of them evolving rapidly.

The paper clarifies key concepts, steps, terminology and outputs of climate change vulnerability assessments of species. It discusses how to find and apply appropriate input data, given the mushrooming of datasets of species occurrences and climatic variables. The review also offers practical guidance to address small-ranged and vulnerable species, which pose particular challenges for most modelling approaches and are thus often excluded from vulnerability assessments.

With mounting evidence of the impacts that climate change is already having on species, ecosystems and human well-being, assessments of species' vulnerability to future changes are here to stay. It was in recognising this need that the IUCN Species Survival Commission developed the Guidelines for Assessing Species' Vulnerability to Climate Change. The recent review builds on this. Vulnerability assessments are needed to inform conservation planning strategies for protected areas and species, but increasingly also to guide adaptation plans for commercial fish and crops and to manage the risk of invasive species and disease vectors that might benefit from climate change.

"We need sound and reliable vulnerability assessments", says Raquel Garcia. "To achieve this goal, it is important to take stock of existing assessment approaches, learn from mistakes and successes, and develop practical guidance".

LOCAL KNOWLEDGE OF ECOSYSTEM SERVICES AND DISSERVICES FROM INVASIVE ALIEN PLANTS IN THE KALAHARI

Understanding the trade-offs of invasive alien species for people's livelihoods and the environment is becoming more prominent to help guide management and to avoid conflicts. One way of framing these benefits and costs are as ecosystem services and disservices.

A study by C·I·B post-doc Ross Shackleton and Sheona Shackleton (African Climate and Development Initiative, UCT) examined people's knowledge and awareness of listed invasive species that were

present in their gardens and the services and disservices they provide in the context of four arid land villages in the Kalahari region (Shackleton & Shackleton 2018; *J. Arid Environm*. 159: 22-33). This paper formed part of a special issue on 'Ecosystem Services in Dryland Systems of the World'.

The study found that local villagers had a good historical knowledge of the introductions and pathways for most of the 13 identified non-native plants. Thirteen different goods and services from the listed invasive plants were recognised, the most common being shade, aesthetics and fuelwood provision which represent supporting and regulating services, cultural services and provisioning services. Some species, such as white mulberry (*Morus alba*) and prickly pear (*Opuntia ficus-indica*), were important for fruit, while eight species were mentioned as being used for fodder.

Respondents also mentioned that prickly pear, mesquite (*Prosopis* spp.; Fig. 16), lead trees (*Leucaena leucocephala*) and syringa (*Melia azedarach*) imposed ecosystem disservices. These disservices included reductions in water supply, damage to buildings and human health impacts. Three quarters of households had one or more invasive species in their gardens, highlighting their importance for local residents. Some of these species were also noted to be spreading beyond homesteads in settlements and into rangelands – and were perceived as a higher threat than those that were not spreading. In the harsh climatic conditions of the Kalahari most residents felt that many species would not be able to spread and were therefore not a threat.

"Understanding the roles of invasive species in people's lives, especially in areas with harsh environmental conditions like the Kalahari, can really help to prioritise future management efforts to ensure that benefits are not lost and that disservices are reduced" states Ross Shackleton. "This kind of work can also help to understand people's motivations to have some invasive species but want to manage others, which can aid with targeted awareness raising and policy development".

Fig. 16. A rural garden with *Prosopis* trees (important for fodder, fuelwood and shade, but provides major disservices by posing a threat to water, grazing and human health). (Photo: R.T. Shackleton)

2 EDUCATION AND TRAINING

2.1 Objectives

At the end of 2018 a new Service Level Agreement (see section 9) was signed with the NRF, as new demographic targets were imposed in agreement with the C·I·B Steering Committee in November 2018. The new targets apply from 2019, and until then we will report on the original targets but provide additional lines showing performance against the Ministerial Targets (see Table 3).

Our criteria for student and post-doc support are:

- Equity targets set in the Service Level Agreement
- Match with C·I·B vision and mission
- Match with C·I·B annual business plan
- Match with priorities of partners
- Synergies and co-funding with SANBI and SARChI Chair bursaries
- Spread among C·I·B core team members, universities and freshwater, marine and terrestrial environments
- History of C·I·B core team member productivity.

Our bursary application and award process takes place as follows:

- Advertisement of positions for post-graduates and post-docs: July
- Where? C·I·B web page, national list-servers such as Invasive Species SA, SANBI etc. Adverts sent to all core team members and life science departments nationally (about 200 posters in total)
- Deadline for applications: late October or early November
- A panel of four C·I·B members, including one who is not employed by SU, considers all complete applications and makes selections: early November
- Awards are made in mid-November via formal award letter from the C·I·B Director (or Deputy Director in the case of awards to the Director).

2.2 Progress

2.2.1 Student support programme

The C·I·B Student Support Programme was a new initiative in 2017, set up in response to the observation that students' performance is sometimes hampered by challenges that are not purely academic and which create anxiety and stress that limit students' performance. It involves a set of interactive self-development workshops for students and post-docs that take place in several locations through the year. The hope is that this will enhance students' abilities to perform well within their academic endeavours and beyond.

In 2018 the programme consisted of three events, including:

1. The On Boarding Workshop (13 participants) held in the Western Cape from 23 to 25 February 2018; the aims of this workshop were to welcome new students, create networking opportunities among them and to develop self-management skills and build resilience.

2. Two Walk & Talk the Talk workshops held at mid-year in Pretoria (9 July) and Stellenbosch (26 July) to provide further support to students on a voluntary basis. Altogether 14 students participated in these two workshops. The aims were to develop knowledge of self, understand perceptions and their effect on communication, learn to listen effectively, how to convey clear messages when speaking and to learn principles of difficult conversations.

The workshops were coordinated and presented by C·I·B Administrative Officer, Ms Mathilda Van Der Vyver, who is an MPhil candidate in Management Coaching at Stellenbosch University. Feedback from the three sessions was overwhelmingly positive, with most participants agreeing that all students should have regular opportunities to participate in such workshops, and that such opportunities should be available nationally.

Figure 23. New C·I·B bursars and affiliated students, and facilitator Mathilda van der Vyver at the second C·I·B On Boarding Weekend held at Stanford, Western Cape, 23-25 February 2018. (Photo: E. Nortje)

2.2.2 Science communication workshops

On 6 and 7 November 2018, the Centre for Invasion Biology offered a science communication workshop to 17 of its post-graduate students. The course was presented by Jive Media (Robert Inglis and his team), who are experts in the field of science communication through different platforms. The first part of the workshop focussed on public speaking, with hands-on practice, feedback and a great deal of interaction between participants. The second part of the course focussed on writing science articles for a public audience, keeping the balance between enough information without losing your audience along the way. This session was also very practical, and Robert Inglis sat with each participant discussing their approach and style, whilst they were writing. The importance of science communication is still greatly under-appreciated , and therefore a skill that the C·I·B wants to develop in its students.

Participants in the workshop commented:

> "I was initially not keen on this course, as I felt like it was 'dumbing down' science. I have completely changed my opinion, though, and have been pleasantly surprised by how relevant and exciting it was. Thank you!"

> "I really enjoyed this course. It certainly opened up my mind to convey my research in a completely different and simple way. It's still a work in progress but I am enjoying it."

The workshops were coordinated by Elrike Marais, C·I·B Projects and Research Manager, who is in charge of the DEA NRM collaborative research projects, which funded the training.

2.2.3 Under-graduate training

The C·I·B contributes to Stellenbosch University's undergraduate academic programme by teaching a third year module on invasion biology. The class consists of roughly 50 students, the majority are final year students in the Department of Botany and Zoology's Biodiversity and Ecology programme with additional students coming from the Department of Conservation and Entomology's Conservation and Ecology programme. The course is co-ordinated by core team member Tammy Robinson-Smythe with teaching contributions by Director Dave Richardson and core team member John Measey. Additionally, C·I·B post-docs are routinely offered the opportunity to give guest lectures on the course. This enriches them with teaching experience and provides the students with exposure to the latest research in the field. The course content is broad and topics include invasion theory, modelling approaches in invasion science, understanding impacts of alien species and managing invasions. The course aims to provide students with a sound theoretical foundation in invasion science while exposing them to the practicalities of researching and managing invasions.

2.2.4 Demographics of students and post-doctoral associates

Table 3. Demographics of students and post-doctoral associates

	No.	%		No.	%
All supported students	60	85	All supported post-doctoral associates	11	15
Academic level					
Honours/4th year B. Agric.	10	17			
Masters	24	40			
PhD	26	43			
Gender			**Gender**		
Male	18	30	Male	3	27
Female	42	70	Female	8	73
Race			**Race**		
Black	35	58	Black	3	27
White	25	42	White	8	73
Funding level			**Funding level**		
Full	29	48	Full	5	46
Partial	17	28	Partial	1	8
Independent	14	24	Independent	5	46
Citizenship			**Citizenship**		
South African	54	90	South African	5	45
Foreign	6	10	Foreign	6	55
Ministerial targets for country of origin:			**Ministerial targets for country of origin:**		
South Africa (target: 87%)	54	90	South Africa (target: 87%)	5	45
SADC	1	2	SADC	0	0
Rest of Africa	1	2	Rest of Africa	0	0
Rest of World	4	7	Rest of World	6	54

2.2.5 Career development (formerly 'Resources in the Market Place')

Dr Mohlamatsane Mokhatla at his graduation at Stellenbosch Unviersity, with PhD advisor Dr John Measey. Dr Mokhatla first joined the C·I·B as an undergraduate student in 2006, studying with Dr Berndt van Rensburg at UP. Dr Mokhatla completed his BSc (Hons.) and MSc at UP and then transferred to NMU and later Stellenbosch Unviersity to work with Dr Measey on his PhD. This case demonstrates the effective pipeline and network that the C·I·B provides for student to pursue their academic careers. (Photo: D.M. Richardson)

Table 4. Current whereabouts of a selection of our recent graduates

Name	Level	Institute	Current affiliation	Sector
Guillaume Latombe	Post-doc	SU	Post-doctoral Associate, University of Vienna, Austria	Academic / research
Thomas Bishop	Post-doc	UP	Leverhulme Fellow, University of Liverpool, UK	Academic / research
Susan Canavan	PhD	SU	Post-doctoral Associate, University of Florida, USA	Academic / research
Chad Cheney	PhD	SU	Environmental Planner, SANParks	Government / implementing agency
Rolanda Julius	PhD	UP	Training Coordinator, NCBI Genomics Resources	Government / implementing agency
Sandra MacFadyen	PhD	SU	Director, BioGIS GIS consultancy	Private sector / consulting
Ingrid Minnaar	PhD	SU	Post-doctoral Associate, SU	Academic / research
Mohlamatsane Mokhatla	PhD	SU	Social Ecologist, SANParks	Government / implementing agency
Mlungele Nsikani	PhD	SU	Post-doctoral Associate, SU	Academic / research
Luke Potgieter	PhD	SU	Post-doctoral Associate, University of Toronto Scarborough, Canada	Academic / research
Lesley Bloy	Masters	Rhodes	Environmental Scientist, JG Africa, SA	Private sector / consulting
Ndivhuwo Maligana	Masters	UP	PhD candidate, UKZN	Studying further
Takalani Nelufule	Masters	UP	SANBI project development internship (PhD track)	Academic / research
Khensani Nkuna	Masters	SU	Research Assistant, SU	Academic / research
Mmatsawela Ramahlo	Masters	UP	PhD candidate, UP	Studying further
Thomas Stielau	Masters	UCT	Postgraduate student (PGCE), UCT	Studying further
Reesher Kearns	Honours	SU	Post-graduate student (PGDEM), SU	Studying further
Lindiwe Khoza	Honours	UKZN	MSc candidate, UKZN	Studying further
Lindelwa Msweli	Honours	UKZN	MSc candidate, UKZN	Studying further
Carla Wagener	Honours	SU	MSc candidate, SU	Studying further

3 NETWORKING

3.1 Objectives

The C·I·B networks broadly within South Africa, the region and internationally, and will continue to encourage a variety of approaches to scientific excellence, and to facilitate networking both among its members and with other like-minded individuals and organizations wherever they are located. In consequence, networking will continue to form a critical component of the C·I·B's work.

3.2 Progress

3.2.1 Agreements with partner institutions

The C·I·B closes formal agreements with organisations with whom we work on a long-term basis. Often a research associate is also appointed at these partner organisations, to ensure that the staff member can supervise students at our partner universities.

Table 5. Partner organisations - formal MOUs in place.

Partner organisation	Contact person	Partnership start date
Western Cape Education Department	Mr Jean Goliath	June 2006
DEA Natural Resources Management Programme	Mr Andrew Wannenburgh	February 2008
CapeNature	Dr Martine Jordaan and Dr Andrew Turner	June 2006
CAPE Invasive Alien Animal Working Group	Ms Julia Wood, Ms Chandre Rhoda	C·I·B was a founding partner in 2008
Honolulu Challenge	n/a	C·I·B became a signatory in December 2016
Soil Ecosystem Research Group	Dr Charlene Janion-Scheepers	C·I·B was a founding partner in 2011
City of Cape Town	Ms Julia Wood and Ms Chandre Rhoda	September 2012
BirdLife South Africa	Mr Dale Wright	April 2014
The Nature Conservancy	Ms Louise Stafford	February 2018
Laboratorio de Invasiones Biológicas, Universidad de Concepción, Chile	Prof. Anibal Pauchard	June 2012
Institute of Botany, Academy of Sciences of the Czech Republic	Prof. Petr Pyšek	May 2012

3.2.2 Developing collaborations - Afromontane Research Unit

The Afromontane Research Unit is situated at the QwaQwa Campus of University of the Free State (UFS). Research at ARU harnesses interdisciplinary expertise to focus on addressing the sustainable development of the Maloti-Drakensberg Afromontane area. Due to the recent emergence of invasive grass species (*Nasella* spp. and *Cortaderia* spp.) in these high-altitude grasslands, collaboration on the understanding on invasion processes and potential solutions for management and control of these species is essential. To this end the C·I·B is collaborating with Dr Sandy-Lynn Steenhuisen and Dr Ralph Clark (Director) Afromontane Research Unit to support the work of this research unit. Initial meetings have been held and terms agreed on. During 2019 the collaboration will support (jointly) the studies of a Masters student registered at UFS.

3.2.3 Developing collaborations - eThekwini Municipality

Late in 2018 the C·I·B was approached by Mr Errol Douwes, a long-time collaborator on invasive species matters in KwaZulu-Natal, to develop a formal collaboration with eThekwini Municipality. This will allow the two organisations to work more closely, hosting joint events, working on collaborative projects and supporting students jointly. The formal MOU will be finalised early in 2019.

3.2.4 Developing collaborations – Global Urban Biological Invasions Consortium

The study of biological invasions has focused largely on the spread and impact of alien species in natural and semi-natural habitats. Yet, invasions are also widespread in human-dominated landscapes, where large economic costs are often incurred due to altered ecosystem services, impacts on human health, and from control efforts. Urban habitats represent the ultimate apex of human modification of the natural ecological and geological processes that structure a given locale. Frameworks, concepts and paradigms for understanding and managing invasions are based largely on insights from natural and semi-natural systems, yet urban ecosystems differ radically from (semi)natural systems in that the environmental impacts of human activity are detrimental for many species and so maintaining native biodiversity and the ecosystem services that benefit people in cities can be difficult and expensive.

The C·I·B worked with Prof. Marc Cadotte (University of Toronto Scarborough, Canada) in developing a proposal for the creation of a Global Urban Biological Invasions Consortium to oversee a network of projects and collaborations to determine the magnitude of invasion economic and ecosystem impacts in cities around the world. There are several reasons why this work is critical at this juncture: (1) More people live in cities than at any other time in our history and the well-being of cities directly impacts the health and happiness of people; (2) trade and the movement of people in and out of cities has resulted in unprecedented movement of species to urban areas outside of their native ranges; (3) pest outbreaks and species invasions have resulted in massive economic costs and environmental degradation (the polyphagous shothole borer is a good example in South Africa); and

(4) there is currently widespread misunderstanding of the potential threats invasive species pose and that existing invasive species management frameworks are not well suited to managing invasive species in urban areas, where human perception, well-being and culture influence what kinds of species persist.

The main objectives of consortium will be: (1) to assess the influence of urban to rural gradients in human impact, economics, and environment within cities on invasive species population sizes and diversity; (2) to determine how political, economic, trade, and environmental differences among cities influence the invasibility of cities; (3) to quantify ecosystem service and disservice provided by non-native species within and among cities; and (4) to evaluate invasive species urban policy and management decision triggers in different socio-economic conditions. Seed funding has been secured from University of Toronto's Connaught Fund to support a scoping workshop in Toronto in June 2019. The consortium provides exciting opportunities to involve C·I·B team members in work on diverse aspects of urban invasions. C·I·B PhD graduate Luke Potgieter will be commencing a post-doc at the University of Toronto in early 2019.

3.2.5 Interaction with peers

See Workshops hosted (section 4.2.1)

Fellowship Programme

During 2018, three visiting fellows participated in our mobility programme. The fellows were hosted or co-hosted at three different participating universities, University of Pretoria (Ben Allen), University of KwaZulu-Natal (Christophe Baltzinger) and Stellenbosch University (Phillipp Lehmann). This broadened the impact of the programme and involved more core team members and students in knowledge transfer. All three fellows held workshops at one or more of their hosting institutions.

Phillipp Lehmann (Stockholm University, Sweden)

John Terblanche hosted Dr Philipp Lehmann for a period of five months on a C·I·B visiting fellowship. During this period Dr Lehmann collated diverse plant and animal data on metabolic flexibility in invasions and used this to workshop several key ideas and draft frameworks for two published papers.

Christophe Baltzinger (Irstea, Forest Ecosystems Research Unit)

Core team member Colleen Downs hosted Dr Christopher Baltzinger a tUKZN and he also spent time at the C·I·B hub in Stellenbosch. A workshop on seed dispersal (especially alien invasives) by ungulates was held at UKZN, to discuss seed dispersal by ungulates in southern Africa, to share and improve collective knowledge on this ecological process and to initiate a network of collaborators. The workshop attendees came from a range of organisations, and included Lindelwa Msweli (Hons.

candidate), who conducted a pilot project on ungulate invasive seed dispersal and will continue to a MSc in 2019.

Ben Allen (University of Southern Queensland, Institute for Agriculture and the Environment)

Michael Somers and John Measey hosted visiting fellow Dr Ben Allen from University of Southern Queensland, Australia. Dr Allen held a workshop at the C·I·B on 'Opportunities and issues associated with vertebrate biological control of invasive species in South Africa'. Dr Allen also spent time at UP with core team member Michael Somers to explore the use similar issues for large mammal pests. The collaboration will lead to a paper on animal welfare considerations for using large carnivores and guardian dogs as vertebrate biocontrol tools against other animals and has been submitted to *Biological Conservation*. Another manuscript on vertebrate biocontrols is in preparation.

4 INFORMATION BROKERAGE

4.1 Objectives

Central among the knowledge brokerage roles envisaged by the C·I·B are the fostering of a knowledge economy, and using the outcomes of its knowledge production to promote a sustainable society. Information brokerage therefore forms a core component of the C·I·B's business. Such knowledge transfer will take place through interactions with the C·I·B core team, staff, post-doctoral associates and students to provide a means for a broad spectrum of society to benefit from the C·I·B's knowledge generation. Typically these interactions takes place via scientific and public lectures; researchers interfacing with students and the general public; interactions at workshops, public meetings and science expos, and through the direct media such as radio talk shows. In addition, the C·I·B's major outreach intervention, the Iimbovane project interacts closely with learners and educators at secondary schools in the Western Cape.

4.2 Progress

4.2.1 Workshops hosted

Biological invasions in South Africa: trends and implications for management

On 7 November 2018 a workshop was held to deliberate on global and national trends in invasions and to discuss the implications for medium-term planning for research on biological invasions in South Africa. The workshop was attended by 24 C·I·B core members, research associates and students as well as four international guests. The workshop was opened by C·I·B Director Dave Richardson with a presentation on 'Where to with invasion science in South Africa?' He began by discussing some overarching global trends in drivers of global change, including biological invasions. Global data show that: 1) the increase in numbers of alien species in all taxonomic groups shows no sign of saturation, and 2) past efforts to mitigate invasions have not been inadequate to slow the effects of increasing globalization. He discussed the emerging insights on invasion debt which show that invasions will increase worldwide even if the main drivers are slowed. He ended with a review

of several recent horizon scanning exercises on biological invasions and proposed some priorities for research to equip us with the knowledge and tools to manage invasions into the future. C·I·B post-doctoral fellow Florencia Yannelli gave an overview of several recent new approaches that aim to ensure a more integrative foundation for invasion science. She discussed concepts such as 'translational ecology' and several related approaches for improved stakeholder engagement.

C·I·B team members discuss the way forward for invasion science in South Africa with an international guest. Left to right, Dr Nitya Mohanty (Stellenbosch University), Dr Guillaume Latombe (post-doctoral associate), Prof. Bo Li (Fudon University, Shanghai, China), Dr Susan Canavan (SANBI and Stellenbosch University). (Photo: S.C. Turner)

The workshop participants then discussed the ideas that they had been asked to send in before the workshop on key questions and issues that need to be addressed in formulating a new agenda for invasion science in the South African context. The ideas were then divided into five broad categories: Baseline understanding; Potential to produce large impacts in future; Potential social responses to invasions; Capacity to address problems; and Changes in key drivers. The group then broke into five teams to deliberations issues in these categories and how they relate to the following taxonomic groups: terrestrial and freshwater plants; vertebrates in terrestrial and freshwater ecosystems; terrestrial invertebrates; marine organisms; and microbial species.

Insights from this workshop will form the basis of the final chapter in the forthcoming book on 'Biological Invasions in South Africa' and will be used to structure future versions of the C·I·B's strategic plans.

BRICS workshop and panel discussion 'The importance of international networks in invasion science'

Developing countries generally have little capacity to reduce the flow of invasions through their borders, relative to the magnitude of that flow. Emerging economies, such as the BRICS nations, sit

in between the highly capacitated nations and the developing world. They are experiencing increasing international and national trade, but have limited capacity to conduct research needed to inform relevant policy in their context and control or eradicate existing invasions.

Panel members at the C·I·B's Annual Research Meeting –Dr Susan Canavan (C·I·B PhD graduate, now at University of Florida), Prof. Bo Li (Fudan Unviersity, Shanghai, China), Prof. Inderjit (University of Delhi, India), Dr Silvia Ziller (Instituto Horus, Brazil), Prof. Marc Cadotte (University of Toronto Scarborough). (Photo: S.C. Turner)

In November 2018, we held discussions to initiate a 'facilitated network' model to build capacity and effective research for BRICS nations. We use the model for this Centre of Excellence, which has resulted in the world leading DST-NRF Centre of Excellence for Invasion Biology. Participants from Brazil, India, China and South Africa all agreed that establishing networks within each country, as well as an international network of invasion biologists, would have a positive impact on invasion challenges currently facing developing and developed nations alike.

4.2.2 Annual Research Meeting

132 people attended the C·I·B's Annual Research Meeting (ARM) on 8 and 9 November 2018. International guests from India, China, Brazil and Canada contributed to keynote addresses and panel discussions on key topics in invasion science. Colleen Downs (core team member, UKZN) could not attend but all her C·I·B-supported students attended the meeting.

It is clear that the ability to communicate effectively is developed with practice, and with exposure to the people who use our research findings. Every year, we design our ARM to provide this exposure for our students, who are able to mingle with top international and South African researchers, post-doctoral associates, partners and funding agencies of the C·I·B in a small conference setting. Usually, they are expected to present their work in the same way they would at an international meeting. In 2018, however, the student presentation awards, which every year

provide a substantial travel award (R30 000) to the best Masters level and PhD level presentations, took on a strong science communication focus. In preparation for the ARM, all current C·I·B post-graduate students were asked to prepare a popular article in the format of *The Conversation Africa* and a short, popular-style talk of under three minutes.

Student travel awards - C·I·B/The Conversation Africa Science Communication Awards

The submitted articles were judged by an internal SU panel to identify ten finalists, after which The Conversation Africa editors, Ozayr Patel, Candice Bailey and Caroline Southey selected the Masters and PhD winners. All 'finalist' articles were displayed at the ARM and the Conversation editors gave valuable feedback to the students on their writing at the end of the meeting. The winning article by PhD candidate Dr Nitya Mohanty will be published in The Conversation Africa. Due to The Conversation's publication policies, the winner in the Masters category cannot publish independently.

Finalists and winners in the C·I·B/The Conversation Africa Science Communication Awards, 2018.

Name	Article title
Masters students	
Liana Isabel de Araujo (SU)	Do dispersal reproduction trade-offs give invasive insects the edge?
Catherine Keanly (SU) (winner in Masters category)	Encapsulating yachts to manage the transfer of marine alien species
Ella Morran	Effects of alien plant invasions on a small endemic tortoise, *Homopus areolatus*.
Anneke Schoeman (NWU)	Understanding the invader: Exploring geographic variation in the parasites of the African clawed frog (Anura: Pipidae: *Xenopus laevis*)
Sophia Turner (SU)	Reaching new heights? Exploring the impacts of exotic flora in a montane ecosystem
PhD students	
Karla Alujevic (SU)	Thermal physiology, behaviour and fitness in the lizard *Agama atra*: exploring inter-individual variation in the context of environmental change
Blair William Cowie (Wits)	*Parthenium hysterophorus*: understanding the invasion and potential controls
Patricia Duncan (SU)	Quantifying the extent of the problem: a case for future biological control of Paterson's Curse (*Echium plantagineum*) within South Africa
Nitya Mohanty (SU) (winner in PhD category)	The invasive Indian bullfrog *Hoplobatrachus tigerinus* on the Andaman Islands: Evaluating drivers of distribution, density, and trophic impact of an early stage invader
Davina Saccaggi (SU)	Mechanisms and determinants of invasion success in terrestrial arthropods

Editor of The Conversation Africa, Caroline Southey, giving feedback to C·I·B students on their popular articles. (Photo: S.C. Turner)

The C·I·B Fame Lab competition

In addition to the popular article competition, C·I·B students were asked to present an aspect of their work as a three-minute talk in the format of Fame Lab, the international science communication competition held annually in South Africa, and globally (https://www.saasta.ac.za/competitions/famelab/). The talks were of a high standard, and the best presenter at the C·I·B heat goes forward to the national finals in early 2019. For the first time in its history, the C·I·B team enjoyed two musical presentations by Masters candidates Ella Morran and Sophia Turner.

The finalists in the Fame Lab heat were Staci Warrington (SU), Anneke Schoeman (North-West University), Kirstin Stephens (SU), Ella Morran (SU), Karla Alujevic (SU), Davina Saccaggi (SU), Dumisani Khoza (Rhodes), Nitya Mohanty (SU), Lerato Maimela (UP), Blair Cowie (Wits). The overall C·I·B FameLab heat winner was Staci Warrington, with Davina Saccaggi the runner-up.

Ella Moran (left) and Sophia Turner (right), demonstrating that song is a viable communication medium for scientific concepts. (Photos: Left: S.C. Turner; right: S.J. Davies)

4.2.3 Iimbovane Outreach Project

Iimbovane is a multi-faceted outreach programme that works with Grade 10 learners at predominantly rural secondary schools in the Western Cape. The broad aims of the project are to inspire young people to appreciate biodiversity and the natural world and to encourage them to take up careers in the life sciences. This is done by supporting learners and educators in the life sciences curriculum.

Four pillars define the Iimbovane project's philosophy and activities. First, the project provides curricular support to learners and educators in South African schools through their sampling of ant fauna around the schools and in nearby nature reserves. Second, it raises awareness of science as an interesting and attractive career path by introducing pupils to young women scientists who are role-models for how South Africa's scientific capacity can be grown. Third, the project advances biodiversity conservation by changing the attitudes of the youth and communities regarding the value of their local biodiversity and the impacts that human activities have on biodiversity. Finally, as part of the long-term research programme of the Centre for Invasion Biology, Iimbovane has contributed to research on ant biodiversity in the Cape Floristic Region.

Classroom lessons and biodiversity assessments

Between April and September 2018, the project team visited the 17 schools to train Grade 10 learners and educators in biodiversity science and the scientific method. The project team successfully trained approximately 644 Grade 10 learners during these visits. During these school visits learners were taken out of the classroom to investigate the ant diversity in their school

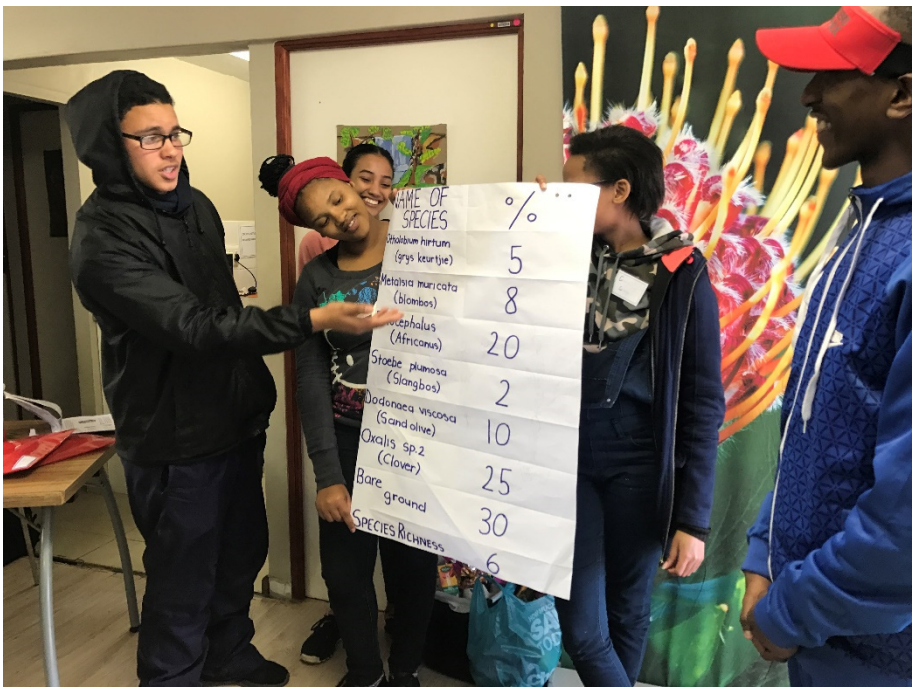
grounds while using mini-microscopes to explore the morphological differences between the different ant species.

One-day programmes on campus

In 2018, the Iimbovane Outreach Project invited two schools to receive training on the Stellenbosch University campus. The Grade 10 Life Sciences learners from Umyezo Wama Apile Combined School, in Grabouw, and Manzomthombo Secondary School in Blue Downs, joined the project for two separate workshops in the Jan Marais Nature Reserve. The groups were introduced to theoretical concepts of biodiversity science which were then followed by practical fieldwork. The learners then took their samples to the laboratories on campus where the Iimbovane staff taught them how to use a microscope for basic ant identification. These workshops provided skills and insights that supplement the theory lessons done in the classroom.

Holiday programmes

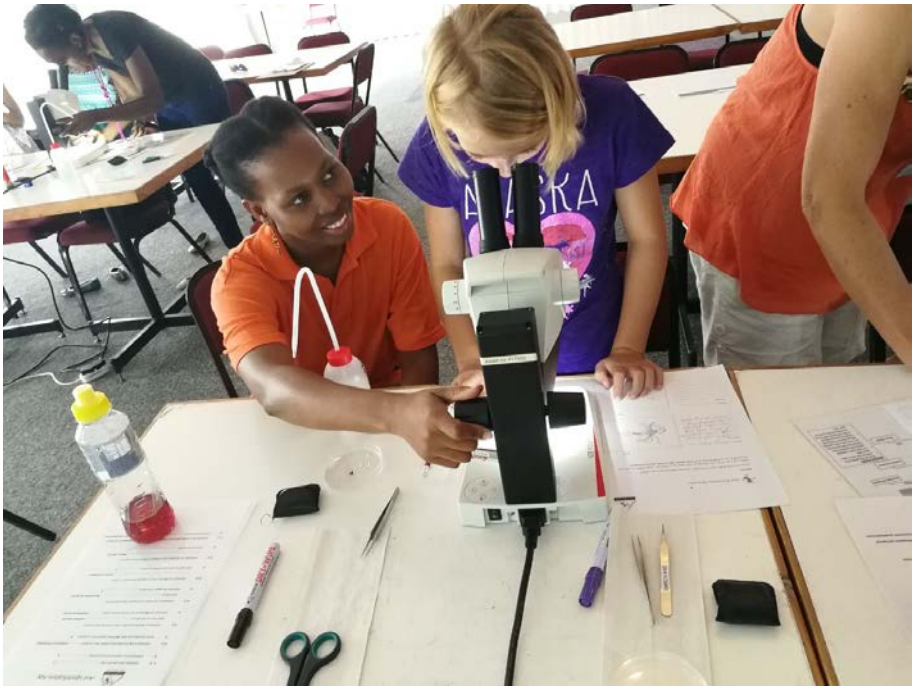
The Iimbovane Outreach Project presented three multi-day workshops during the 2018 school holidays. These workshops are aimed at exposing learners to mini-research projects in a variety of ecosystems. During these mini research projects the budding scientists learned how to collect, analyse, interpret and finally present data by using computer programmes. Beyond the biodiversity studies, the learners were also exposed to campus life, by staying in a university residence, exploring the lecture halls, student centre and library. These workshops were attended by 56 learners.



Learners presenting the results of their field studies during Iimbovane workshops. (Photo: S.C. Turner)

Science festivals and career expos

In 2018, the Iimbovane team took part in a number of events promoting and popularising science and biodiversity related careers. Southern Africa's largest science festival, SciFest Africa, took place in Grahamstown from the 6-13 March. Here, the Iimbovane team presented six interactive workshops, called 'Magnific-ANT life below ground'. The aim of the workshops was to introduce participants to ants and their fascinating ecology in the hope of inspiring them to appreciate the smaller, often overlooked life forms. The Iimbovane team were joined by Ntsiki Langa, Recruitment Officer for Stellenbosch University's Faculty of Science, who explained the biodiversity related courses offered at the Stellenbosch University and admission requirements to the older learners.



Londiwe Msomi, Iimbovane Environmental Educator, showing a learner at SciFest Africa how to identify ant species. (Photo: S.C. Turner)

Inclusion of people with disabilities

On 27 June 2018, the Iimbovane project team intrigued a group of Camphill Village West Coast residents with interesting facts about ants. The group consisted of 14 residents whose daily duties include working in the village's vegetable and herb gardens together. Camphill Village West Coast is a dynamic community that provides a safe environment for intellectually challenged adults where they can experience a meaningful and fulfilling life. It is set on a farm where the residents work at enterprises on the farm, for example, a bakery, dairy, herbal workshop, or in vegetable gardens, producing quality produce.

The workshop began with a brief introduction to the importance of ants and the Camphill residents were surprised to hear there are more than just one type of small black ants. They also found it

interesting that the tunnels made by ants are important for aeration of the soil which is good for the crops in their vegetable and herb gardens. After a brief background on ants and ant ecology residents went out searching for ants around the buildings, under rocks and in trees.

The workshop had a positive impact on all the participating residents, and for one resident in particular, as described by James Sleigh, Managing Director of Camphill Village West Coast. “Eckhart, who has been like a disinterested teenager, was so sparked and triggered by your workshop, that he went to Antonius (the farm manager) and asked him to teach him about the cows, and other animals, and said he now really wants to learn. The other residents too, have been really looking around at insects and asking about them. It really was so inspiring for everyone, so again, thank you.”

Camphill participants were again invited for another one-day workshop on biodiversity. The aim of the second workshop was to take look at biodiversity in biomes and how plants adapt in certain biomes. This time, the group visited the Jan Marais Nature Reserve in Stellenbosch and the Stellenbosch University Botanical Garden, where the group were introduced to the different garden themes and visited the nursery where the host explained how temperatures are adjusted to manage the growth of the plants. One of the international volunteers at Camphill Village West Coast had this to say about her day:

> “The programme was very nice, we really enjoyed it, now we know the difference between grass and flowers. We also know that Stellenbosch University Botanical Garden have many different species in a small area for example herbs, ferns, flowers and plants that can survive without water for a long time such as aloes and euphorbias. We really appreciate it.”

Iimbovane project staff working with residents of Camphill Village; during 2019 we conducted two workshops with Camphill residents, one on the West Coast and one in Stellenbosch. (Photo: S.C. Turner)

C·I·B Outreach

In May 2018, several C·I·B staff members, academics and students took part in the annual Cell C Take a Girl Child to Work Day initiative. During the outreach event a group of ten highly motivated Grade 11 girls from Vusisizwe Secondary School in Worcester had the opportunity to interview a variety of women about their careers in science, the highlights and challenges that come with their jobs and why they chose their respective careers.

> "The day was very fruitful. Our learners got the opportunity to visit the University, laboratories and a state-of-the-art library. They had fun working in the laboratories and got a clear understanding of science orientated careers. They also got to see what people do in different careers" says Boniswa Mphepuka, educator at Vusisizwe Secondary School, who accompanied the group of girls.

The C·I·B further participated and inspired learners at the Western Cape Education Department (WCED) Biodiversity Careers Expo and interacted with approximately 110 learners at the expo. Learners visiting the C·I·B exhibit were introduced to a variety of careers that are offered in biological sciences, the subjects needed and entry requirements. They interacted with Iimbovane Education Outreach Officer, Londiwe Msomi and SANBI intern, Tumeka Mbobo, who is currently pursuing her PhD with the C·I·B.

In August 2018, Iimbovane hosted an exhibit for educators at the Fieldtrip Fair 2018. The event was organised by the WCED Metro North Education District. At the event the Iimbovane team interacted with more than 40 educators, mostly from primary schools and who were exited to learn about Iimbovane and how it can be implemented on an extra-curricular basis for lower grades.

Further training

A big highlight for the Iimbovane project team in March 2018 was the opportunity to attend the first ever Ant Identification Course held at Wits Rural Facility, Hoedspruit. A team of international scientists, including Prof. Kate Parr, Prof. Alan Anderson and Dr Tom Bishop, led the participants through an intense week of 'ant-ing'. The course covered everything from the various methods of collecting ants, choosing the correct method, mounting of ants for reference collections and how to use an ant key for identification.

4.2.4 Web-based services and social media

Table 6. IRSS, web site and and social media statistics.

Instrument and number of interactions			
IRSS https://ir.sun.ac.za/cib/:			
245 items were submitted to the IRSS during the year			
Web page www.sun.ac.za/cib:			
18250 unique visitors (down from 22063 previous year)			
29861 unique page views			
Africa	**11137**	Oceania	**441**
Europe	**2199**	South America	**368**
North America	**1679**	Central America	**25**
Asia	**1126**	Other	**1275**
Facebook page centreforinvasionbiology:			
1147 follows in total			
52 posts			
762 viewers per post (average)			
Posts that received the most attention:			
6 November	*Report on status of biological invasions in South Africa a world first* (4569 people reached)		
19 June	*Residence time and its link to Lantana performance in India and South Africa* (2648 reached)		
12 March	*Can prickly pear invasions be controlled by cochineal scale insects?* (2149 reached)		
14 May	*Port Jackson impacts the restoration of Protea repens long after its removal* (1597 reached)		
17 August	*Natural vegetation increases macadamia pest control by bats* (1388 reached)		
7 February	*Are beetles and microbes the key to overcoming famine week?* (1360 reached)		
Twitter @invasionscience:			
2865 total Tweets			
181 photos and videos			
765 followers (remains 48% Male and 52% Female)			

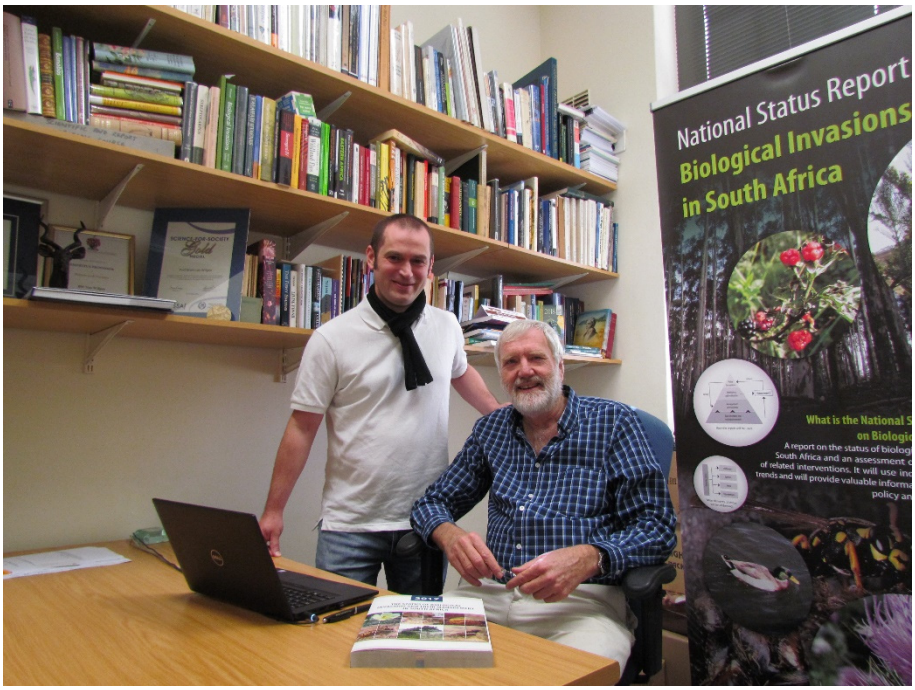
4.2.5 Media highlights

The complete list of media mentions can be viewed in the media interactions section of the report; however, there are a few highlights that deserve special mention.

A paper published by C·I·B core team member, Brian van Wilgen, and colleagues received numerous mentions in the media. The paper, which was published in the scientific journal Fire Ecology, highlighted that the replacement of natural fynbos vegetation with pine plantations in the southern Cape, and the subsequent invasion of surrounding land by invasive pine trees, significantly increased the severity of the 2017 Knysna wildfires. Articles about these findings featured in newspapers including Cape Times, The Mercury, Sunday Times and The Herald. Further articles featured on online sites such as Science Daily, Business Live, Cape Times, The Newspaper and Phys.org. The matter received further exposure through a radio interview with Brian van Wilgen on Cape Talk and an interview for television news, SABC News.

The contribution of C·I·B core team members Brian van Wilgen and John Wilson as lead editors of the first comprehensive national-scale report on the status of invasive species resulted in several

articles in the media. The report, The Status of Biological Invasions and their Management 2017, was compiled by a team of 37 editors and authors from 14 organisations, led by the South African National Biodiversity Institute (SANBI) in collaboration with the C·I·B. The publication of the report has led to articles on the online media platforms of Saturday Star, Business Insider SA, Nature and Scientific American and in the print media in newspapers such as The Saturday Star, Sawubona and the Diamond Fields Advertiser.



John Wilson (left) and Brian van Wilgen were the lead authors and editors for the first National Status Report on Biological Invasions in South Africa. (Photo: Wiida Basson)

In December 2018, a paper by C·I·B core team member John Measey and former C·I·B Research Fellow James Vonesh in *African Journal of Ecology* drew attention from international science media platforms. The paper, which found that invasive African clawed frogs feed on the tadpoles of the endangered Cape platanna, led to articles on online news sites such as New Scientist, Daily Mail and Times Live.

The arrival of the invasive alien beetle, polyphagous shot hole borer, and the threat that this beetle poses to suburban and indigenous trees received wide media attention. It has led to an article on the News24 website in which C·I·B core team member Marcus Byrne explains how the beetles infect tree trunks with the fungus that eventually kills the trees. Marcus Byrne was further interviewed on several radio stations and online radio shows including Radio Sonder Grense, Radio 86, My Ballito and The South African.

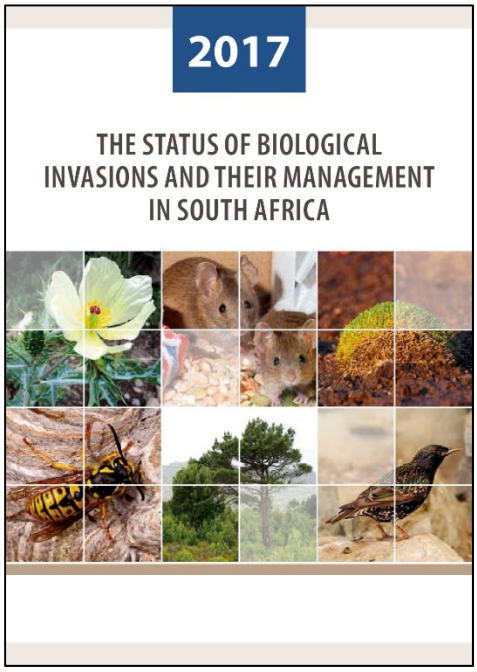
5 SERVICE PROVISION

5.1 Objectives

The C·I·B strives to be valued for its excellent, evidence-based, reliable, affordable and impartial service. Moreover, the C·I·B strives to ensure that clients will always be in a position to follow up on the service they have received in such a way that they derive the full benefit from the C·I·B services available. The C·I·B's overall approach to service provision is to provide service at a reasonable cost i.e. it does not seek to make substantial profits but to undertake work in accordance with SU's full-cost budgeting procedures, especially where the service is clearly in line with its overall vision 'to provide the scientific understanding required to reduce the rate and impacts of biological invasions in a manner that will improve the quality of life of all South Africans, during times of change.' Research outputs from service provision will continue to be a key goal of the activity.

5.2 Progress

5.2.1 National Status Report on Biological Invasions in South Africa



In 2016 the C·I·B was contracted by SANBI to assist in the compilation of the first status report at a national level specifically on biological invasions (required by NEM:BA). The writing of the report was completed in 2017 and it was submitted to the Department of Environmental Affairs as required by the National Environmental Management: Biodiversity Act (Chapter 5 regulations). The process of compiling the report and its importance was summarised in the 2017 annual report.

Early in 2018, South Africa's first National Status Report on Biological Invasions was formally published. The lead editors were C·I·B core team members Brian Van Wilgen (C·I·B) and John Wilson (SANBI). Chapter lead authors from the C·I·B included Katelyn Faulkner (C·I·B post-doc, UP), Sebataolo Rahlao (core team member) and Tsungai Zengeya (core team member). Contributing authors included core team members Llewellyn Foxcroft, Charles Griffiths, John Measey, Dave Richardson and Tammy Robinson-Smythe, and research associates Pat Holmes and David Le Maitre.

5.2.2 Risk analysis framework

The risk analysis framework for alien taxa has been published open access for people to use (https://www.preprints.org/manuscript/201811.0551/v1), and a publication in a peer-reviewed journal is

planned. The framework is being used to establish the evidence base for regulating alien species in South Africa through the Alien Species Risk Analysis Review Panel (ASRARP) of DEA. Furthermore, a MSc thesis by C·I·B student Khensani Nkuna assessed all *Paspalum* species alien to South Africa with the framework.

5.2.3 Risk analysis training courses

A four-day training course to teach practitioners and students to use the Risk Analysis Framework has been developed. Three courses were given by C·I·B team members during the year in different parts of the country (Stellenbosch, Pretoria and Pietermaritzburg) and 34 people were trained. Participants learned about risks of alien species in general, how to assess and analyse them, and the practical section led to the assessment of one species per participant. Participants were also taught about cognitive biases, the need for evidence-based decision-making and the value of peer-review, including reviewing each other's analysis.

5.2.4 Alien Species Risk Analysis Review Panel

The Alien Species Risk Analysis Review Panel is coordinated by SANBI, with participation of several C·I·B core team members as panel members. This national panel is responsible for the review of risk analyses submitted to the Department of Environmental Affairs and supports decision-making regarding regulation and importation of alien species.

6 GENDER IMPACT

Women form 24 % of the C·I·B's core team and 41% of our research associate network. All of the hub staff are women, and importantly, the all-woman Iimbovane team is a strong role model for inspiring secondary science learners to take up scientific careers. Our student body is 70% female, and 73% of our post-doctoral associates are female. The C·I·B makes every effort to provide an inclusive and friendly yet professional environment where all genders and cultural groups feel welcome and are given opportunities to be productive and grow. These efforts include a range of events and academic meetings where training takes place, as well as science communication and personal development training opportunities and coaching. Women consistently perform well in our annual awards for writing (80% of the finalists in the C·I·B/The Conversation Africa Science Communication Awards were women) and oral presentation (70% of the Fame Lab finalists were women).

7 RETURN ON INVESTMENT - INVASION SCIENCE FOR SOCIETY

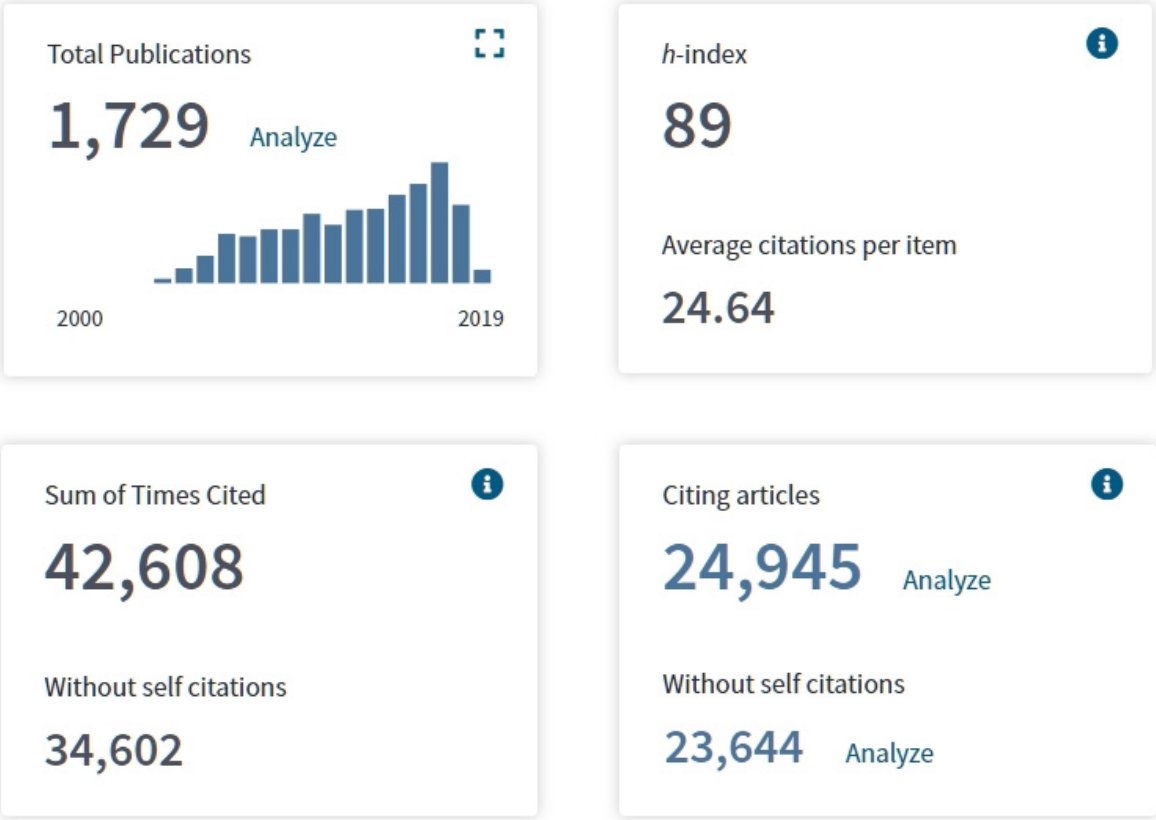
We believe that the C·I·B adds value in the following ways:

- Providing a research partner to several government institutions
- Building South Africa's science capacity, especially in invasive species science

- Performing cutting-edge research to place SA on the global stage
- Working towards better management of invasive species in South Africa and its neighbouring countries
- Playing a leading role in improving policy and supporting managers
- Supporting life science teachers in under-resourced schools
- Providing a role model for learners who wish to enter scientific careers.

The C·I·B is recognised as a leading research entity in the field of invasion science. Prof. Marc Cadotte (University of Toronto Scarborough), keynote speaker at the C·I·B's annual research meeting in November 2018, commented:

> "Overall, the C·I·B is a world-class institute that clearly exceeds all expectations of the mandated objectives of the Centre of Excellence programme, and has established itself as a global powerhouse. During my visit to the CIB, my initial impressions were continually reinforced. The CIB is home to a top-tier and collegial group of researchers, and enthusiastic and motivated students. Overall the research culture and productivity are second to none. Further, the dedication to student-led research and training create a globally unique graduate and post-doctoral experience."



Citation report for the C·I·B (2004-2018). Downloaded 12 February 2019; http://apps.webofknowledge.com.

Over the past 14 years we have supported over five hundred graduates in the life sciences and social sciences. The greatest number of our graduates (36%) take up positions in academic institutions. However, fully 18% work in government and implementing agencies, and 15% in private consultancies or businesses. Six percent have taken up positions in non-government or non-profit, civil society organisations. Eighteen percent are continuing their studies either within or outside the C·I·B's network. Of our graduate whose whereabouts we know, 70% have remained in South Africa. This network of scientists and researchers contributes to the capacity of South Africa to meet the challenges of global change, of which biological invasions are a key aspect.

Participants in the C·I·B's Annual Research Meeting held on 8 and 9 November 2018 at Stellenbosch University. (Photo: Anton Jordaan)

The C·I·B partners with SANBI, SANParks and several municipalities, particularly metros, to understand the impact of invasive species on their areas of work and to support the challenges of managing invasive species. We have also worked closely with the Department of Environmental Affairs to develop the regulations supporting NEM:BA, produced the National Strategy on dealing with biological invasions and co-led the National Status Report. These contributions have drawn together many core team members, research associates, students and post-docs and catalysed workshops and joint publications. The C·I·B's expertise has grown and we are now well-positioned to contribute to policy development in biodiversity, resource management and agricultural pest management.

The C·I·B's Iimbovane Outreach programme makes four major contributions to the science education sector by providing education support to learners, raising awareness of science as an interesting and attractive career path for young people, advancing awareness of and changing attitudes to

biodiversity conservation and the impacts that human activities have on biodiversity, and generating long term data on ant biodiversity in the Cape Floristic Region.

8 GOVERNANCE AND ORGANISATIONAL STRUCTURE

8.1 Steering Committee

The C·I·B Steering Committee is composed of 14 members, and meets twice a year in March and October/November. The role of the Committee is to advise on the objectives and Strategic Plan and to discuss and resolve matters of policy that relate to the CoE. The Steering Committee approves the annual Business Plan including the budget (within the constraints set by the NRF) and approves Annual Progress Reports prior to submission to the NRF. At the end of each stage of the COE's progress, the Steering Committee makes recommendations to the NRF concerning the progress through developmental gates. In general it monitors, evaluates and comments on performance of the CoE and assists in the promotion and resourcing, including the financing.

Table 7. The Steering Committee of the C·I·B in 2018.

Name	Affiliation	Role
Prof. Eugene Cloete	Vice Rector, Research, Innovation & Postgraduate Studies, Stellenbosch University	Ex officio
Dr Sarah Davies	Deputy Director: Operations, Centre for Invasion Biology, Stellenbosch University	Ex officio
Prof. John Donaldson	Chief Director: Biodiversity Research, Assessment & Monitoring, South African National Biodiversity Institute	Industry Representative
Prof. Piero Genovesi	ISPRA Institute for Environmental Protection and Research, Italy	International Science Advisor
Mr Ahmed Khan	Deputy Director, Strategic Services, DEA NRM	Industry Representative
Dr Makobetsa Khati	Executive Director, Research Chairs and Centres of Excellence, National Research Foundation	NRF Representative
Prof. Laura Meyerson	Department of Natural Resources Science, The University of Rhode Island, USA	International Science Advisor
Prof. Dave Richardson	Director, Centre for Invasion Biology, Faculty of Science, Stellenbosch University	Ex officio
Prof. Sheona Shackleton	African Climate and Development Initiative (ACDI)	Industry representative
Prof. Michael Somers	Eugène Marais Chair in Wildlife Management, Mammal Research Institute, University of Pretoria	Core Team Representative
Mr Nathan Sassman	Director: Centres of Excellence, National Research Foundation	NRF Representative
Prof. Louise Warnich	Dean, Faculty of Science, Stellenbosch University	Ex officio
Mr Angus Paterson	Director, South African Institute for Aquatic Biodiversity	Industry representative

8.2 Core team members

Table 8. C·I·B core team members in 2018.

Name	Institute	Race	Gender	Citizenship	% Time in CoE	NRF rating
Prof. Marcus Byrne	Wits	White	Male	SA	10	C
Prof. Chris Chimimba	UP	Black	Male	SA	25	C
Prof. Susana Clusella-Trullas	SU	White	Female	Perm res	50	C
Dr Sarah Davies	SU	White	Female	SA	100	Unrated
Prof. Colleen Downs	UKZN	White	Female	SA	10	C
Prof. Karen Esler	SU	White	Female	SA	10	C
Prof. Stefan Foord	UniVen	White	Male	SA	20	C
Prof. Llewellyn Foxcroft	SANParks	White	Male	SA	20	C
Prof. Cang Hui	SU	White	Male	Perm res	40	B
Dr Sabrina Kumschick	SU	White	Female	Switzerland	90	C
Prof. Jaco Le Roux*	SU	White	Male	SA	70	Y
Dr John Measey	SU	White	Male	UK	100	C
Dr Thabiso Mokotjomela	SANBI	Black	Male	Perm res	15	Unrated
Dr Sebataolo Rahlao	SANBI	Black	Male	Perm res	10	Unrated
Prof. Dave Richardson	SU	White	Male	SA	100	A
Prof. Mark Robertson	UP	White	Male	SA	40	C
Dr Tammy Robinson-Smythe	SU	White	Female	SA	40	C
Dr Sheunesu Ruwanza	Rhodes	Black	Male	Perm res	30	Y
Prof. Michael Somers	UP	White	Male	SA	10	C
Prof. Peter Taylor	UniVen	White	Male	SA	10	B
Prof. John Terblanche	SU	White	Male	SA	15	B
Prof. Olaf Weyl	SAIAB	White	Male	Perm res	20	B
Prof. John Wilson	SANBI	White	Male	Perm res	80	B
Dr Tsungai Zengeya	SANBI	Black	Male	Perm res	40	Y
Emeritus core team members						
Prof. Charles Griffiths	UCT	White	Male	Perm res	10	B
Prof. Brian van Wilgen	SU	White	Male	SA	90	B

***left the core team during the year**

8.3 Research associates

Table 9. C·I·B research associates in 2018.

Full name	Affiliation
Dr Mhairi Alexander	University of the West of Scotland, UK
Prof. Tim Blackburn	University College London, UK
Dr Ryan Blanchard	Natural Resources and the Environment, CSIR
Dr Jane Carruthers	Private (retired academic)
Prof. Franz Essl	University of Vienna, Austria
Dr Mirijam Gaertner	Nürtingen-Geislingen University of Applied Science, Germany
Dr Sjirk Geerts	Cape Peninsula University of Technology

Full name	Affiliation
Prof. Piero Genovesi	Institute for Environmental Protection and Research, Italy & Chair, IUCN Species Survival Commission Invasive Species Specialist Group
Prof. Jan Giliomee	Department of Botany & Zoology, Stellenbosch University
Dr Patricia Holmes	Cape Ecological Services
Dr Michelle Jackson	Imperial College London, UK
Dr Charlene Janion-Scheepers	Iziko South African Museum
Dr Martine Jordaan	CapeNature Scientific Services
Dr Jesse Kalwij	Kiel University, Germany
Prof. Christoph Küffer	ETH Zurich, Switzerland
Dr David Le Maitre	Natural Resources and the Environment, CSIR
Prof. Jaco Le Roux	Department of Biological Sciences, Macquarie University, Australia
Prof. Melodie McGeoch	Faculty of Science, Monash University, Australia
Mr Dave Pepler	Stellenbosch University
Prof. Petr Pyšek	Institute of Botany, Academy of Sciences of the Czech Republic
Prof. Tony Ricciardi	Redpath Museum, McGill University, Canada
Dr Nicola Van Wilgen	Global Change Scientist, South African National Parks
Dr Darragh Woodford	University of the Witwatersrand

8.4 Staff employed by the C·I·B

The table below shows all staff who are employed by the Centre in 2018

Table 10: C·I·B staff in 2018.

Name	Institute	Position	Race	Gender
Ms Lorraine Cilliers	SU	Personal Assistant	Female	White
Ms Karla Coombe-Davis	SU	Principal Technical Officer	Female	White
Dr Sarah Davies	SU	Research Manager	Female	White
Ms Dorette Du Plessis	SU	Iimbovane Programme Manager	Female	White
Ms Kerryn Grenfell*	UP	Northern Node Technical Officer	Female	White
Ms Megan Mathese	SU	Molecular Lab Manager	Female	Coloured
Ms Suzaan Kritzinger-Klopper	SU	Chief Technical Officer	Female	White
Dr Sabrina Kumschick	SU	Researcher	Female	White
Dr Elrike Marais	SU	5/8 C·I·B Research & Project Mgr	Female	White
Dr John Measey	SU	Senior Researcher	Male	White
Mrs Christy Momberg	SU	5/8 Management Assistant	Female	White
Ms Rhoda Moses	SU	Administrative Officer	Female	Coloured
Ms Londiwe Msomi	SU	Education Outreach Officer	Female	African
Ms Erika Nortje	SU	Ecophysiology Lab Manager	Female	White
Prof. Dave Richardson	SU	Distinguished Professor	Male	White
Ms Sophia Turner	SU	Iimbovane Technical Assistant	Female	White
Ms Mathilda Van Der Vyver	SU	Administrative Officer	Female	White
Prof. Brian Van Wilgen	SU	Professor	Male	White

* **Position jointly supported by the C·I·B and the University of Pretoria**

Please see appendix sections A.2.1 and A.2.2 for student and post-doc registration and progress.

9 STAGE PROGRESS AGAINST SERVICE LEVEL AGREEMENT

This CoE is currently in **Stage 6** (2015-2019).

Timeframes

The pending Gate review (Gate 6) shall take place during February or March 2020

Two COE Steering Committee (virtual or real) meetings should take place per annum during this Stage, typically during March and November of each year

2015: The Steering Committee met on 18 March and 19 October 2015

2016: The Steering Committee met on 18 March and 27 October 2016

2017: The Steering Committee met on 24 March and 26 October 2017

2018: The Steering Committee met on 29 March and 14 November 2018

Activities related to the Current Stage

The COE shall provide to the NRF a list of students that are being supported by the Centre by end April of each year. Additional students can be appended to this list as and when they arrive

2015: Student list provided and entered onto the NRF online system as requested

2016: Student list provided and entered onto the NRF online system as requested

2017: Student list provided and entered onto the NRF online system as requested

2018: Student list provided and entered onto the NRF online system as requested

The COE will publish 'vignettes' (formerly termed 'nuggets') of information on its website and provide these at six-monthly intervals to the NRF.

2015: Vignettes were published regularly on the C·I·B web site, Facebook page and Twitter feed and sent in batches to the NRF on 1 April, 29 July and 1 November

2016: Vignettes were sent to the NRF on 7 June, 5 July 2016 and 28 Feb 2017

2017: Vignettes were sent to the NRF on 13 April 2017

2018: Vignettes were sent to the NRF on 12 April, 17 July, 5 October 2018 and 18 January 2019

Financial responsibilities

The COE shall present an audited set of financial statements annually at the March Steering Committee meeting reflecting the financial situation of the COE during the previous financial year

2015: The 2015 financial statements will be presented at the Steering Committee meeting on 18 March 2016

2016: The 2016 financial statements will be presented at the Steering Committee meeting on 24 March 2017

2017: The 2017 financial statements will be presented at the Steering Committee meeting on 29 March 2018

2018: The 2018 financial statements will be presented at the Steering Committee meeting on 11 March 2019

The COE shall submit monthly cash-flow statements within 15 days of the end of each calendar month according to the NRF template for cash flow reporting

2015: Cash flow statements submitted on a quarterly basis as requested in the COE Handbook (2014 version)

2016: Cash flow statements submitted on a quarterly basis as requested

2017: Cash flow statements submitted on a quarterly basis as requested

2018: Cash flow statements submitted on a quarterly basis as requested

Reports due in this Stage

The COE shall submit an Annual Progress Report by no later than end March each year, including the Stage 6 Gate Review Documentation by no later than March 2020 to be reviewed by the COE Steering Committee

2015: The annual report for 2015 was approved by the Steering Committee on 18 March 2016

2016: The annual report for 2016 was approved by the Steering Committee on 24 March 2017

2017: The annual report for 2017 will be presented to the Steering Committee on 29 March 2018

2018: The annual report for 2018 will be presented to the Steering Committee on 11 March 2019

The COE shall submit a Statement of Compliance by no later than March 2020 referring to Stage 6

2015: The statement of compliance for 2015 was signed off at the Steering Committee meeting on 18 March 2016

2016: The statement of compliance for 2016 was signed off at the Steering Committee meeting on 24 March 2017

2017: The statement of compliance for 2017 was signed off at the Steering Committee meeting on 29 March 2018

2018: The statement of compliance for 2018 will be signed off at the Steering Committee meeting on 11 March 2019

Standard Output Targets per annum in the Current Stage

Total number of students supported ≥ 60 on average per annum

2015: 67 students supported

2016: 71 students supported

2017: 71 students supported

2018: 60 (excluding post-docs)

Women students ≥ 50% of all students on average per annum

2015: Women students 54% of student group

2016: Women students 56% of student group
2017: Women students 70% of student group
2018: Women students 70% of student group

Black students ≥ 50% of all students on average per annum
2015: Black students 52% of student group
2016: Black students 46% of student group
2017: Black students 46% of student group
2018: Black students 58% of student group

Number of social science students ≥ 2 on average per annum
2015: Two social science students supported (i.e. registered in the social sciences; several other students and post-doctoral associates engaged in projects that ask socially-relevant questions and use social science methods)
2016: Two social science students supported (Thomas Stielau, MA; Brent Abrahams, PhD)
2017: One student registered for a social science degree (Thomas Stielau, MA, UCT) was supported. Another two students have projects that explicitly address social science issues (Sinazo Ntsonge, MSc, Rhodes University and Brent Abrahams, PhD, Stellenbosch University).
2018: Two students were registered for social science focused degrees: Sinazo Ntsonge (PhD candidate, Rhodes) and Brent Abrahams (PhD candidate, SU)

Average duration of submitted Masters degrees (post Honours) ≤ 2.5 years at end of stage
2015: 2.25 years
2016: 2.7 years
2017 2.6 years
2018: 2 years

Average duration of submitted PhD degrees (post Masters) ≤ 3.5 years at end of stage
2015: 4.4 years
2016: 3.8 Years
2017 4 years
2018: 4.7 years

Average duration of submitted PhD degrees (upgraded from Masters) ≤ 5 years at end of stage
2015: 4.4 years
2016: None completed in 2016
2017 4.8 years
2018: 4 years

Post-doctoral researchers ≥ 10% of all students at end of stage

2015: Post-doctoral associates made up 20% of the students and post-doctoral associates supported
2016: Post-doctoral associates made up 18% of the students and post-doctoral associates supported
2017: Post-doctoral associates made up 15% of the students and post-doctoral associates supported
2018: Post-doctoral associates made up 15% of the students and post-doctoral associates supported

Each core team member must undertake at least one scientific review per annum on behalf of the NRF (postal peer review process or panel)
2015: 20 reviews performed
2016: 19 reviews performed
2017: 33 reviews performed
2018: 29 reviews performed

Number of patents ≥ 1
2015: 0
2016: 0
2017: 0
2018: 0

Number of peer reviewed publications ≥ 85 on average per annum
2015: 178
2016: 201
2017: 216
2018: ~~162~~ 161

Number of peer reviewed publications ≥ 2 with an impact rating of ≥ 15 on average per annum
2015: 2
2016: 1
2017: 4
2018: 1

Number of peer reviewed publications ≥ 20 with an impact rating of ≥ 4.0 on average per annum
2015: 33
2016: 36
2017: 47
2018: 43

Number of national conference presentations ≥ 30 on average per annum

2015: 41 (2 plenary/keynote, 34 oral, 5 poster)

2016: 38 (6 plenary/keynote, 25 oral, 7 poster)

2017: 90 (6 plenary/keynote, 75 oral, 9 poster)

2018: 56 (4 plenary/keynote 43 oral 9 poster)

Number of international conference presentation ≥ 10 on average per annum

2015: 26 (2 plenary/keynote; 22 oral; 2 poster)

2016: 40 (7 plenary/keynote; 26 oral, 7 poster)

2017: 42 (6 plenary/keynote, 27 oral, 9 poster)

2018: 38 (7 plenary/keynote 28 oral 3 poster)

Number of joint venture student training initiatives ≥ 20 on average per annum

2015: 67 (including co-supervisions and UCT Humanities students)

2016: 58 (including co-supervisions)

2017: 115 (including co-supervisions)

2018: 70 (including co-supervisions)

Number of local conferences organized ≥ 2 at end of stage

2015: One meeting organised (Conservation in the Cape Floristic Region, 13 April 2015)

2016: Two meetings organised (43rd Annual Research Symposium on the Management of Biological Invasions in South Africa, Goudini Spa, 18-20 May 2016, co-hosted with SANBI ISP; workshop on 'Biological invasions in urban areas: understanding the problems and identifying research priorities' held at University of Pretoria, 25-26 August 2016, by the Northern Hub)

2017: The C·I·B held a joint workshop with the South African Centre for Epidemiological Modelling and Analysis (SACEMA) on 'Integrating techniques in invasion biology and epidemiology for practical management of species invasions and emerging infectious diseases'.

2018: A team workshop on 'Biological invasions in South Africa: trends and implications for management' was held prior to the ARM on 7 November 2018

Number of international conferences organized ≥ 2 at end of stage

2015: Two meetings organised (Evolutionary dynamics of tree invasions: drivers, dimensions, and implications for management; Functional responses as a tool in invasion ecology, 9-10 November 2015)

2016: One meeting organised (Non-native species in urban environments: Patterns, processes, impacts and challenges, Lanzerac, Stellenbosch, 7-9 November 2016)

2017: One meeting organised (Invasion syndromes – moving towards generalizations in invasion science, Stellenbosch University, 6-8 November 2017).

2018: International workshop on 'The importance of international networks in invasion science' to establish an invasion science network among BRICS countries

Special Output Targets for the Current Stage

At least one full COE team activity per annum

2015: The C·I·B held both a Core Team Meeting (Tuesday 14 July 2015 at SAIAB, Grahamstown) and an Annual Research Meeting (12 and 13 November 2015, at Stellenbosch University). Although a few core team members were unable to attend due to other commitments, both meetings were well-attended.

2016: A mid-year Core Team Meeting was held on 18 May 2016 at Goudini Spa, and 18 members attended (six were not able to attend). The Annual Research Meeting was held on 10 and 11 November at Stellenbosch University and was well attended by the Core Team, science advisors, students and post docs as well as research associates, guests and partners of the Centre.

2017: 151 people attended the C·I·B's thirteenth Annual Research Meeting held in Stellenbosch on 9-10 November 2017; two core team members were unable to attend.

2018: 132 people attended the 14th Annual Research Meeting held in Stellenbosch on 8-9 November 2018 ARM; one core team member was not able to attend.

Successful continuation of Iimbovane outreach project to schools in the WCED region

2015: 28 participating schools (17 rural/11 urban of which 26 are serving previously disadvantaged communities; 18 full participation/10 subscription)

2016: 28 participating schools (17 rural/11 urban of which 26 are serving previously disadvantaged communities; 18 full participation/10 subscription).

2017: 23 participating schools (16 rural/7 urban of which 21 are serving previously disadvantaged communities; 17 full participation/6 subscription).

2018: 23 participating schools (16 rural/7 urban of which 21 are serving previously disadvantaged communities; 17 full participation/6 subscription)

10 CONCLUSION

The C·I·B has fulfilled all its obligations as a centre of excellence over the last 14 years. It is globally recognized as one of the most productive, if not THE most productive centres in the field of invasion science globally. Our national and global networks ensure that we apply cutting-edge science to the diverse problems associated with biological invasions in South Africa. We have achieved many successes in translating the outputs of our research into management actions and policy, but substantial challenges remain in this area. Some of the challenges are common problems associated with the "knowing-doing gap" that exist worldwide. However, there are special challenges that relate to issues peculiar to the South African situation. We have yet to find the perfect model for interacting productively with our key stakeholders such as DEA NRM and national and provincial nature conservation agencies. A serious stumbling block in our attempts to forge more productive relationships is the lack of a mechanism to enable these agencies to directly commission and fund research. We are actively seeking ways to overcome this barrier. The Centre clearly needs a broader funding base to ensure its continued service to South Africa.

A. 1. Appendices - Outputs

Research

Books

Hui, C., Landi, P., Minoarivelo, H.O. and Ramanantoanina, M. (2018). *Ecological and Evolutionary Modelling*. Springer International Publishing, Cham, Switzerland. 86 pp, ISBN: 9783319921495.

Book chapters

Mucina, L., Bustamante-Sánchez, M.A., Pedra, B.D., Holmes, P., Keeler-Wolf, T., Armesto, J.J., Dobrowolski, M., Gaertner, M., Smith-Ramírez, C. and Vilagrosa, A. (2018). Ecological restoration in mediterranean-type shrublands and woodlands. In: *Routledge Handbook of Ecological and Environmental Restoration.* Allison, S. and Murphy, S. (eds.). Taylor & Francis, Abingdon, UK. pp. 173-196.

Richardson, D.M. (2018). Australian acacias – super invaders of Mediterranean-type ecosystems. In: *The Biology of Mediterranean-Type Ecosystems*. Esler, K.J., Jacobsen, A.L. and Pratt, R.B. (eds.). Oxford University Press, Oxford. pp. 247-250.

Somers, M.J., Davies-Mostert, H., Maruping-Mzileni, N., Swanepoel, L., Do Linh San, E., Botha, A., Tjelele, J., Dumalisile, L., Marnewick, K., Tafani, M., Hunnicutt, A., Tambling, C.J., Minnie, L. and Hawkins, H.-J. (2018). Biology, ecology and interaction of other predators with livestock. In: *Livestock predation and its management in South Africa: a scientific assessment.* Kerley, G.I.H., Wilson, S.L. and Balfour, D. (eds.). Centre for African Conservation Ecology, Nelson Mandela University, Port Elizabeth. pp. 228-254.

Weyl, O.L.F., Ellender, B.R., Ivey, P., Jackson, M.C., Tweddle, D., Wasserman, R.J., Woodford, D.J. and Zengeya, T.A. (2018). Africa: Brown trout introductions, establishment, current status, impacts and conflicts. In: *Brown Trout: Biology, Ecology and Management.* Lobón-Cerviá, J. and Sanz, N. (eds.). John Wiley & Sons Ltd. pp. 623-639.

Published Conference Proceedings and Abstracts

Fey, S.B., Vasseur, D.A., Logan, M.L., Alujevic, K., O'Connor, M. and Clusella-Trulla, S. (2018). Resolving constraints and opportunities for behavioural rescue in response to rapid environmental change. In: *Society for Integrative and Comparative Biology: 2018 Annual Meeting.* San Francisco, CA.

Foxcroft, L.C., Spear, D., van Wilgen, N.J. and McGeoch, M.A. (2018). Associations between pathways of alien plant invaders and their impacts in South African protected areas. In: *10th International Conference on Biological Invasions: New Directions in Invasion Biology.* Dún Laoghaire, Ireland. (ed. Osborne, B.). p. 115.

Hall, S.A., Holmes, P.M., Gaertner, M. and Esler, K.J. (2018). Assessing restoration potential of a critically endangered vegetation type following alien acacia removal. *South African Journal of Botany* **115**, 287-287.

Novoa, A., Richardson, D.M., Bacher, S., Canavan, S., Catford, J.A., Čuda, J., Essl, F. and Foxcroft, L.C. (2018). Invasion syndromes – moving towards meaningful generalisations in invasion science. In: *10th International Conference on Biological Invasions: New Directions in Invasion Biology.* Dún Laoghaire, Ireland. (ed. Osborne, B.). p. 36.

Plasman, M., McCue, M.D., Reynoso, V.H., Terblanche, J.S. and Clusella-Trulla, S. (2018). Temperature alters digestive energetics and fuel selection in a lizard. In: *Society for Integrative and Comparative Biology: 2018 Annual Meeting.* San Francisco, CA.

Wilson, J.R., Faulkner, K., Henderson, L., Munyai, T., Rahlao, S., Zengeya, T. and van Wilgen, B.W. (2018). Plant invasions in South Africa: Insights from the 2017 National Status Report on Biological Invasions. *South African Journal of Botany* **115**, 314-315.

Peer-reviewed Journal Articles

Arnan, X., Andersen, A.N.*, et al.* (2018). Dominance–diversity relationships in ant communities differ with invasion. *Global Change Biology* **24**, 4614-4625.

Avidon, S., Shelton, J.M., Marr, S.M., Bellingan, T.A., Esler, K.J. and Weyl, O.L.F. (2018). Preliminary evaluation of non-native rainbow trout (*Oncorhynchus mykiss*) impact on the Cederberg ghost frog (*Heleophryne depressa*) in South Africa's Cape Fold Ecoregion. *African Journal of Aquatic Science* **43**, 313-318.

Bacher, S., Blackburn, T.M., Essl, F., Genovesi, P., Heikkilä, J., Jeschke, J.M., Jones, G., Keller, R., Kenis, M., Kueffer, C., Martinou, A.F., Nentwig, W., Pergl, J., Pyšek, P., Rabitsch, W., Richardson, D.M., Roy, H.E., Saul, W.-C., Scalera, R., Vilà, M., Wilson, J.R.U. and Kumschick, S. (2018). Socio-economic impact classification of alien taxa (SEICAT). *Methods in Ecology and Evolution* **9**, 159-168.

Becker, F.S., Tolley, K.A., Measey, G.J. and Altwegg, R. (2018). Extreme climate-induced life-history plasticity in an amphibian. *The American Naturalist* **191**, 250-258.

Bennett, J.M., Calosi, P., Clusella-Trullas, S., Martínez, B., Sunday, J., Algar, A.C., Araújo, M.B., Hawkins, B.A., Keith, S., Kühn, I., Rahbek, C., Rodríguez, L., Singer, A., Villalobos, F., Olalla-Tárraga, M.A. and Morales-Castilla, I. (2018). GlobTherm, a global database on thermal tolerances for aquatic and terrestrial organisms. *Scientific Data* **5**, #180022, 7 pages. DOI: 10.1038/sdata.2018.22.

Boardman, L., Mitchell, K.A., Terblanche, J.S. and Sørensen, J.G. (2018). A transcriptomics assessment of oxygen-temperature interactions reveals novel candidate genes underlying variation in thermal tolerance and survival. *Journal of Insect Physiology* **106**, 179-188.

Boersma, N., Boardman, L., Gilbert, M. and Terblanche, J.S. (2018). Sex-dependent thermal history influences cold tolerance, longevity and fecundity in false codling moth *Thaumatotibia leucatreta* (Lepidoptera: Tortricidae). *Agricultural and Forest Entomology* **20**, 41-50.

Bonebrake, T.C., Brown, C.J.*, et al.* (2018). Managing consequences of climate-driven species redistribution requires integration of ecology, conservation and social science. *Biological Reviews* **93**, 284-305.

Bosc, C., Roets, F., Hui, C. and Pauw, A. (2018). Interactions among predators and plant specificity protect herbivores from top predators. *Ecology* **99**, 1602-1609.

Campoy, J.G., Acosta, A.T.R., Affre, L., Barreiro, R., Brundu, G., Buisson, E., González, L., Lema, M., Novoa, A., Retuerto, R., Roiloa, S.R. and Fagúndez, J. (2018). Monographs of invasive plants in Europe: *Carpobrotus*. *Botany Letters* **165**, 440-475.

Chakona, G., Swartz, E.R. and Chakona, A. (2018). The status and distribution of newly identified endemic galaxiid in the eastern Cape Fold Ecoregion, of South Africa. *Aquatic Conservation: Marine and Freshwater Ecosystems* **28**, 55-67.

Cheney, C., Esler, K.J., Foxcroft, L.C., van Wilgen, N.J. and McGeoch, M.A. (2018). The impact of data precision on the effectiveness of alien plant control programmes: a case study from a protected area. *Biological Invasions* **20**, 3227-3243.

Clusella-Trulla, S. (2018). All-in-one: physics, chemistry and ecology are essential fields to thermal ecologists. *Frontiers of Biogeography* **10**, 39387, 2 pages. DOI: 10.21425/F5FBG39387.

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Cowie, B.W., Venter, N., Witkowski, E.T.F., Byrne, M.J. and Olckers, T. (2018). A review of *Solanum mauritianum* biocontrol: prospects, promise and problems: a way forward for South Africa and globally. *BioControl* **63**, 475-491.

Cowie, B.W., Witkowski, E.T.F., Byrne, M.J., Strathie, L.W., Goodall, J.M. and Venter, N. (2018). Physiological response of *Parthenium hysterophorus* to defoliation by the leaf-feeding beetle *Zygogramma bicolorata*. *Biological Control* **117**, 35-42.

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Diedericks, G., Henriques, R., von der Heyden, S., Weyl, O.L.F. and Hui, C. (2018). Sleeping with the enemy: introgressive hybridization in two invasive centrarchids. *Journal of Fish Biology* **93**, 405-410.

Divíšek, J., Chytrý, M., Beckage, B., Gotelli, N.J., Lososová, Z., Pyšek, P., Richardson, D.M. and Molofsky, J. (2018). Similarity of introduced plant species to native ones facilitates naturalization, but differences enhance invasion success. *Nature Communications* **9**, 4631, 10 pages. DOI: 10.1038/s41467-018-06995-4.

Dlamini, P., Zacharides, C. and Downs, C.T. (2018). The effect of frugivorous birds on seed dispersal and germination of the invasive Brazilian pepper tree (*Schinus terebinthifolius*) and Indian laurel (*Litsea glutinosa*). *South African Journal of Botany* **114**, 61-68.

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Richardson, D.M. (2018). Which taxa are alien? Criteria, applications, and uncertainties. *BioScience* **68**, 496-509.

Evans, T., Kumschick, S., Şekercioğlu, C.H. and Blackburn, T.M. (2018). Identifying the factors that determine the severity and type of alien bird impacts. *Diversity and Distributions* **24**, 800-810.

Evans, T., Pigot, A., Kumschick, S., Şekercioğlu, C.H. and Blackburn, T.M. (2018). Determinants of data deficiency in the impacts of alien bird species. *Ecography* **41**, 1401-1410.

Fill, J.M., Kritzinger-Klopper, S. and van Wilgen, B.W. (2018). Short-term vegetation recovery after alien plant clearing along the Rondegat River, South Africa. *Restoration Ecology* **26**, 434-438.

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Gibb, H., Sanders, N.J., Dunn, R.R., Arnan, X., Vasconcelos, H.L., Donoso, D.A., Andersen, A.N., Silva, R.R., Bishop, T.R., Gomez, C., Grossman, B.F., Yusah, K.M., Luke, S.H., Pacheco, R., Pearce-Duvet, J., Retana, J., Tista, M. and Parr, C.L. (2018). Habitat disturbance selects against both small and large species across varying climates. *Ecography* **41**, 1184-1193.

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M., Pyšek, P., Seebens, H., Tanner, R., Touza, J., Verbrugge, L., Weber, E., Dawson, W., Kreft, H., Weigelt, P., Winter, M., Klonner, G., Talluto, M.W. and Dehnen-Schmutz, K. (2018). The changing role of ornamental horticulture in alien plant invasions. *Biological Reviews* **93**, 1421-1437.

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Wilson, J.R.U., Faulkner, K.T., Rahlao, S.J., Richardson, D.M., Zengeya, T.A. and van Wilgen, B.W. (2018). Indicators for monitoring biological invasions at a national level. *Journal of Applied Ecology* **55**, 2612-2620.

Witt, A., Beale, T. and van Wilgen, B.W. (2018). An assessment of the distribution and potential ecological impacts of invasive alien plant species in eastern Africa. *Transactions of the Royal Society of South Africa* **73**, 217-236.

Yannelli, F.A., Karrer, G., Hall, R., Kollmann, J. and Heger, T. (2018). Seed density is more effective than multi-trait limiting similarity in controlling grassland resistance against plant invasions in mesocosms. *Applied Vegetation Science* **21**, 411-418.

Yapi, T.S., O'Farrell, P.J., Dziba, L.E. and Esler, K.J. (2018). Alien tree invasion into a South African montane grassland ecosystem: impact of Acacia species on rangeland condition and livestock carrying capacity. *International Journal of Biodiversity Science, Ecosystem Services & Management* **14**, 105-116.

Zurell, D., Gallien, L., Graham, C.H. and Zimmermann, N.E. (2018). Do long-distance migratory birds track their niche through seasons? *Journal of Biogeography* **45**, 1459-1468.

Zurell, D., Graham, C.H., Gallien, L., Thuiller, W. and Zimmermann, N.E. (2018). Long-distance migratory birds threatened by multiple independent risks from global change. *Nature Climate Change* **8**, 992-996.

Products, artefacts and patents

None in 2018.

Conferences attended

International plenary/keynote addresses

Byrne, M.J. 2018. The Aliens Are Here! And You Don't Care? Comparing Weed Control in Sweden vs South Africa. The Biology in Lund annual meeting, Palaestra, Lund University, Sweden. 15-16 March 2018 (Byrne)

Richardson, D.M. 2018. 10 the International Conference on Biological Invasions: New directions in invasion biology, Dublin, Ireland. September 2018 (Richardson)

Richardson, D.M. 2018. International Conference on Ecological Sciences, Rennes, France [Invited speaker]. October 2018 (Richardson)

Van Wilgen, B.W. 2018. Science review meeting, National Geographic Okavango Wilderness Project, Cape Town. 2018 (van Wilgen)

Van Wilgen, B.W. 2018. Quantifying the economic and social benefits of biological control XV International Symposium on Biological Control of Weeds, Engelberg, Switzerland. Invited keynote speaker. Switzerland. September 2018 (van Wilgen)

Van Wilgen, B.W., 2018. Economics and feasibility of managing invasive species. International stakeholder's workshop on Tackling invasive species in Africa, Nairobi, Kenya. 2018 (van Wilgen).

Weyl, O.L.F. 2018. One man's meat is another's poison: benefits, impacts and conflicts of fisheries based on alien species in South Africa. Pan African Fish and Fisheries Association Conference, Mangochi, Malawi. September 2018. (Weyl)

National plenary/keynote addresses

Esler, K.J. 2018. Invasion biology and management: addressing the complexity of research and training. 45th Annual Research Symposium on the Management of Invasive Species. Thohoyandou, Venda. July 2018 (Esler)

Foxcroft, L.C. 2018. Invasive alien species know no boundaries. 45th Annual Research Symposium on the Management of Biological Invasions in Southern Africa. University of Venda, Thohoyandou. July 2018 (Foxcroft).

Wilson, J. 2018. Biological invasions in the arid zones of South Africa [Plenary], Arid Zone Ecology Forum, Robertson, South Africa. 16–18 September, 2018 (Wilson)

Van Wilgen, B.W. 2018. Fire ecology as it relates to the Miombo forests of the Angolan highlands. Science review meeting, National Geographic Okavango Wilderness Project, Cape Town, South Africa. February 2018 (van Wilgen).

International oral contributions

Byrne, M.J., Machimane, Z., Paterson, I., Witt, A., Cowie, B., Venter, N. 2018. Cochineal and cactus: are new associations biocontrol winners. ISBCW, Engelberg, Switzerland). 27-31 August, 2018 (Byrne)

Cory-Toussaint, D. Taylor, P. J., Barnhoorn, I. E. J. 2018. Bats and Diamonds: Good Bioindicators or Resource Junkies. 9th Oppenheimer-De Beers Group Research Conference, Johannesburg, 16-17 October 2018 (Taylor)

Cowie, B., Venter, N., Strathie L., Goodall, J., Witkowski, E.T.F., Byrne, M.J. 2018. New insights and prospects into *Parthenium hysterophorus* biocontrol from South Africa. XV International Symposium on the Biological Control of Weeds (ISBCW), Engelberg, Switzerland. 27-31 August, 2018 (Byrne)

Cowie, B.W., Olckers, T., Venter, N., Witkowski, E.T.F., & Byrne, M.J. 2018. The future of *Solanum mauritianum* biocontrol in South Africa: prospects, problems and promise. XV International Symposium on the Biological Control of Weeds (ISBCW), Engelberg, Switzerland. 27-31 August, 2018 (Byrne)

Garcia R., Allen J., Clusella-Trullas S. March 2018. Rethinking climate change vulnerability indices. Climate Change Biogeography' IBS meeting (http://www.ibs2018.uevora.pt/), Portugal; (Garcia, session keynote speaker). March 2018 (Clusella-Trullas)

Impson, N.D., Muir, D., Madikizela, B., Jordaan, M. &Weyl, O.L.F. 2018. Control of invasive fishes in priority fish conservation areas in South Africa's Cape Fold Ecoregion: partner agencies collaborate to ensure successful use of the piscicide rotenone. Pan African Fish and Fisheries Association Conference, Mangochi, Malawi. (Weyl)

Javal, M., Thomas, S., Barton, M.G., Gillespie, D., Conlong, D.E., Terblanche, J.S. 2018. Understanding the recent invasion of *Cacosceles newmanii* (Coleoptera: Cerambycidae) into sugarcane from a thermal perspective. Proc. Sugar Tech. Assoc. 91:66-69. (Terblanche)

Khosa, D., Wasserman, R., Cuthbert, R., Weyl, O.L.F., & Marr, S.M. 2018. Comparative functional response of two invasive species and linking it to temperature. International Conference on Biological Invasions: NeoBiota 2018, Dun Laoghaire, Ireland. September 2018 (Weyl)

Makoni, T. & Taylor, P.J. 2018. The Conservation Conference, St Ives, South Africa. November 2018. (Taylor)

Marlin, D., Venter, N., Machiame, Z., Molekoa, L., Byrne, M.J. 2018. Current and future work to control the spread of invasive Tamarix in South Africa (15 minute talk). XV International Symposium on the Biological Control of Weeds (ISBCW), Engelberg, Switzerland). 27-31 August, 2018 (Byrne)

Mayonde, S.G., Paterson, I., & Byrne, M.J. 2018. Molecular investigations into the association of cactus biotypes and cochineal lineages: implications for biocontrol. XV International Symposium on the Biological Control of Weeds (ISBCW), Engelberg, Switzerland). 27-31 August, 2018 (Byrne).

Measey, J. 2018. A distributed network to study biological invasions. China - Africa Seminar on the Development and Education of Ecological Science, Yunnan University, Kunming, China. June 2018 (Measey)

Mofu, L., Cuthbert, R.N., Dalu, T., Woodford, D.J., Wasserman, R.J., Dick, J.T.A. & Weyl, O.L.F. 2018. Field impacts of invasive fishes under a seasonal temperature gradient are forecasted using the Relative Impact Potential (RIP) metric. International Conference on Biological Invasions: NeoBiota 2018, Dun Laoghaire, Ireland. September 2018 (Weyl)

Mohanty N.P. & Measey, J. 2018. Reconstructing biological invasions using public surveys: a new approach to retrospectively assess spatio-temporal changes in invasive spread. Neobiota 2018: 10th International Conference on Biological Invasions: New Directions in Invasion Biology. Dun Laoghaire, Dublin, Ireland, September 2018 (Measey)

Mukarugwiro, J.D., Newete, S.W., Byrne, M.J. 2018. Water turbidity affects the establishment of *Neochetina eichhorniae*: implications for biological control of water hyacinth. XV International Symposium on the Biological Control of Weeds (ISBCW), Engelberg, Switzerland). 27-31 August, 2018 (Byrne)

Nelufule, M. and Taylor, P. J. 2018. Comparative analysis of bat communities at two protected areas (Venetia Reserve and Mapungubwe National Park) in the Limpopo Valley. 9th Oppenheimer-De Beers Group Research Conference, Johannesburg, 16-17 October 2018 (Taylor)

Newete, S.W., Malan, S., Venter, N., Byrne, M.J.. 2018. Salt excretion in *Tamarix* species and its effects on the sap-feeding *Opsius stactogalus* in South Africa. XV International Symposium on the Biological Control of Weeds (ISBCW), Engelberg, Switzerland). 27-31 August, 2018 (Byrne)

Potgieter, L. 2018. Do alien plants promote criminal activity? Neobiota at Dun Laoghaire, Dublin, Ireland. 4 – 7 September (Richardson).

Rahlao, S. 2018. Botswana National Strategy on the Management of Prosopis. Gaborone, November 2018 (Rahlao)

Richardson, D.M. 2018. The Centre for Invasion Biology: An experiment in research, capacity building, and service provision for invasion science and management. NeoBiota Conference, Dublin, Ireland, September 2018. (Richardson)

Richardson, D.M. 2018. The changing face of invasion science. International Conference on Ecological Sciences, Rennes, France [Invited speaker] October 2018 (Richardson)

Secondi, J., Vimercati, G., Kruger, N., Courant, J., Measey, J., Herrel, A. 2018. Evolutionary processes, connectivity and control strategies in *Xenopus laevis*. International Conference on Ecological Studies in Rennes, France, October 2018 (Measey)

Swanepoel, L. H., Swanepoel, C. M., Keith, M., Belmain, S., Taylor, P., Roetter, R.P., Hoffmann, M.P. & Williams, S. 2018. The potential of small and medium mammalian carnivores to mediate rodent pest damage in commercial agriculture. International Conference on Rodent Biology and Management, Potsdam, Germany. September 2018 (Taylor)

Taylor, P. J. Kearney, T., Dalton, D. L., Chakona G, Kelly, C.M.R, Barker, N.P. 2018. Phylogeography, taxonomy and diversity of montane populations of laminate-toothed rats (Muridae: Otomys) in the southern Great Escarpment, South Africa, with the description of a new species. International Conference on Rodent Biology and Management, Potsdam, Germany. September 2018 (Taylor)

Taylor, P.J., Neef, G., Keith, M. Weier, S., Parker, D. 2018. The Okavango source lakes region of Angola as a diversity hotspot for small mammals. National Geographic Wilderness Project Research Symposium, Cape Town, 17-18 January 2018 (Taylor).

Taylor, P.J., Neef, G., Keith, M. Weier, S., Parker, D. 2018. The Okavango source lakes region of Angola as a diversity hotspot for small mammals. 2nd Botswana Biodiversity Symposium, Maun, Botswana. 13-15 February, 2018 (Taylor).

Thomas, S., Conlong, D.E., Barton, M.G., McElligott, D., Maher, G., Terblanche, J.S. 2018 Impacts of sampling effort on estimating abundance of the aphid *Sipha flava* (Forbes) in sugarcane in Mazabuka, Zambia. Proc. Sugar Tech. Assoc. 91:78-82. (Terblanche)

Venter, N., Cowie, B., Witkowski, E.T.F., Byrne, M.J. 2018. Will the predicted rise in atmospheric CO_2 alter the interaction between *Opuntia stricta* and its biocontrol agent *Dactylopius opuntiae*? International Symposium on the Biological Control of Weeds (ISBCW), Engelberg, Switzerland. 27-31 August, 2018 (Byrne)

Wilson, J.R.U., Faulkner, K.T., Rahlao, S.J., Richardson, D.M., Zengeya, T.A., van Wilgen, B.W. 2018. Indicators for monitoring biological invasions at a national level. 6th International conference of the Pan African Fish and Fisheries Association, Mangochi, Malawi, September 2018 (Zengeya)

National oral contributions

Altwegg, R., Measey, J., Borches, D. & Stevenson, B. 2018. Estimating density, occupancy and species richness from acoustic data. African Bioacoustics Community Conference, University of Cape Town, Cape Town. December 2018 (Measey)

Cheney, C., van Wilgen, N.J., Foxcroft, L.C., McGeoch, M.A. & Esler, K.J. 2018. Factors influencing management effectiveness of alien plant control programmes in Table Mountain National Park, The Conservation Symposium 2018 Abstract book, St Ives, KZN Midlands, 5-8 November 2018, p. 88 (Esler)

Hall, S. A., Holmes, P. M., Gaertner, M., & Esler, K. J. 2018. Assessing restoration potential of a critically endangered vegetation type following alien acacia removal. South African Association of Botanists Annual Meeting. Pretoria. January 2018. (Esler)

Bitani, N. and Downs, C.T. 2018. Dispersal of invasive *Lantana camara* by native bird species. Fountainhill Estate Research Symposium, Wartburg. (Downs)

Burness, A., Williams, V.L., Jaca, T.P., & Byrne, M.J. 2018. An investigation of the international traditional medicine trade as an introduction pathway for lien and potentially invasive species. 45th Annual Research Symposium on the Management of Biological Invasions, University of Venda, Thohoyandou, Limpopo. 3-6 July 2018. (Byrne)

Byrne, M.J., Machimane, Z., Cowie, B., & Venter, N., 2018. Sink or swim: inundation tolerance in the riparian invader genus, *Tamarix* and the implications of flooding regimes on its species composition. 45th Annual Research Symposium on the Management of Biological Invasions, University of Venda, Thohoyandou, Limpopo. 3-6 July 2018. (Byrne)

Castañeda, R.E/, Mandrak, N.E., Weyl, O.L.F. 2018. Assessing a novel detection technique for invasive and endangered freshwater fishes. Southern African Society of Aquatic Sciences Congress, St Francis Bay. June 2018 (Weyl)

Drude, L., Marlin, D. & Byrne, M.J. 2018. Does salty *Tamarix* have an effect on the host preference of the biocontrol agent *Diorhabda carinulata*? 45th Annual Research Symposium on the Management of Biological Invasions, University of Venda, Thohoyandou, Limpopo, South Africa. 3-6 July 2018. (Byrne)

Foord, S.H., Modiba, R.V., Joseph G.S., Seymour, C.L., Fouché, P.S.O. 2018. Restoration of riparian systems through clearing of invasive plant species improves functional diversity of odonate assemblages. 45th Annual Research Symposium on the Management of Biological Invasions 'Invasions trans-boundary' University of Venda, Thohoyandou, Limpopo. 3–6 July 2018 (Foord)

Impson, D., Muir, D., Madikizela, B., Jordaan, M. & Weyl, O. 2018. Invasive fish control projects in the Cape: Progress so far and plans for the next three years. Southern African Society of Aquatic Sciences Congress, St Francis Bay. June 2018 (Weyl)

Khosa, D., Wasserman, R., Cuthbert, R., Weyl, O.L.F., & Marr, S.M. 2018. Comparative functional response of two invasive species and linking it to temperature. Southern African Society of Aquatic Sciences Congress, St Francis Bay. June 2018 (Weyl)

Kostauli, M.R., Mokotjomela, T.M., Sematele, D.M. 2018. Towards the implementation of co-management governance in Silaka Nature Reserve, Eastern Cape province, South Africa, The Conservation Symposium (Special Session: Co-management of protected areas: challenges, lessons and success stories), Howick, KwaZulu-Natal. November 2018 (Mokotjomela)

Kumschick, S. and SEICAT team. 2018. Socio-Economic Impact Classification for Alien Taxa (SEICAT). 45th Annual Research Symposium on the Management of Biological Invasions in Southern Africa, University of Venda, Thohoyandou, Limpopo. July 2018 (Kumschick)

Kutama M., Minnaar I.A., Starostova Z., Allen J., Clusella-Trullas S. 2018. Does the trade-off between melanisation and performance limit the dispersal capacity of the globally invasive beetle *Harmonia axyridis*? 45th Annual Research Symposium on the Management of Biological Invasions in Southern Africa. 3-6th of July 2018, University of Venda, Thohoyandou, Limpopo, South Africa. (Clusella-Trullas)

Machimane, Z., Venter, N., Witt, A., Cowie, B., & Byrne, M.J., 2018. Evaluating different lineages of *Dactylopius opuntiae* (cochineal) for biological control of the invasive cactus *Opuntia*

engelmannii in Kenya and South Africa. 45th Annual Research Symposium on the Management of Biological Invasions, University of Venda, Thohoyandou, Limpopo, South Africa. 3-6 July 2018. (Byrne).

Marneweck, C., Becker, P.A., Beverley, G., Davies-Mostert, H.T., du Plessis, C, Forsmann, K., Graf, J., Gusset, M., Hofmeyr, M., Kelly, C., Kilian, H., Marchal, A.F.J., Marneweck. D.G., Marnewick, K., Owen, C., Postiglione, G., Slotow, R., Somers, M.J., Szykman Gunther, M., van Dyk, G., Whittington-Jones, B. & Parker, D.M. (2018). Factors affecting the success of artificial pack formation in an endangered, social carnivore: the African wild dog. Southern African Wildlife Management Association Annual Conference, September 2018. (Somers)

Marr, S.M., Dalu, T., Bellingan, T., Jordaan, M., Slabbert, E, & Weyl, O.L.F. 2018. Ecosystem responses to rotenone treatment in two dams in the Western and Northern Cape provinces. Southern African Society of Aquatic Sciences Congress, St Francis Bay. June 2018 (Weyl)

Marr, S.M., Luus-Powell, W.J., & Weyl, O.L.F. 2018. How safe is it to eat freshwater fish from South Africa's inland fisheries? Southern African Society of Aquatic Sciences Congress, St Francis Bay. June 2018 (Weyl)

Measey, J., Stevenson, B., Scott, T., Altwegg, R. & Borchers, D. 2018. Counting chirps: acoustic monitoring of cryptic frogs. African Bioacoustics Community Conference, UCT December 2018 (Measey)

Mobonani, S.E., Glennon, K., & Byrne, M.J. 2018. Towards a molecular characterisation of *Opuntia engelmannii* lineages in Africa. 45th Annual Research Symposium on the Management of Biological Invasions, University of Venda, Thohoyandou, Limpopo, South Africa, 3-6 July 2018. (Byrne)

Mofu, L., Cuthbert, R.N., Dalu, T., Woodford, D.J., Wasserman, R.J., Dick, J.T.A. & Weyl, O.L.F. 2018. Field impacts of invasive fishes under a seasonal temperature gradient are forecasted using the Relative Impact Potential (RIP) metric. Southern African Society of Aquatic Sciences Congress, St Francis Bay. June 2018 (Weyl)

Molekoa, L. J., Newete, S., Adam, E. & Byrne, M. 2018. Discriminating between *Tamarix* species and their putative hybrids using remote sensing. 45th Annual Research Symposium on the Management of Biological Invasions, University of Venda, Thohoyandou, Limpopo, South Africa, 3-6 July 2018. (Byrne).

Msweli, L. and Downs, C.T. 2018. Effects of indigenous southern African ungulates on seed germination of alien invasive lantana (*Lantana camara*) and bugweed (*Solanum mauritianum*). Fountainhill Estate Research Symposium, Wartburg. (Downs)

Msweli, L. and Downs, C.T. 2018. Effects of indigenous southern African ungulates on seed germination of alien invasive lantana (*Lantana camara*) and bugweed (*Solanum mauritianum*). 4th Annual National Global Change Conference, Polokwane. (Downs)

Mudau, P., Witkowski, E.T.F., van der Westhuizen, L., & Byrne, M.J. 2018. Feeding impact of *Liothrips tractabilis* on *Campuloclinium macrocephalum* and its abundance in full-sun and shade. 45th Annual Research Symposium on the Management of Biological Invasions, University of Venda, Thohoyandou, Limpopo, South Africa, 3-6 July. (Byrne).

Mukarugwiro J.A., Newete, S., Adam, E. & Byrne, M. 2018. Effect of water turbidity on the establishment of *Neochetina eichhorniae* (Warner) (Coleoptera:Curculionidae), a biocontrol

agent of the aquatic invasive species water hyacinth. 44th Conference of the South African Association of Botanists. University of Pretoria, South Africa. January 2018. (Byrne)

Musungi, K. and Byrne, M.J. 2018. Biological control of *Opuntia*: basis of host selection in the 'stricta' biotype of *Dactylopius opuntiae*. 45th Annual Research Symposium on the Management of Biological Invasions, University of Venda, Thohoyandou, Limpopo, South Africa, 3-6 July 2018. (Byrne)

Poongavanan, J., Altwegg, R., Durbach, I. & Measey, J. 2018. Modelling range-wide density patterns of Lightfoot's Moss Frog (*Athroleptella lightfooti*) using acoustic monitoring data: Do the same factors affect occurrence and density? African Bioacoustics Community Conference, UCT. December 2018 (Measey)

Potgieter, L. 2018. International Network for Urban Biodiversity and Design, Cape Town, South Africa. September 2018. (Richardson)

Purdon, J., Somers, M.J., Shabangu, F., Findley, K., Pienaar, M. (2018). Seismic surveys in South Africa: Are the current mitigation measures adequate to protect marine fauna? African Bioacoustics Community conference, Cape Town. December 2018 (Somers)

Shelton, J., Weyl, O., Esler, K., Paxton, B., Impson, D. & Dallas H. 2018. Trout in hot water? Evaluating consequences of climate warming for non-native rainbow trout and associated impacts on native fishes in South Africa's Cape Fold Ecoregion. Southern African Society of Aquatic Sciences Congress, St Francis Bay. June 2018 (Weyl)

Shivambu, C. and Downs, C.T. 2018. Invasive ring-necked parakeets in EThekwini Municipality, Durban, South Africa. Durban Research Action Partnership, Paradise Valley Nature Reserve. (Downs)

Shivambu, C.T. 2018. Alien tarantula species in the South African pet trade, Restoration Ecology Workshop, Durban Natural Science Museum Research Centre. (Downs)

Taylor, P. J. 2018. The economic value of ecosystem services of bats in the biocontrol of invasive stinkbug pests in macadamia orchards. 45th Annual Research Symposium on the Management of Biological Inventions in Southern Africa, Thohoyandou, July 2018. (Taylor)

Terblanche, J.S. (2018). Manipulating insect performance. Mass Rearing of Insects Workshop; University of Stellenbosch, South Africa. October 2018. (Terblanche)

Truter, M., Přikrylová, I., Weyl, O.L.F. & Smit, N.J. 2018. Co-introduced parasites on the invasive largemouth bass *Micropterus salmoides* (Lacépède, 1802) in South Africa: A first contribution using morphological and molecular approaches. Southern African Society of Aquatic Sciences Congress, St Francis Bay. June 2018 (Weyl)

Van der Berg, C.M., Somers, M.J., Slotow, R., Pretorius, Y. 2018. The prevalence of, and common factors associated with elephant attacks on humans in South Africa. Southern African Wildlife Management Association Annual Conference, September 2018. (Somers)

Van Lelyveld, H.M., Pretorius, Y., Slotow, R., Peel, M.J.S., Swart, J., Somers, M.J. 2018. Elephant diet from the Kalahari to the Lowveld: A multi-nutrient objective approach. Southern African Wildlife Management Association Annual Conference, September 2018. (Somers)

Venter, N., Cowie, B., Paterson, I. D., Witkowski, E.T.F., & Byrne, M.J. 2018. How atmospheric CO_2 levels influence the past and future and invasiveness of the weedy cactus *Pereskia aculeata*.

45th Annual Research Symposium on the Management of Biological Invasions, University of Venda, Thohoyandou, Limpopo, South Africa, 3-6 July 2018. (Byrne)

Vezi, M., Downs, C.T. and O'Brien, G. 2018. Overview on the management of aquatic invasive alien fauna in a tropical estuarine ecosystem in KwaZulu-Natal. International Workshop (Newton Fund and British Council): Research capacity for sustainable ecosystem-based management (EBM) of estuaries and coasts, Durban. (Downs)

Wilson, J.R.U., Faulkner, K.T., Rahlao, S.J., Richardson, D.M., Zengeya, T.A., van Wilgen, B.W. 2018. Indicators for monitoring biological invasions at a national level. 15th Biodiversity Planning Forum, Cape St Francis, Eastern Cape, June 2018 (Zengeya)

Van Wilgen, B.W. 2018. Insights from the management community on the value of research in South Africa, led workshop. 45th Annual Research Symposium on the Management of Biological Invasions, Thohoyandou, South Africa. July 2018 (van Wilgen)

Weyl, O.L.F. 2018. What are appropriate management goals for inland fisheries in South Africa? Southern African Society of Aquatic Scientists Conference: 2018, Cape St Francis Resort, Eastern Cape. June 2018 (Weyl)

International posters

Blanco Pérez, M.F., Strauss, W.M., Somers, M.J. Sharing is caring: burrow use by mammals and birds. 9th Oppenheimer De Beers Group Research Conference, October 2018. (Somers)

Foxcroft, L.C., Spear, D., van Wilgen, N.J. and McGeoch, M.A. Associations between pathways of alien plant invaders and their impacts in South African protected areas. NEOBIOTA: The 10th International Conference on Biological Invasions, Dun Loaghaire, September 2018.

Weyl O.L.F., Khosa, D. 2018. Black Bass introductions, status, fisheries, impacts and management approaches in South Africa. Fisheries Society of the British Isles, the sustainable use and exploitation of fishes. University of East Anglia, UK. July 2018.

National posters

Kearns, R., Louw, M., Turner, A., Slingsby, J., Altwegg, R. Borches, D., Stevenson, B.C. & Measey, J. No more singin' in the rain? As acoustic assessment of changing calling densities of the Cape peninsula moss frog (*Athroleptella lightfooti*). African Bioacoustics Community Conference, UCT, December 2018.

Mokotjomela, T.M., Nombewu, N., & Pamla, L. Influential factors for success in implementation of the National Biodiversity Economy Strategy in the Eastern Cape Province. The Conservation Symposium, Howick, KwaZulu-Natal, November 2018.

Mokotjomela, T.M. & Pamla, L. Bird species diversity and ecological functions in the Wild Coast nature reserves, Eastern Cape Province. South African Wildlife Management Association conference, Bela Bela, Limpopo, September 2018.

Mokotjomela, T.M., Maimela, C., Willis, C., Jama, K. Management of the Alien and Invasive Plant Species in the New Kwelera National Botanical Garden, Eastern Cape. 45th Annual Research Symposium on the Management of Biological Invasions in Southern Africa, University of Venda, Thohoyando, July 2018

Mokotjomela, T.M., Maimela, C., Willis, C., Jama, K. Management of the Alien and Invasive Plant Species in the New Kwelera National Botanical Garden, Eastern Cape. Conservation Symposium, Howick, KwaZulu-Natal, November 2018.

Pamla, L. & Mokotjomela, T.M. Seed dispersal by Chacma baboons (*Papio ursinus*) and germination of indigenous plants in Mkhambathi Nature Reserve, Eastern Cape. Primate Ecology & Genetics Group conference, Port Elizabeth, June 2018.

Poongavanan, J., Altwegg, R., Durbach, I. & Measey, J. Modelling range-wide density patters of Lightfoot's Moss Frog (*Athroleptella lightfooti*) using acoustic monitoring data: Do the same factors affect occurrence and density? African Bioacoustics Community Conference, UCT December 2018.

Ramotjiki, L., Foord, S.H., Schoeman, C. The impact of exotic plants on Macadamia crop flower visitors in Luvuvhu valley, Soutpansberg Mountain, Limpopo Province. 45th Annual Research Symposium on the Management of Biological Invasions 'Invasions trans-boundary' University of Venda, Thohoyandou, Limpopo, 3–6 July 2018

Vezi, M., Downs. C.T., O'Brien, G. 2018. Assessing the effects of aquatic invasive alien fauna in a protected tropical estuarine ecosystem in KwaZulu-Natal, South Africa. 45th Annual Research Symposium on the Management of Biological Invasions in southern Africa. University of Venda, Thohoyandou, Limpopo, July 2018

Education and training

Students supported by the Centre in 2018

Name	Citizenship	Institution	Race	Gender	Status	Funding level*
BSc (Honours)/4th year B. Agric.						
Ms Amy Collop	South Africa	SU	Coloured	F	Completed	Full
Mr Jarryd Foster	South Africa	SU	White	M	Completed	Full
Ms Reesher Kearns	South Africa	SU	Coloured	F	Completed	Independent
Ms Lindiwe Khoza	South Africa	UKZN	Black	F	Completed	Full
Ms Nokwanda Mkhize	South Africa	UKZN	Black	F	Completed	Full
Ms Lindelwa Msweli	South Africa	UKZN	Black	F	Completed	Partial
Ms Thandoluhle Ngwenya	South Africa	UKZN	Black	F	Completed	Partial
Mr Samuel Peta	South Africa	UL	Black	M	Completed	Full
Mr Damian van Aswegen	South Africa	SU	White	M	Completed	Independent
Ms Carla Wagener	South Africa	SU	White	F	Completed	Independent
Masters						
Mr Luca Afonso	South Africa	SU	White	M	Current	Independent
Ms Nasiphi Bitani	South Africa	UKZN	Black	F	Current	Independent
Ms Lee-Anne Botha	South Africa	UP	Coloured	F	Current	Full
Ms Liana de Araujo	South Africa	SU	White	F	Completed	Full
Ms Aviwe Homani	South Africa	SU	Black	F	Current	Full
Ms Catherine Keanly	South Africa	SU	White	F	Submitted	Partial
Ms Dianah Kutama	South Africa	SU	Black	F	Current	Full
Ms Ndivhuwo Maligana	South Africa	UKZN	Black	F	Completed	Independent
Mr Malukhanye Mbopha	South Africa	SU	Black	M	Current	Independent

Name	Citizenship	Institution	Race	Gender	Status	Funding level*
Ms Lucia Mokubedi	South Africa	UCT	Black	F	Current	Full
Ms Ella Morran	South Africa	SU	White	F	Current	Partial
Ms Puseletso Motsomane	South Africa	UP	Black	F	Current	Partial
Mr Takalani Nelufule	South Africa	UP	Black	M	Completed	Full
Ms Khensani Nkuna	South Africa	SU	Black	F	Completed	Independent
Mr Nkosinathi Ntuli	South Africa	NMU	Black	M	Current	Full
Ms Mmatsawela Ramahlo	South African	UP	Black	F	Completed level	Independent
Ms Mancha Ramotjiki	South Africa	UniVen	Black	F	Current	Partial
Ms Anneke Schoeman	South Africa	NWU	White	F	Current	Full
Mr Cavin Shivambu	South African	UKZN	Black	M	Completed level	Independent
Ms Thabang Sibiya	South Africa	SU	Black	F	Pending overtime	Independent
Ms Kirstin Stephens	South Africa	SU	White	F	Completed	Full
Ms Sophia Turner	South Africa	SU	White	F	Submitted	Partial
Ms Nicole Vorster	South Africa	SU	White	F	Current	Full
Ms Staci Warrington	South Africa	SU	White	F	Current	Full
PhD-Upgrade						
Mr Brent Abrahams	South Africa	SU	Coloured	M	Current	Full
Ms Susan Canavan	Ireland	SU	White	F	Completed	Full
Mr Mlungele Nsikani	Zimbabwe	SU	Black	M	Completed	Full
Ms Lisa Skein	South Africa	SU	White	F	Current	Full
PhD						
Ms Karla Alujevic	Croatia	SU	White	F	Current	Independent
Ms Henrika Bosua	South Africa	SU	White	F	Current	Full
Ms Maria Castillo	Chile	SU	White	F	Current	Full
Mr Chad Cheney	South Africa	SU	White	M	Completed	Independent
Mr Blair Cowie	South Africa	Wits	White	M	Current	Partial
Ms Patricia Duncan	South Africa	SU	White	F	Current	Partial
Ms Rolanda Julius	South Africa	UP	Coloured	F	Completed	Full
Mr Dumisani Khosa	South Africa	Rhodes	Black	M	Current	Partial
Ms Natasha Kruger	South Africa	SU	White	F	Current	Partial
Ms Sandra MacFadyen	South Africa	SU	White	F	Completed	Independent
Ms Lerato Maimela	South Africa	UP	Black	F	Current	Partial
Ms Ndivhuwo Maligana	South Africa	UKZN	Black	F	Current	Partial
Ms Ingrid Minnaar	South Africa	SU	White	F	Completed	Independent
Mr Lubabalo Mofu	South Africa	Rhodes	Black	M	Current	Partial
Mr Nitya Mohanty	India	SU	Indian	M	Completed	Partial
Ms Jeanne Mukarugwiro	Rwanda	Wits	Black	F	Current	Full
Ms Sinazo Ntsonge	South Africa	Rhodes	Black	F	Current	Full
Mr Luke Potgieter	South Africa	SU	White	M	Completed	Full
Ms Mmatsawela Ramahlo	South Africa	UP	Black	F	Current	Full
Ms Davina Saccaggi	South Africa	SU	White	F	Current	Partial
Mr Cavin Shivambu	South Africa	UKZN	Black	M	Current	Partial
Mr Thozamile Yapi	South Africa	Rhodes	Black	M	Current	Partial

***Funding is categorised as full (student is fully supported with bursary and running costs supplied at standard CoE levels), partial (in the form of a full or partial bursary or 'top-up', or running costs only) and independent (funding comes entirely from other sources, but the student is supervised by a core team member).**

Post-doctoral associates supported in 2018

Post-doctoral associates are early career researchers engaged on two-year fellowships to focus on research deliverables such as peer-reviewed publications, organizing workshops and journal special issues, and often play a key role in student training.

Name	Citizenship	Institution	Race	Gender	Status	Funding
Dr Katelyn Faulkner	South Africa	UP	White	F	Current	Independent
Dr Raquel Garcia	Portugal	SU	White	F	Current	Independent
Dr Heidi Hirsch	Germany	SU	White	F	Current	Full
Dr Sanet Hugo	South Africa	SAIAB	White	F	Current	Independent
Dr Sean Marr	South Africa	SAIAB	White	M	Current	Independent
Dr Koebraa Peters	South Africa	SU	Coloured	F	Current	Full
Dr Wolf-Christian Saul	Germany	SU	White	M	Current	Partial
Dr Josie South	UK	SAIAB	Coloured	F	Current	Independent
Dr Madonna Vezi	South Africa	UKZN	Black	F	Current	Full
Dr Florencia Yannelli	Argentina	SU	White	F	Current	Full
Dr Guillaume Latombe	France	SU	White	M	Completed	Independent

*** Funding is categorised as full (post-doc is fully supported with bursary and running costs supplied at standard COE levels), partial (in the form of a full or partial bursary or 'top-up', or running costs only) and independent (funding comes entirely from other sources, but the post-doc is hosted by a core team member).**

Networking

Academic visitors to core team members

Dr Ben Allen of the University of Southern Queensland, Institute for Life Sciences and the Environment, Australia. *Collaborator on use of humaneness of vertebrate biocontrols* (Measey, Somers)

Prof. Res Altwegg; University of Cape Town, South Africa (Hui)

Dr Christopher Baltzinger, National Research Institute of Science and Technology for Environment and Agriculture, IRSTEA, France. *Collaborator on Ungulate invasive seed dispersal* (Downs)

Prof. Brett Bennett, University of Western Sydney. Historical perceptions of invasions (Richardson)

Prof. William Bond; University of Cape Town, South Africa (Hui, Richardson)

Prof. Jonathan Chase; iDiv, Leipzig, Germany (Hui, Richardson)

Dr Ralph Clark, Director of the Afromontane Study Unit of QwaQwa. *Collaborator on mountain research including AIP impacts, including a joint USDP staff doctoral support programme* (Taylor)

Prof. Franck Courchamp; CNRS / Université Paris Sud, France (Hui, Richardson)

Pauline Dufour (PhD Student), University of Hong Kong. Project 'Climate change implications of nocturnality' (Clusella-Trullas)

Prof. Sonia Durán, Universidad de Rosario, Colombia. Discussion on potential student exchange (Richardson)

Dr Francisco Javier Escobedo, Universidad de Rosario, Colombia. Project on alien trees and ecosystem services in Bogota (Richardson)

Ms Laura Fernandez, PhD candidate, Macquarie University, Sydney, Australia. Myrtle rust in South Africa (Richardson)

Dr Llewellyn Foxcroft visited the University of Venda as part of collaboration on Parthenium in the Kruger National Park (Foord)

Prof. Ara Monadjem, Department of Biological Sciences, University of Swaziland. *Collaborator on small mammal ecology* (Chimimba)

Dr Casper Nyamukondiwa, Botswana International University of Science. The study of invasions in Botswana (Richardson)

Prof. Petr Pyšek, Department of Invasion Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Průhonice, and Charles University in Prague, Czech Republic. *Collaborator on biodiversity maintenance in African savanna systems* (Foxcroft)

Prof. Ilya Raskin, Global Institute for BioExploration, Rutgers University, USA. *Collaborator on biochemical and functional profile of secondary metabolites of invasive alien plants*. (Foxcroft)

Dr Chris Trisos, National Socio-Environmental Synthesis Center, University of Maryland, USA. Consequences for biodiversity of climate change (Richardson)

Dr Tsungai Zengeya, SANBI Kirstenbosch, Cape Town. *Collaborator on aquatic biology* (Chimimba)

Academic visits by core team members to other institutions

Centre for Cellular & Molecular Biology, Hyderabad, India. *Invasive amphibians of southern Africa* with Karthikeyan Vasudevan (Measey)

Centre for Invasion Biology (C·I·B), Department of Botany and Zoology, Stellenbosch University, and Invasive Species Programme, South African National Biodiversity Institute. *Collaborator on an alien species risk analysis framework for South Africa with Dr Sabrina Kumschick* (Foxcroft)

College of Plant Protection, China Agricultural University, Beijing, China. *Collaboration on Invasion and Mathematical Ecology* with Dr Zihua Zhao (Hui)

Department of Biological Sciences, Eduardo Mondlane University, Maputo, Mozambique. *Collaboration on mammal ecology with Carlos Bento* (Chimimba)

Department of Biological Sciences, University of Namibia, Windhoek, Namibia. *Collaboration on small mammal ecology with Prof. John Mfune* (Chimimba)

Department of Zoology at Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, Brazil. *South African frogs: invaders and invaded* with Marcio Borges-Martins (Measey)

Fundación Para El Estudio De Especies Invasivas, Buenos Aires, Argentina. Discussions with Dr Alejando Sosa on plant invasions in Argentina (Richardson)

Insect Biology Research Institute (IRBI, University of Tours, Tours, France. Prospecting collaboration on thermal biology of ectotherms and thermal landscapes with Dr Sylvain Pincebourde (Clusella-Trullas)

Institute of Ecology and Environment, CNRS, Moulis, France. Prospecting collaboration on thermal biology of ectotherms and thermal landscapes with Dr Julien Cote (Clusella-Trullas)

IUCN, Merida, Spain. *Collaboration and course to assess freshwater species in the Iberian Penninsula with EICAT under the IUCN umbrella with Helena Clavero Sousa and Catherine Numa* (Kumschick)

Laboratório de Ecofisiologia e Fisiologia Evolutiva at the University of São Paulo, Brazil. *Does an invasion come from a single population* with Carlos Navas (Measey)

Laboratório de História Natural de Anfíbios Brasileiros (LaHNAB), Departamento de Biologia Animal, Instituto de Biologia, Universidade Estadual de Campinas, Campinas, São Paulo, Brazil. *Invasive amphibians of southern Africa* with Felipe Toledo (Measey)

McMaster University, Hamilton, Canada, 23-27 July 2018. *Collaboration on SA-Canada Chairs jointly-funded project on rodents from high elevations with Dr Graham Scott.* (Taylor)

Natural History Museum of London, UK. *Collaboration on the project 'The evolution of complex phenotypes in lizards' with Dr Jeff Streicher, visited by Karla Alujevic* (Clusella-Trullas)

School of Biological Sciences, University of Melbourne, Australia. *Collaboration on EICAT assessment of insects alien to Australia with Melodie McGeoch* (Kumschick)

University of Alberta in Edmonton (Canada), Faculty of Agricultural, Life, and Environmental Sciences. *Collaborative research with SARChI Chair and team supported by grant from the IRG-South Africa-Canada Research Chairs Mobility Initiative,* with Prof. Fangliang He (Hui)

University of Fribourg, Fribourg, Switzerland. *Collaboration on EICAT assessments and guidelines with Sven Bacher and Lara Volery* (Kumschick)

University of Toulouse, Toulouse, France, June 2018. *Collaboration and co-supervision with Prof. J Braga of work by PhD student Paul Sabatier, on 3D morphometry and sensory ecology of rodents* (Taylor)

Awards to core team members

Cang Hui, John Measey and Dave Richardson were awarded the Research Excellence Award, 2018 by Stellenbosch University in the category 'Research Outputs' (4 December 2018).

Dr John Measey received a Stellenbosch University BRICS travel award to visit three Universities in Brazil. Dr Measey also travelled to China to represent the C·I·B at the China-Africa Seminar on the Development and Education of Ecological Science at Yunnan University, Kunming, China (June 2018).

Prof. Karen Esler was honoured with a Women in Science Award for her research excellence in ecology including ecosystem restoration and invasion biology. Also a NRF-rated researcher, she is considered a world leader in her field and has supervised many postgraduate students (August 2018).

Prof. Karen Esler, C·I·B core team member (fourth from left) at the 2018 Women in Science Awards.

Research collaborations

Acoustic monitoring of amphibians in the fynbos. Collaborators: Prof. Res Altwegg, Department of Statistical Sciences, University of Cape Town, South Africa; Dr David Borchers, School of Mathematics and Statistics, University of St Andrews, Scotland. (Measey)

African Great Lakes research. Collaborator: Prof. Jay Stauffer, Pennsylvania State University, Pennsylvania, USA. (Weyl)

Alien amphibians in China. Collaborators: Dr Supen Wang, Institute of Zoology, Chinese Academy of Sciences, Beijing, China. (Measey)

Alien plant distribution in protected areas and evidence based management. Collaborators: Prof. Karen Esler, Conservation Ecology and Entomology, Stellenbosch University; Prof. Melodie McGeoch, School of Biological Sciences, Monash University, Australia. (Foxcroft)

Ant diversity in changing landscapes of KwaZulu-Natal. Dr Caswell Munyai, University of KwaZulu-Natal. (Foord)

Aquatic biology of freshwater systems. Collaborator: Professor Stephan Woodborne, iThemba Laboratories, University of the Witwatersrand, Johannesburg. (Chimimba)

Assessing impacts of invasive species. Collaborator: Prof. S. Bacher, Department of Biology, University of Fribourg, Switzerland (Richardson)

Assessing silver carp distribution using e-DNA in Kruger National Park. Collaborators: Dr Steven Crookes, Great Lakes Institute for Environmental Research, University of Windsor and Biodiversity Institute of Ontario, University of Guelph, Canada; Prof. Nicholas Mandrak, Department of Biological Sciences, University of Toronto Scarborough, Canada. (Foxcroft)

Biochemical and functional profile of secondary metabolites of invasive alien plants. Collaborator: Prof. Ilya Raskin, Global Institute for BioExploration, Rutgers University, USA. (Foxcroft)

Biocontrol of alien weeds. Collaborator: Prof. Martin Hill, Rhodes University. (Byrne)

Biocontrol of Opuntia. Collaborator: Dr Iain Paterson, Rhodes University. (Byrne)

Biocontrol of Bugweed. Collaborator: Mr Hugh Gourlay, Landcare, New Zealand; and Prof. Ed Witkowski, Animal, Plant and Environmental Sciences (APES), University of the Witwatersrand. (Byrne)

Biocontrol of Tamarix. Collaborators: Dr Tom Dudley, Marine Science Institute, University of California; and Dr Dan Bean, Colorado Department of Agriculture; and Dr Massimo Cristifaro, Academia Nazionale Italiana di Entomologia. (Byrne)

Biodiversity effects of animal burrows, 2016-2018. Collaborators: Maria Blanco-Perez, Imperial Collage, London; Maartin Strauss, University of South Africa; Mark Keith, University of Pretoria; Jan Venter, Nelson Mandela University. (Somers)

Carnivores and people, 2017-2018. Collaborators: Florence Weise, CLAWS conservancy, Matt Hayward, Newcastle University (Somers).

Carnivore Reintroduction Biology and effects on biodiversity, 2004-2018. Collaborator: David Marneweck, Endangered Wildlife Trust; Dave Druce, Ezemvelo KZN Wildlife (Somers).

Chromolaena odorata, *habitat structure and biodiversity in Hluhluwe-iMfolozi Park, 2011 – 2018*. Collaborators: Kate Parr, University of Liverpool; William Bond, SAEON (Somers).

Cities as Hotspots for Invasions: The Case of eThekwini Municipality. Collaborator: Prof. Serban Proches, UKZN. (Wilson)

Climate change implications of nocturnality. Collaborator: Prof. Tim Bonebrake, School of Biological Sciences, University of Hong Kong. (Clusella-Trullas)

Comparing invasive success of the plant species Parthenium hysterophorus in- and outside the Kruger National Park. Collaborator: Prof. Ana Treydte, University of Hohenheim, Department of Agroecology, Germany, and The Nelson Mandela African Institution of Science and Technology, Tanzania. (Foxcroft)

Comparing key functional traits between native and invasive populations of the balloon vine, Cardiospermum halicacabum. Collaborators: Prof. Johannes J Le Roux, Department of Biological Sciences, Macquarie University, Australia; Department of Botany and Zoology, Stellenbosch University. (Foxcroft)

Concepts in invasion ecology. Collaborators: Prof. P. Pyšek, Academy of Sciences of the Czech Republic (Institute of Botany) (Richardson)

Conflict species, inland fisheries. Collaborator: Prof. Ian Cowx, Hull, Hull International Fisheries Institute, University of Hull. (Weyl)

Conservation monitoring of otters in South Africa, 2014-2018. Collaborator: Trevor McIntyre, University of South Africa. (Somers)

Determinants of species distributions in Mozambique, 2015-2018. Collaborator*:* Marcus Rowcliff, Imperial Collage, London. (Somers)

Development of a monitoring system for invasive species in protected areas. Collaborator: Dr R.T. Shackleton, Institute of Geography and Sustainability, University of Lausanne, Switzerland (Richardson)

Dispersal pathways of alien plants. Collaborators: Prof. Bethany Bradley (University of Massachusetts at Amherst, USA ex. C·I·B visiting scientist); and Prof. Jenica Allen (University of New Hampshire, USA). Wilson

Ecology and biocontrol of Lantana. Collaborator: Prof. Ed Witkowski, University of the Witwatersrand, APES. (Byrne)

Ecology and biocontrol of Parthenium. Collaborator: Prof. Ed Witkowski, University of the Witwatersrand, APES. (Byrne)

Ecology of fishes. Collaborator: Prof. Jurgen Geist, Lehrstuhl für Aquatische Systembiologie, Technische Universität München. (Weyl)

Ecology of range expansions. Collaborator: Prof. F. Essl. Division of Conservation Biology, Vegetation,and Landscape Ecology, University of Vienna, Austria (Richardson)

Effects of invasive Parthenium hysterophorus on native plant establishment, soil characteristics and soil enzymatic activities as indicators of impacts in Kruger National Park. Collaborators: Dr Ana Novoa, Academy of Sciences of the Czech Republic, Department of Invasion Ecology, Czech Republic; Prof. Stefan Foord, Department of Zoology, University of Venda. (Foxcroft)

EICAT assessment of alien insects in Australia. Collaborators: Melodie McGeoch, University of Melbourne, Melbourne, Australia; Helen Roy; Sandy Liebold; Lori Lach; Myron Zalucki; Manu Saunders; David Yeates; Markus Riegler; Treena Burgess; Andrew Cox; Sarah Hilton; Dave Palmer; Carol Booth; Steven Chown; Chris McGrannachan; Sandra Parson; Rebecca O'Connor. (Kumschick)

EICAT assessments of freshwater species on the Iberian Peninsula. Collaborators: Helena Clavera Sousa, IUCN, Malaga, Spain; Catherine Numa, IUCN, Malaga, Spain; Thomas Evans, UCL, London, UK. (Kumschick)

Environmental Impact Classification of Alien Taxa (EICAT). Collaborators: Tim Blackburn, University College London, London; Tom Evans, University College London, London; Jonathan Jeschke, Ecosystem Research, IGB Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany.; Sven Bacher, Department of Biology, Unit Ecology & Evolution, University of Fribourg, Switzerland; Piero Genovesi, ISPRA (Institute for Environmental Protection and Research), Italy; Petr Pyšek, Institute of Botany, Academy of Sciences of the Czech Republic and Department of Ecology, Faculty of Science, Charles University in Prague, Czech Republic; Montserrat Vilà, Estación Biológica de Doñana (EBD-CSIC), Sevilla, Spain; John Wilson, SANBI and Centre for Invasion Biology, Stellenbosch University; Kevin Smith, IUCN, Cambridge, UK. (Kumschick)

Environmental risk perceptions and public policy preferences for ornamental horticulture. Collaborators: Dr Katherina Dehnen-Schmultz; Dr Jana Fried, Coventry University. (Wilson)

Establishment of a 'Global Urban Biological Invasions Consortium'. Collaborator: Prof. M. Cadotte, University of Toronto, Canada. (Richardson)

Functional responses in aquatic ecosystems. Collaborator: Prof. Robert Britton, Department of Life and Environmental Sciences Bournemouth University Poole. (Weyl)

Functional responses in aquatic ecosystems. Collaborator: Prof. Jaimie Dick, School of Biological Sciences, Queens University Belfast. (Weyl)

Functional responses in aquatic ecosystems. Collaborator: Mr Ross Cuthbert, School of Biological Sciences, Queens University Belfast. (Weyl)

Functional responses in aquatic ecosystems. Collaborator: Prof. Tony Ricciardi, Redpath Museum, McGill University, Canada. (Weyl)

Functional responses in aquatic ecosystems. Collaborator: Dr R.J. Wassermann, School of Science, Monash University Malaysia. (Weyl)

Functional responses of the cosmopolitan invader Carcinus meanas. Collaborators: Dr Daniel Barrios-O'Neill and Prof. Jamie Dick, The Queen's University Belfast, United Kingdom; Dr Thomas Therriault, Fisheries & Oceans Canada; Prof. Isabelle Cote, Simon Fraser University, Canada. (Robinson-Smythe)

Genetics of Opuntia and Tamarix. Collaborator: Dr Kelsey Glennon, University of the Witwatersrand, APES. (Byrne)

Generic Impact Scoring System. Collaborators: Sven Bacher, Department of Biology, Unit Ecology & Evolution, University of Fribourg, Switzerland; Tom Evans, University College London, London; Zuzana Marková, Institute of Botany, Academy of Sciences of the Czech Republic; Jan Pergl, Institute of Botany, Academy of Sciences of the Czech Republic; Petr Pyšek, Institute of Botany, Academy of Sciences of the Czech Republic and Department of Ecology, Faculty of Science, Charles University in Prague, Czech Republic; Montserrat Vilà, Estación Biológica de Doñana (EBD-CSIC), Sevilla, Spain; and Wolfgang Nentwig, Institute of Ecology and Evolution, University of Bern, Switzerland. (Kumschick)

Guidelines for impact scoring. Collaborators: Sven Bacher, Department of Biology, Unit Ecology & Evolution, University of Fribourg, Switzerland ; Lara Volery, Department of Biology, Unit Ecology & Evolution, University of Fribourg, Switzerland. (Kumschick)

How will changing seasonality affect biodiversity and water provisioning in the Greater Cape Floristic Region? Collaborators: Prof. Res Altwegg, Department of Statistical Sciences, University of Cape Town, South Africa. (Foord)

Humaneness of vertebrate biocontrols, 2018-2019. Collaborator: Ben Allen of the University of Southern Queensland; Matthew Hayward, University of Newcastle; Dan Parker and Liaan Minnie, Mpumalanga University. (Somers)

iDIV working group sTWIST (Theory and Workflows for Alien and Invasive Species Tracking) (Wilson)

Impacts of alien birds. Collaborators: Tim Blackburn, University College London, London; and Tom Evans, University College London, London. (Kumschick)

Impacts of Opuntia stricta on soil properties in Kruger National Park. Collaborators: Dr Ana Novoa, Academy of Sciences of the Czech Republic, Department of Invasion Ecology, Czech Republic; Prof. Jaco Le Roux, Department of Biological Sciences, Macquarie University. (Foxcroft)

Insect low temperature biology. Collaborators: Prof. Vlad Kostal and Dr Petr Simek, Institute of Entomology, Czech Academy of Sciences, Czech Republic; and Prof. Jesper Sorensen, Dep't of BioScience, Aarhus University, Aarhus, Denmark. (Terblanche)

Insect Microclimate Modelling. Collaborators: Prof. Art Woods University of Montana (USA), Dr Sylvain Pincebourde, IRBI-CNRS, France. (Terblanche)

Invasion of African clawed frogs in France. Collaborators: Dr Jean Secondi, University of Angers and University of Lyon. Dr Anthony Herrel CNRS and MNHM. (Measey)

Invasion Research Social Networks. Collaborator: Dr Nadia Sitas, CSIR, Stellenbosch (Abrahams PhD). (Esler)

Invasive Guttural toads in Cape Town. Collaborators: Prof. Fernando Ribeiro Gomes, Departamento de Fisiologia, Instituto de Biociências, Universidade de São Paulo, São Paulo, Brazil. (Measey)

Invasive porcelain crab Porcellana platycheles Africana introductions. Collaborators: George M Branch, Department of Biological Sciences, University of Cape Town; Christoph Schubart, University of Regensberg Germany; Raphael Lemaitre, Smithsonian Institution, Washington, USA. (Griffiths)

Kelp bed canopy invasions by the introduced mussel Mytilus galloprovincialis. Collaborator: R Anderson, Department of Biological Sciences, University of Cape Town. (Griffiths)

Metabolic fuel use in ectotherms. Collaborators: Prof. Marshall McCue, Sable Systems, USA. (Terblanche)

Molecular biology of Tamarix. Collaborator: Prof. Glynis Goodman Cron, Animal, Plant and Environmental Sciences (APES), University of the Witwatersrand. (Byrne)

Monitoring tree health at sentinel sites: botanic gardens and arboreta. Collaborators: Dr Trudy Paap; Prof. Mike Wingfield; others, University of Pretoria. (Wilson)

National red list assessment of spiders. Collaborator: Prof. A.S. Dippenaar-Schoeman, Agricultural Research Council. (Foord)

Novel detection methods for early invaders and rare species. Collaborators: Ms Becky Cudmore, Fisheries and Oceans Canada, Regional Manager, Aquatic Invasive Species Program. (Weyl)

Novel detection methods for early invaders and rare species. Collaborator: Mr Antonio Pegado, Instituto de Investigacao Pesquera, Mozambique. (Weyl)

Novel detection methods for early invaders and rare species & centrarchid fisheries and impacts. Collaborator: Prof. Nicholas Mandrak, Department of Biological Sciences, University of Toronto at Scarborough, Canada. (Weyl)

Pest biosecurity in sugarcane. Prof. Des Conlong, SASRI, Dirk McGelligott, Zambia Sugar/Illovo. (Terblanche)

Phylogenetics of Australian acacias and eucalypts. Collaborator: Dr J. Miller, National Science Foundation, USA. (Richardson)

Practical integration of invasion biology and epidemiology. Collaborator: Dr Nick Ogden (Public Health Canada); Prof. Julliet Pulliame (SACEMA, Stellenbosch University). (Wilson)

Predicting the impacts of climate change on terrestrial insects across Africa. Collaborators: Dr Brent Sinclair, Department of Biology, University of Western Ontario, Canada; and Dr Mhairi McFarlane, The Nature Conservancy of Canada, Canada. (Terblanche)

Priorities for invasion science. Collaborator: Prof. A. Ricciardi, Redpath Museum, McGill University, Montreal, Canada. (Richardson)

Sani Pass ant diversity project. Collaborator Prof. Kate Parr, School of Environmental Sciences, University of Liverpool, Liverpool. (Robertson)

Small carnivores in space and time, 2012-2018. Collaborators: Emmanuel do Linh San, University of Fort Hare; Jerry Balant, Mississippi State University, USA; Dr Jun Sato, Fukuyama University, Japan. (Somers)

Small mammal ecology. Collaborator, Professor Ara Monadjem, Department of Biological Sciences, University of Swaziland. (Chimimba)

Small mammal parasitology. Collaborator: Dr Volker Schwan, Department of Veterinary Tropical Diseases, University of Pretoria, Onderstepoort. (Chimimba)

SnapShot Safari South Africa - Mammal distributions in South Africa, 2018. Collaborators: Jan Venter, Dr Herve Fritz, Nelson Mandela University; Rob Slotow, Prof. Colleen Downs, Sandi Willows-Munro, University of KwaZulu-Natal; Mike Peel, ARC; Mark Keith, University of Pretoria; Craig Packer, University of Minnesota, Craig Tambling, University of Fort Hare; Lourens Swanepoel, University of Venda; Charlene Bissett, SANParks, Dan Parker, University of Mpumalanga. (Somers)

Socio-economic Benefits of Ecological Infrastructure (EI). Collaborators: Prof. Niels Fold & Dr Laura Vang Rasmussen, University of Copenhagen, Dep. of Geosciences and Natural Resource Management, Denmark; Prof. Mark New, Prof. Stephanie Midgley, Dr Petra Holden, Dr Nadine Methner, Prof. Sheona Shackleton, University of Cape Town, African Climate & Development Initiative; Dr Alanna Rebelo, University of Stellenbosch, Dep. Conservation Ecology and Entomology; Dr Sabine Stuart-Hill, University of KwaZulu Natal, Centre for Water Resources Research; Aurecon; DHI South Africa. (Esler)

Socio-Economic Impact Classification for alien Taxa (SEICAT): Sven Bacher, Department of Biology, Unit Ecology & Evolution, University of Fribourg, Switzerland ; Lara Volery, Department of Biology, Unit Ecology & Evolution, University of Fribourg, Switzerland; Petr Pyšek, Institute of Botany, Academy of Sciences of the Czech Republic and Department of Ecology, Faculty of Science, Charles University in Prague, Czech Republic; Montserrat Vilà, Estación Biológica de Doñana (EBD-CSIC), Sevilla, Spain; Wolfgang Nentwig, Institute of Ecology and Evolution, University of Bern, Switzerland; Dave Richardson, C·I·B, Stellenbosch University; and John Wilson, SANBI and Centre for Invasion Biology, Stellenbosch University; Piero Genovesi, ISPRA (Institute for Environmental Protection and Research), Italy; Tim Blackburn, University College London, London; Marc Kenis, CABI, Delemont, Switzerland; Wolfgang Rabitsch, Umweltbundesamt, Vienna, Austria; Jonathan Jeschke, Freie Universitaet Berlin, Germany; : Franz Essl, Umweltbundesamt, Vienna, Austria; Jaakko Heikkilä, Natural Resources Institute Finland (Luke), Helsinki, Finland; Glyn Jones, The Food and Environment Research Agency, UK; Reuben Keller, Institute of Environmental Sustainability, Loyola University Chicago, USA; Christoph Kueffer, Institute of Integrative Biology, ETH Zurich, Switzerland; Angeliki F. Martinou, Joint Services Health Unit, Cyprus; Jan Pergl, The Czech Academy of Sciences, Průhonice, Czech Republic; Helen E. Roy, Centre for Ecology & Hydrology, UK; Wolf-Christian Saul, Freie Universitaet Berlin, Germany; Riccardo Scalera, IUCN/SSC Invasive Species Specialist Group, Italy. (Kumschick)

Spider assemblages in South African grasslands and the factors that shape them. Collaborator: Prof. Charles Haddad, Department of Zoology and Entomology, University of the Free State. (Foord)

Stable isotopes in invasion biology. Collaborator: Marshall McCue, St. Mary's University, Texas, USA. (Clusella-Trullas)

Understanding Echium invasion & impacts. Collaborators: Dr Candice-Lee Lyons, PPRI, ARC, Stellenbosch; Dr Erika Podest, JPL, NASA, USA (Duncan PhD); Dr Colleen Seymour, Dr James Pryke (Homani MSc). (Esler)

Ungulate invasive seed dispersal. Collaborators: Dr Christopher Baltzinger, National Research Institute of Science and Technology for Environment and Agriculture, IRSTEA, France. (Downs)

Use of Remote Sensing in management and control of alien weeds. Collaborator: Dr Elhadi Adam, Geography, Archaeology and Environmental Studies (GAES), University of the Witwatersrand. (Byrne)

Use of Remote Sensing in management and control of bugweed and tamarix. Collaborator: Dr Solomon Newete, Agricultural Research Council. (Byrne)

Woody Weeds in East Africa. Collaborators: Dr Urs Schaffner, CABI Switzerland; Dr Arne Witt, CABI, Nairobi. (van Wilgen)

Information brokerage

Popular articles and talks

Articles

Kumschick, S., Bacher, S. 2018. A novel approach could help manage the impact of invasive species. The Conversation, [Online] January 29, 2018. Available at: <https://theconversation.com/a-novel-approach-could-help-manage-the-impact-of-invasive-species-89787>

Cowie, B.W. 2018. How South Africa is keeping its worst invader - famine weed - at bay. The Conversation, [Online] February 1, 2018. Available at: <http://theconversation.com/how-south-africa-is-keeping-its-worst-invader-famine-weed-at-bay-89783>

Talks

Chimimba, C.T. 2018. Experiences on the supervision of graduate students from Mozambique. Swedish-Mozambique Bilateral relation (SIDA), December 2018.

Downs, C.T. 2018. Persistence of wildlife in urban areas: A KwaZulu-Natal perspective. UKZN Alumni, Howard College campus, October 2018.

Griffiths, C.L. 2018. Getting to know the seashore of the Cape Peninsula. Public lecture to Wildlife Society of South Africa. Somerset West, September 2018.

Mokotjomela, T.M. & Nombewu, N. 2018. World environmental health day – Connecting people with nature. Buffalo City Metro, Mdantsane, East London, September 2018.

Nsikani, M.M. 2018. Barriers to ecosystem restoration: soil legacy effects, secondary invaders and weedy native species. EThekwini Municipality Restoration Ecology Workshop. Durban, November 2018.

Robertson, M.P. 2018. The Shot Hole Borer in South Africa. Workshop on the shot hole borer invasion. University of Pretoria, Pretoria, April 2018.

Ruwanza, S. 2018. *Eucalyptus camaldulensis* impacts and management. Stellenbosch University Botanical Garden, Stellenbosch, March 2018.

Weyl, O.L.F. 2018. Conservation and management of freshwater fishes in South Africa, Lehrstuhl für Aquatische Systembiologie, Technische Universität München, July 2018.

Media interactions

Newspaper articles

Anonymous. 2018. Pine trees intensified 2017 fires. The Herald (Main). 7 September 2018.

Anonymous. 2018. The world`s first national status report on biological invasions by South Africa. Sawubona (Inside). 1 December 2018.

Bega, S. 2018. Alien species rapidly expanding – landmark research findings. The Saturday Star (Main). 10 November 2018.

Bega, S. 2018. Serendipitous new bats. The Saturday Star. 05 May 2018.

Jordan B. 2018. Danger signs add up to a perfect firestorm. Sunday Times (Cape Town) (Main), 20 Jan 2019.

Jordan B. 2018. Danger signs add up to a perfect firestorm. Sunday Times (KZN), 20 Jan 2019.

Jordan B. 2018. Danger signs add up to a perfect firestorm. Sunday Times (Port Elizabeth), 20 Jan 2019.

Jordan B. 2018. Danger signs add up to a perfect firestorm. Sunday Times (Country) 20 Jan 2019.

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Jordan B. 2018. Danger signs add up to a perfect firestorm. Sunday Times (East London) 20 Jan 2019.

Jordan B. 2018. Danger signs add up to a perfect firestorm. Sunday Times (Gauteng) 20 Jan 2019.

Mercury correspondent. 2018. Pine plantations fueled wildfires. 2018. The Mercury (Main). 7 September 2018.

Rogers, G. 2018. Clearing aliens 'vital' in catchment areas. The Herald (Main). 30 Jul 2018.

Staff writer. 2018. Fires fueled by invasive pines. Cape Times (Main). 7 September 2018.

Wildenboer, N. 2018. Alien species rapidly expanding in NC. Diamond Fields Advertiser (Main). 15 November 2018.

Electronic sources/Articles published by Stellenbosch University

Anonymous. 2018. Acting Minister of Environmental Affairs, Minister Derek Hanekom announces the release of the Status Report on Biological Invasions in South Africa. South African National Biodiversity Institute, [Online] 1 November 2018. Available at: <https://www.sanbi.org/media/the-status-of-biological-invasions-and-their-management-in-south-africa/>

Anonymous. 2018. Alien invasive pines fueled Knysna. The Newspaper, [Online] September 6, 2018. Available at: <https://www.thenewspaper.co.za/alien-invasive-pines-fueled-knysna-fires/>

Anonymous. 2018. Invasive pines fueled 2017 fires in Knysna, South Africa. EurekAlert, [Online] September 6, 2018. Available at: <https://www.eurekalert.org/pub_releases/2018-09/su-ipf090618.php>

Anonymous. 2018. Invasive pines fueled 2017 fires in Knysna, South Africa. Science Daily, [Online] September 6, 2018. Available at: <https://www.sciencedaily.com/releases/2018/09/180906100442.htm>

Anonymous. 2018. Invasive pines fueled 2017 fires in South Africa. Phys.org, [Online] September 6, 2018. Available at: <https://phys.org/news/2018-09-invasive-fueled-south-africa.html>

Bega, E. 2018. Hunting for eco-balance. The Saturday Star, [Online] May 26, 2018. Available at: <https://www.iol.co.za/saturday-star/news/hunting-for-eco-balance-15172019>

Bega, S. 2018. Alien species rapidly expanding – landmark research. Saturday Star, [Online] 13 November 2018. Available at: <https://www.iol.co.za/saturday-star/alien-species-rapidly-expanding-landmark-research-findings-18098898>

Bega, S. 2018. How to save Joburg's trees. The Saturday Start, [Online] November 10, 2018. Available at: <https://www.iol.co.za/saturday-star/news/how-to-save-joburgs-trees-17848970>

Chambers, D. 2018. Alien cannibals could make cape frogs croak, warn scientists. Times Live, [Online] December 27, 2018. Available at: <https://www.timeslive.co.za/news/south-africa/2018-12-27-alien-cannibals-could-make-cape-frogs-croak-warn-scientists/>

Chambers, D. 2018. Invasive pines intensified killer Knysna fires, say scientists. Herald Live, [Online] September 6, 2018. Available at: < https://www.heraldlive.co.za/news/2018-09-06-invasive-pines-intensified-killer-knysna-fires-say-scientists/>

Chambers, D. 2018. Study shows how invasive pine trees added fuel to the flames in Knysna fires. 2018. Business Live, [Online] September 6, 2018. Available at: <https://www.businesslive.co.za/bd/national/science-and-environment/2018-09-06-study-shows-how-invasive-pine-trees-added-fuel-to-the-flames-i%E2%80%A6/>

Cowie, B.W. 2018. Ecophysiology insights aid in the biological control of Parthenium weed. Science Trends, [Online] May 23, 2018. Available at: <https://sciencetrends.com/ecophysiology-insights-aid-in-the-biological-control-of-parthenium-weed/>

De Bruin, L. 2018.Woody plants are changing Africa's savannas — and this may have an impact on all of us, University of Pretoria, [Online] May 9, 2018. Available at: <https://www.up.ac.za/zoology-entomology/news/post_2676724-woody-plants-are-changing-africas-savannas-and-this-may-have-an-impact-on-all-of-us>

Fourie-Basson, W. 2018. Report on status of biological invasions in South Africa a world first. SU News, [Online] November 2, 2018. Available at: <https://www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=6065>

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Fourie-Basson, W. 2018. Invasive pines fueled Knysna fires. SU News, [Online] September 6, 2018. Available at: < https://www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=5908>

Fourie-Basson, W. 2018. Uitheemse dennebome het Knysna-brand aangevuur. US Nuus [Aanlyn] September 6, 2018. Beskikbaar by: <https://www.sun.ac.za/afrikaans/Lists/news/DispForm.aspx?ID=5828>

Fourie-Basson, W. 2018. Africa's smallest horseshoe bat weighs in at five grams. SU News, [Online] May 16, 2018. Available at: <https://www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=5652>

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Ghosh, P. 2018. A bullfrog invasion in the Andamans is threatening biodiversity. Scroll.in, [Online] March 5, 2018. Available at: <https://scroll.in/article/870601/a-bullfrog-invasion-is-threatening-the-biodiversity-of-the-andamans>

Grobler, R. 2018. Tiny beetle is killing SA's trees – and nothing can stop it. News 24, [Online] May 7, 2018. Available at: <https://www.news24.com/Green/News/tiny-beetle-is-killing-sas-trees-and-nothing-can-stop-it-20180904>

Haran, H.P. 2018. Croak croak, who's there? Bullfrogs in the Andamans. Research Matters, [Online] October 30, 2018. Available at: <https://researchmatters.in/news/croak-croak-who%E2%80%99s-there-bullfrogs-andamans>

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Staff writer. 2018. Knysna fires fueled by invasive pines, says study. Cape Times, [Online] September 7, 2018. Available at: <https://www.iol.co.za/capetimes/news/knysna-fires-fueled-by-invasive-pines-says-study-16929195>

Wild, S. 2018. Alien plants threaten to guzzle a third of the water in Cape Town and PE, according to a state report. Business Insider SA, [Online] November 4, 2018 Available at: <https://www.businessinsider.co.za/invasive-species-guzzle-cape-water-2018-11>

Wild, S. 2018. South Africa's invasive species guzzle precious water and cost US$450 million a year. Nature, [Online] November 2, 2018. Available at: https://www.nature.com/articles/d41586-018-07286-0>

Wild, S. 2018. South Africa's Invasive Species Guzzle Water and Hurt the Economy. Scientific American, [Online] November 7, 2018. Available at: <https://www.scientificamerican.com/article/south-africas-invasive-species-guzzle-water-and-hurt-the-economy/>

Radio and television

Byrne, M.J. 2018. Interview on My Ballito on the Polyphagous shot hole borer, September 2018. Available at: <http://myballito.co.za/listen-trees-killed-south-africa-small-beetle-discovered-durban/>

Byrne, M.J. 2018. Interview on Radio 86 on the Polyphagous shot hole borer, September 2018.

Byrne, M.J. 2018. Interview on Radio Sonder Grense on the Polyphagous shot hole borer, September 2018.

Byrne, M.J. 2018. Interview on The South African on the Polyphagous shot hole borer, September 2018. Available at: <https://thesouthafrica.co.za/listen-trees-are-being-killed-in-south-africa-by-a-small-beetle/>

Van Wilgen, B. 2018. Interview on Cape Talk on the role of alien species in the 2017 Knysna fires, September 2018.

Van Wilgen, B. 2018. Television interview on SABC News on the role of alien species in the 2017 Knysna fires, September 2018.

Service provision

Panels and committees

International

EICAT Authority: Convener (Kumschick)

Executive committee of MEDECOS Association, ISOMED: National Representative (Esler)

Future Earth bioDISCOVERY Core Project, Scientific Committee member (Weyl)

GEO BON Species Populations Working Group: Member (Wilson)

International Ornithological Congress: Fellow (Downs)

Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES): Lead author – Chapter 6 and Contributing author – Chapter 4 – Africa Assessment (Rahlao)

Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment: Review Editor (Esler)

Invasive Organism Observation Information Charter: A Task Group of Biodiversity Data Quality Interest Group. Biodiversity Information Standards (TDWG): Member (Wilson)

IUCN Species Survival Commission- Afrotheria specialist Group: Member (Downs)

IUCN Species Survival Commission- Amphibian Specialist Group (Measey)

IUCN Species Survival Commission- Crocodile specialist Group: Member (Downs)

IUCN Species Survival Commission (SSC) - Freshwater Fish Specialist Group, Regional Chair Southern Africa (Weyl)

IUCN Species Survival Commission- Hippo specialist Group: Member (Downs)

IUCN Species Survival Commission- Invasive Species Specialist Group: Member (Foxcroft, Kumschick Richardson, van Wilgen, Wilson)

IUCN Species Survival Commission- Ladybird specialist group: member (Clusella-Trullas)

IUCN Species Survival Commission- Otter Specialist Group: Member and Southern African Coordinator (Somers)

IUCN Species Survival Commission- Re-introduction specialist Group: Member (Somers)

IUCN Species Survival Commission- Small Carnivore Specialist Group: Member (Somers)

IUCN Species Survival Commission- Stork specialist Group: Member (Downs)

IUCN Species Survival Commission- Wild Pig Specialist Group: Member (Somers)

Society for Ecological Restoration: Programme Committee, SER 2019 (Esler)

National

Alien Species Risk Analysis Review Panel (ASRARP): Core team members participating in the panel: Sabrina Kumschick (SU); John Wilson (SANBI; acting Chair), Olaf Weyl (SAIAB), Mark Robertson (UP), Sheunesu Ruwanza (Rhodes), Sebataolo Rahlao (SANBI), Thabiso Mokotjomela (SANBI); research associate - Ryan Blanchard (CSIR)
Academy of Sciences of SA peer reviews of journals (x2) (Griffiths)
African Wildlife Institute, Advisory Board Member (Hui)
Birdlife South Africa (Southern African Ornithological Society)(1985 - present): member (Richardson)
South African Association of Botanists (1981 - present) (Richardson)
Berg River Clearing and Rehabilitation Advisory Committee: Technical Advisor (Esler)
CAPE Invasive Alien Animal Working Group: members (Davies, Kumschick, Measey, Wilson)
Flower Valley Conservation Trust Sustainable Harvesting Programme Research Working Group: Member (Esler)
Fynbos Forum Committee: Member (Esler)
HERS Advisory Board: Chair (Esler)
IUCN-Species Specialist Group - Invasive Species (1996 - present): member (Richardson)
IUCN-Species Specialist Group - Conifers (1999 - present): member (Richardson)
IUCN-Species Specialist Group - Southern African Plants (2006-present): member (Richardson)
IUCN Wild Dog Advisory Group of South Africa: Member (Somers)
National Biosecurity Steering Committee (Rahlao)
Royal Science Society of South Africa: Council Member (Foxcroft)
SAIAB Advisory Board Member, Grahamstown (Griffiths)
SACNASP Professional Qualifications Advisory Committee: member (Taylor)
South African National Biodiversity Institute (SANBI), board member (van Wilgen)
WRC Reference Group: The use of long-term, large-scale data combined with historic ecological data to support reserve implementation: Member (Esler)

Editorial and refereeing activities

Editor-in-Chief / Editor / Thematic/Regional Editor

Conservation Biology (Regional Editor, Africa) (Esler)
Koedoe (Foxcroft)

Associate Editor

African Journal of Ecology (Downs)
African Journal of Wildlife Research (Somers)
Aquatic Invasions (Zengeya)
Austral Entomology (Terblanche)
BioInvasions Records (Measey; Zengeya)
Biological Invasions (Hui, Kumschick, Richardson, Weyl)
Diversity and Distributions (Robertson, Wilson)

Ecological Complexity (Hui)

Frontiers in Physiology (Terblanche)
Functional Ecology (Clusella-Trullas)
Herpetological Conservation & Biology (Measey)
Ibis (Downs)
Journal of Fish Biology (Weyl)
Journal of Thermal Biology (Clusella-Trullas)
Koedoe (Somers)
Neobiota (Foxcroft, Richardson)
PeerJ (Measey)
Salamandra (Measey)
South African Journal of Science (Chimimba)
Urban Ecosystems (Downs)

Editorial Boards

Acta Chiropterologica (Taylor)
Animals, Editorial Board Member (Griffiths)
AoB PLANTS, Editorial Board Member (Richardson)
African Entomology, Editorial Board member (Terblanche)
Applied Mathematics and Computational Sciences, Editorial Board Member (Hui)
BMC Ecology, Editorial Board Member (Hui)
Forest Ecosystems, Editorial Board Member (Richardson)
Frontiers in Biogeography, Editorial Board Member (Richardson)
Frontiers in Ecology and Evolution, Editorial Board Member (Hui)
Journal of Thermal Biology, Editorial Board member (Terblanche)
Koedoe, Editorial Board Members (Foord, Griffiths)
Malagasy Nature, Editorial Board member (Taylor)
Mammalia, Editorial Board member (Taylor)
Nature Conservation Research, Editorial Board member (Somers)
NeoBiota, Subject Editor (Richardson, Wilson)
Ostrich, Editorial Board member (Downs)
Open Zoology Journal, *The,* Editorial Board Member (Hui)
Russian Journal of Biological Invasions, Editorial Board Member (Richardson)

Reviewing

For national (SA) journals

African Entomology; African Journal of Aquatic Science; African Journal of Herpetology; African Journal of Marine Science; South African Journal of Plant and Soil; Ostrich; South African Journal of

Science; African Zoology; Bothalia - African Biodiversity and Conservation; South African Journal of Botany; South African Journal of Science; Transactions of the Royal Society of South Africa; Water SA

For international journals

Acta Zoologica Cracoviensia; African Journal of Aquatic Science; African Journal of Ecology; African Journal of Herpetology; African Zoology; Agriculture, Ecosystems and Environment; Ambio; American Naturalist; Amphibia-Reptilia; Annals of the Brazilian Academy of Sciences; Aquaculture; Aquatic Invasions; Auk; Auk-Ornithological Advances; Austral Ecology; Austral Entomology; Basic and Applied Ecology; Biodiversity and Conservation; Biological Conservation; Bioinvasions Records; Biological Control; Biological Invasions; Biology Letters; Botany; Bulletin of Entomological Research; Condor; Conservation Biology; Current Zoology; Diversity; Diversity and Distributions; Ecography; Ecological Processes; Ecology and Evolution; Ecology Letters; Ecosphere; Environmental Monitoring and Assessment; Environmental Research Letters; Environmental Systems Research; Estuarine, Coastal Shelf Science; European Journal of Forest Research; F1000 Faculty Reviews; Fisheries Management and Ecology; Frontiers in Ecology and the Environment; Frontiers: Marine Conservation and sustainability; Forest Ecology and Management; Functional Ecology; Global Change Biology; Global Ecology and Biogeography; Hess Reviews; Ibis; Integrative and Comparative Biology; Integrative Zoology; Integrative Zoology Journal of Arid Environments; International Forestry Review; Invertebrate Systematics; Journal of Animal Ecology; Journal of Applied Ecology; Journal of Avian Biology; Journal of Biogeography; Journal of Comparative Physiology B; Journal of Environmental Management; Journal of Experimental Biology; Journal of Fish and Wildlife Management; Journal of Fish Biology; Journal of Freshwater Ecology; Journal of Herpetology; Journal of Insect Physiology; Journal of Natural History; Journal of Vegetation Science; Journal of Zoology; Land Degradation & Development; Landscape and Urban Planning; Mammalia; Marine Biology; Marine Ecology Progress Series; Methods in Ecology and Evolution; Nature Conservation; Nature Ecology & Evolution; NeoBiota; New Phytologist; New Zealand Journal of Forest Science; Oecologia; Ostrich; PeerJ; Plant Ecology & Diversity; PLoS-ONE; Polar Research; Philosophical Transactions of the Royal Society B; Proceedings of the Royal Society of London B Biological Sciences; Restoration Ecology; Science; Science of Nature, The; Science of the Total Environment; Scientific Reports; South American Journal of Herpetology; Southern Forests; Trends in Ecology and Evolution; Tropical Conservation Science; Water Research; Waterbirds

Grant reviews for external bodies

ASSAf: review of scientific journal (Taylor)

Belmont Forum - BiodivERsA International joint call on Scenarios of Biodiversity and Ecosystem Services (Wilson)

Claude Leon Foundation Post-Doctoral awards (Somers)

Czech Science Foundation (Weyl)

FWO (Flanders Research Foundation) (Clusella-Trullas)

Irish Research Council (Weyl)

JRS Biodiversity Foundation (Weyl)

National Geographic (Downs)
National Geographic (Somers)
Netherlands Organisation for Scientific Research - Domain Science (Esler)
Royal Society, UK (University Research Fellowship): (Richardson)
Swiss National Science Foundation (van Wilgen)
University of the Free State: Application for funding (Taylor)
Water Research Commission (Weyl)

Appointment reviews and committees

CABI book proposal review (Kumschick)
Chapman University, USA. Promotion to Professor (Richardson)
Honorary Assistant Professor in the School of Biological Sciences, University of Hong Kong (2018-2022) (Clusella-Trullas)
Nelson Mandela University, Game Ranch Management Diploma review panel (Somers)
University of Melbourne, Australia. Promotion to Professor (Richardson)
University of Pretoria, promotion application (Byrne)
University of Pretoria, South Africa: extra-ordinary lecturer (Zengeya)

Consulting and other services rendered

Consultancy products

Nyingi, W., Oguge, N., Dziba, L., Chandipo, R., Didier, T.A., Gandiwa, E., Kasiki, S., Kisanga, D., Kgosikoma, O., Osano, O., Tassin, J., Sanogo, S., von Maltitz, G., Ghazi, H., Archibald, S., Gambiza, J., Ivey, P., Logo, P.B., Maoela, M.A., Ndarana, T., Ogada, M., Olago, D., Rahlao, S. and **van Wilgen, B.** (2018). *Direct and indirect drivers of change in biodiversity and nature's contributions to people*. In: IPBES (2018): The IPBES regional assessment report on biodiversity and ecosystem services for Africa. Archer, E., Dziba, L., Mulongoy, K.J., Maoela, M.A. and Walters, M. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem services, Bonn, Germany. pp. 207-296.

Kumschick, S., Wilson, J.R. and Foxcroft, L.C. (2018). *Framework and guidelines for conducting risk analyses for alien species*. Preprints 2018, 2018110551, 64 pp. https://doi.org/10.20944/preprints201811.0551.v1

This report presents a framework for analysing the risk of alien taxa under South Africa's National Environmental Management: Biodiversity Act of 2004, and the Alien and Invasive Species Regulations of 2014. The report provides a structure for collating data relevant to the process of listing taxa as well as a process for developing recommendations that is both mathematically sound, transparent, and that explicitly takes uncertainty into account. The risk analysis framework is currently being implemented in South Africa in an effort to underpin national regulatory lists of invasive species.

Van Wilgen, B. W. and Wilson, J. R. (Eds.) 2018. *The status of biological invasions and their management in South Africa*. South African National Biodiversity Institute and DST-NRF

Centre of Excellence for Invasion Biology. ISBN: 978-1-928224-18-1. https://www.sanbi.org/wp-content/uploads/2018/11/National-Status-Report-web-6MB.pdf. **Note:** Chapter lead authors included Katelyn Faulkner (C·I·B post-doc, UP), Sebataolo Rahlao (core team member), Brian W. van Wilgen(core team member), John R. Wilson (core team member) and Tsungai Zengeya (core team member). Contributing authors included core team members Llewellyn Foxcroft, Charles Griffiths John Measey, David Richardson and Tamara Robinson and research associates Pat Holmes and David Le Maitre.

NRF service provision

NRF rating and proposal reviews

Review of project proposal (Marine and Coastal Research Call) (3)
NRF rating application reviews (15)
Review of African Research Chairs Initiative (1)
Focus Area - Conservation and Management of Ecosystems and Biodiversity: project proposal reviews (1)
Community Engagement Programme 2019: Project proposal review (1)
NRF Masters and Doctoral Scholarships, DAAD, DST, Scarce Skills etc. (8)

NRF panel and committee service

RG - South Africa / Austria Joint Scientific and Technological Cooperation Programme
NRF/ São Paulo Research Foundation (FAPESP); review of proposals.

A. 2. Audited financial statements