DST-NRF Centre of Excellence for Invasion Biology

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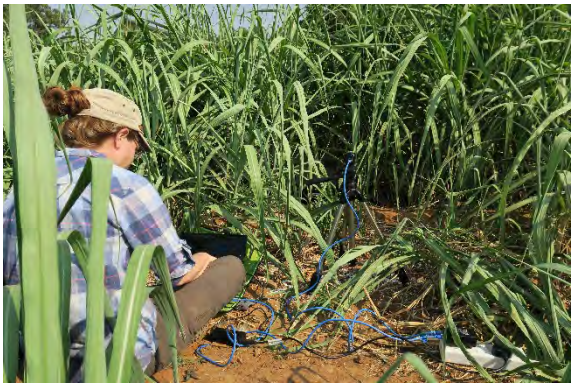
Annual Report

2017



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Dianah Kutama is studying the effects of an ectoparasitic fungus on the performance of the harlequin ladybird *Harmonia axyridis*. Her research can potentially lead to finding a biological control system for this widely spread invasive beetle in South Africa. In this picture, Dianah is collecting ladybirds from kale plants at the experimental farm of Stellenbosch University.

Executive summary

Reporting period	:	1 January 2017 - 31 December 2017
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 2017 addressed a wide range of disciplines, scientific approaches, issues, spatial and temporal scales, and taxa. We published 216 peer-reviewed papers in 97 journals, including contributions in the high-impact journals *BioScience*, *Ecology Letters*, *Journal of Applied Ecology*, *Functional Ecology*, *Nature Communications*, *PLoS Biology*, *Proceedings of the National Academy of Sciences of the USA*, *Science*, and *Trends in Ecology and Evolution* (all with impact factors greater than 5). Thirty-nine papers were published by C·I·B-affiliated authors in the premier journal in our field, *Biological Invasions*, 12 of which formed part of a special issue on 'Non-native species in urban environments: patterns, processes, impacts and challenges' that emerged from a workshop hosted by the C·I·B in Stellenbosch in November 2016[1]. Another two journal special issues that appeared in 2017 were dominated by C·I·B contributions. Sixteen papers with C·I·B-affiliated authors appeared in a special issue of the journal *Bothalia: African Biodiversity and Conservation* on 'Contributions to the National Status Report on Biological Invasions in South Africa'. A special issue of *AoB PLANTS* on 'Tree invasions: towards a better understanding of their complex evolutionary dynamics' (from a workshop hosted by the C·I·B in November 2016) had five papers with the C·I·B address. The open-access journal *NeoBiota* which has the aim of 'advancing research on alien species and biological invasions' carried six contributions from the C·I·B in 2017. Ten contributions appeared in edited books. The book '*Invasion Dynamics*' by Core Team Members Cang Hui and David Richardson was published by Oxford University Press in 2017 and received favourable reviews in the journals *Biological Invasions*, *BioScience* and *Transactions of the Royal Society of South Africa*. C·I·B Research associate Jane Carruthers' book 'National Park Science: A Century of Research in South Africa' was published by Cambridge University Press in 2017. The book describes the emergence of scientific study in South African national parks, including the rapid growth after 1990 in the study of invasive species. It details the profound changes in conservation science that have taken place in recent decades and highlights the remarkable contributions of South African ecologists in this field.

[1] An analysis, on 8 January 2018, of the 2780 papers published in *Biological Invasions* since 2001 and listed in Web of Science showed that the C·I·B ranks third among listed funding sources, after the National Science Foundation (USA) and the Australian Research Council. Dave Richardson (C·I·B) tops the list of authors with the most papers in the journal (40), followed by C·I·B associate Petr Pyšek (22 papers).

Our publications covered many of the most pressing issues in invasion ecology internationally, with special emphasis on the South African context. All focal areas identified in the C·I·B's strategic plan for 2015-2019 feature in our research outputs for 2017. Our research addresses fundamental issues related to the biology of invasive species, aspects of invaded ecosystems, invasion processes, and many facets of the human dimension of invasions. In 2017, urban invasions featured strongly in our research outputs.

The report that follows gives a sample of the research outputs; further details of these and many other publications produced during 2017 are available in the appendix lists and on the C·I·B website.

Education and Training

Seventy one students (86% from SA) and 13 post-docs (23% from SA) were supported by the Centre during 2017. Fourteen of our PhD and MSc students completed their degrees. Many of our alumni occupy important positions in a range of sectors including businesses, consultancies, government agencies and NGOs and CBOs. C·I·B staff and team members continued the 3rd year undergraduate module on Invasion Ecology at Stellenbosch University. This module has proved effective in introducing undergraduates to invasion science.

Networking

The C·I·B enjoyed ongoing productive interactions with partner organizations and assisted our key partners with important interactions. A new partnership was established with The Nature Conservancy Africa Region to explore the impacts of alien trees and shrubs on water resources in the Western Cape. The C·I·B held a joint workshop with the South African Centre for Epidemiological Modelling and Analysis (SACEMA) on the theme of 'Integrating techniques in invasion biology and epidemiology for practical management of species invasions and emerging infectious diseases'. The workshop, facilitated by Dr Nick Ogden, a visiting scientist from the Public Health Agency of Canada, was attended by researchers from the C·I·B, SACEMA and several other organizations. It provided an exciting opportunity to compare and contrast approaches in the two fields and will result in at least one multi-author publication and hopefully new collaborations.

Information Brokerage

In November 2017 the C·I·B 2017 hosted an international workshop on 'Invasion syndromes – moving towards generalizations in invasion science'. The workshop was coordinated by former C·I·B post-doc Ana Novoa. Its main aim was to discuss the advantages and disadvantages of focusing on functional or taxonomic groups when studying biological invasions from theoretical and practical points of view. The workshop was attended by 29 researchers from seven countries other than SA. The C·I·B's annual workshops held in the same week as the C·I·B Annual Research Meeting have become an important entry on the calendar for invasion researchers around the world.

The C·I·B published a series of five articles in the online magazine *The Conversation* (https://theconversation.com/africa/topics/invasive-species-series-39958) co-ordinated by Core Team Members John Measey and Sarah Davies. The articles summarised publications from the

special issue of the journal *Bothalia: African Biodiversity and Conservation* and the C·I·B's work in support of the National Status Report on Biological Invasions in South Africa. These articles generated a total of 11 516 reads on *The Conversation's* online platform (in addition, one of the articles was translated and received an additional 29 143 reads in French); they created considerable interest from the public who engaged by leaving comments at the end of the text. Explaining why South Africa should keep out the worst invasive species, newly appointed C·I·B Core Team Member Tsungai Zengeya expanded on the different ways that invasive species are known to impact South Africans, and how to prioritise action to deal with them. This article in particular resulted in robust discussions on and off the website which helped to inform members of the public and policy makers alike.

Service Provision

The C·I·B's major service provision role in 2017 was its involvement in completing the drafting of the National Status Report on Biological Invasions in South Africa. The C·I·B played a key capacity-building and mentorship role in partnership with the South African National Biodiversity Institute (SANBI) by seconding a senior staff member onto the drafting team. Prof. Brian van Wilgen worked with SANBI to complete the report in late 2017. C·I·B staff and researchers hold positions as Editors, Associate Editors and members of Editorial Advisory Boards and are frequently called on to review funding proposals and staff appointments from many parts of the world. C·I·B Core Team Members serve on no fewer than twelve of the IUCN's Species Survival Commission's (SSC) specialist groups and on many other influential international panels and committees.

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

Women make up 23% of the Core Team and 43% of the research associate network of the Centre. All the hub staff are women, and the all-woman Iimbovane team is a strong role model for aspiring young scientists at secondary school level. Females made up 70% of our students, and 69% of our post-doctoral associates in 2017. The C·I·B makes a concerted effort to provide an inclusive and friendly yet professional environment where all individuals feel comfortable and are able to be productive and grow. These efforts include a range of training events and academic meetings where capacity building and training takes place. Women consistently perform well in our annual presentation awards (in 2017, four out of the five award-winners were women). Two women students were awarded the top science communication prizes at SAASTA's 2016/2017 Young Science Communicator's Competition. In 2017, we initiated a series of support workshops for C·I·B students and post-docs, with the aim of improving the level of preparedness of all students entering the C·I·B and make the Centre a more 'student-ready' institution. Workshops were held in Pretoria and Stellenbosch and the programme will be expanded to include a workshop at the University of Venda in the next reporting year.

Red Flags

The overriding red flag for the C·I·B is the lack of clarity regarding funding after the end of 2019. Numerous meetings were held in 2017 with the NRF, DST, Stellenbosch University, and several partner organizations. Uncertainty about the sustainability of the C·I·B is seriously impeding the

building of long-term partnerships and is unsettling to our staff. Another red flag is the demise of incentive funding for researchers from the NRF. These funds have been a crucial component of the research budget of C·I·B Core Team Members.

General Comments

In the words of the C·I·B's International Science Advisors Professor Laura Meyerson and Dr Piero Genovesi after attending the 2017 Annual Research Meeting, the Centre 'continues to maintain its status as the world leader in invasion biology research, graduate education and management'. As this annual report clearly shows, the C·I·B is providing crucial service to South African science and essential service to its partners.

THE CENTRE FOR INVASION BIOLOGY IN 2017

C·I·B
DST-NRF Centre of Excellence for Invasion Biology

84 STUDENTS & POST-DOCS SUPPORTED

	supported	completed
Honours/4th year	11	11
Masters	30	8
PhD	30	6

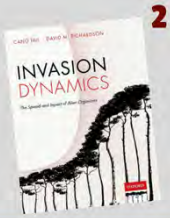
13 post-doctoral associates were hosted at the hub and partner institutions

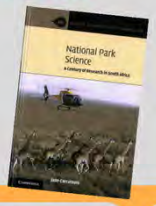
49 STUDENTS AND POST-DOCS PARTICIPATED IN SCIENCE COMMUNICATION AND STUDENT SUPPORT SESSIONS

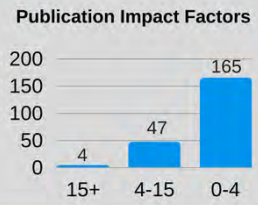
216 PAPERS IN ISI-ACCREDITED JOURNALS

10 BOOK CHAPTERS

2 BOOKS







12 PARTNER ORGANISATIONS

DEVELOPING PARTNERSHIP: The Nature Conservancy

2 WORKSHOPS HOSTED:

'Model Groups & Invasion Syndromes': 29 participants from 7 Countries.
Annual Research Meeting: 150 participants and guests.

IIMBOVANE OUTREACH PROJECT

INTERACTED WITH 18 SCHOOLS

BIODIVERSITY CHANGE IIMBOVANE EXPLORING

Held 4 Iimbovane workshops with 152 secondary school learners
Held 8 SciFest workshops with 120 primary and secondary school learners

SERVICE PROVISION

- Co-produced South Africa's first National Status Report on Biological Invasions with SANBI
- Performed 33 NRF reviews
- Held 43 journal editorships
- Served on 23 national & 31 international panels

SANBI Biodiversity for Life
South African National Biodiversity Institute

NRF National Research Foundation

Reducing the rate and impacts of biological invasions

Infographic: Sarah Davies Data source: C·I·B Annual Report for 2017

Contents

1 Scientific 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 thus target all aspects of the phenomenon of biological invasions, all taxonomic groups and all ecosystems (Fig. 1). A better understanding of invasion patterns and processes is required, and options for management and remediation need to be explored. 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; and 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 2017 (Fig. 1).

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.

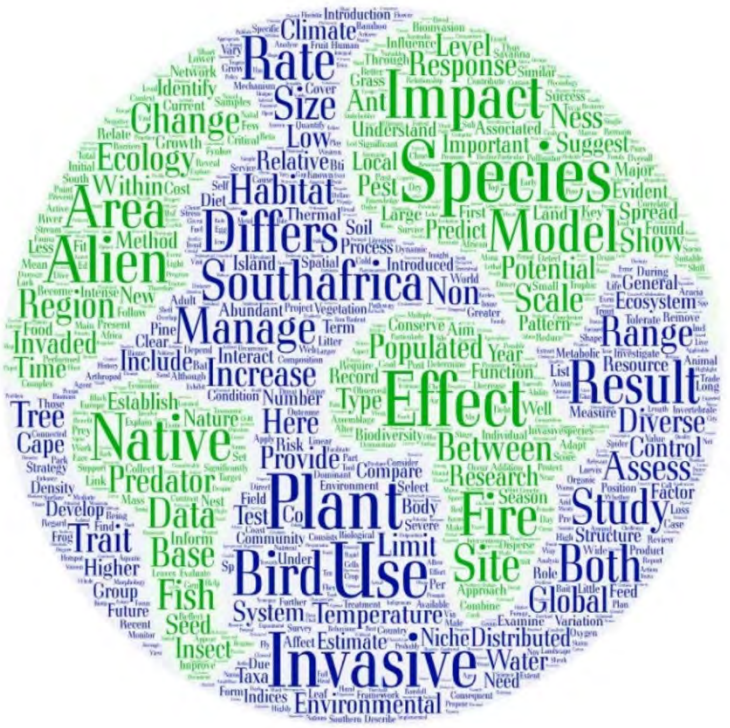


Figure 1. Word cloud reflecting key words in the titles and abstracts of C·I·B publications in 2017

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 the 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).

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

Type of sampling	No. of sites	Replicates per site	Traps per replicate	Aspect	Sampling periods	Elevation range (m amsl)	Arthropod groups sampled
Cederberg (2002-2014):							
climate; biological	17	4	10	W	Mar, Sep	0-1926	Ants, carabid beetles and spiders*
Sani Pass (2006-):							
climate; biological	8	4	10	E	Jan, Sep	900-3000	Ants
Soutpansberg (2009-):							
climate; biological	11	4	10	N, S	Jan, Sep	800-1700	Ants, beetles and spiders*

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

COPING WITH THE COLD: MINIMUM TEMPERATURES AND THERMAL TOLERANCES DOMINATE THE ECOLOGY OF MOUNTAIN ANTS

Ants (Hymenoptera: Formicidae) are highly thermophilic and this has led to many studies on their thermal tolerances. It is unknown, however, whether the geographic distribution of ant thermal tolerance conforms to the two major macrophysiological rules that have been found in other taxa: Janzen's and Brett's rules. In addition, there is a paucity of data on how the lower thermal tolerances of ants are able to influence behaviour.

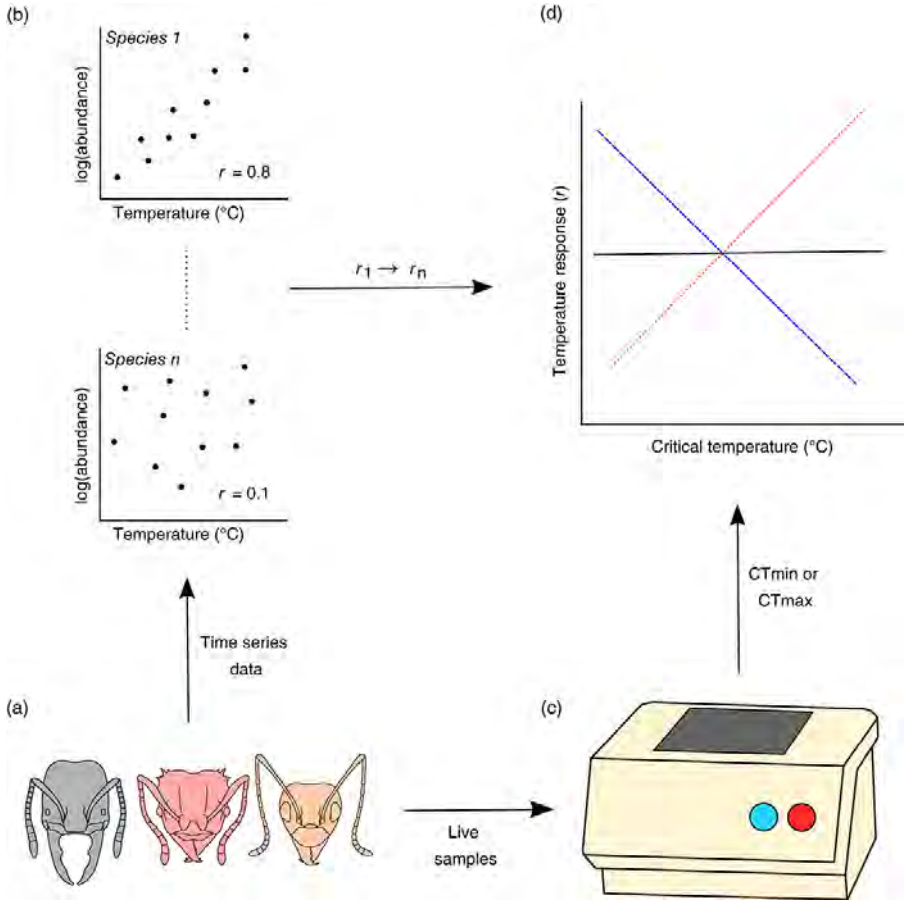


Figure 2. Schematic illustrating the analysis for relating thermal tolerance and foraging behaviour. (a) Multiple ant species are collected from the Sani Pass. (b) The correlation between abundance (pitfall trapping over 7 years, 2006–2012) and temperature (obtained from data loggers) is calculated for each species and within each elevational band. This can be done using minimum, mean or maximum environmental temperatures. (c) Critical thermal maxima (CT_{max}) and minima (CT_{min}) are estimated from live specimens collected in 2014 using a dry heat bath. (d) The temperature responses, i.e. the correlation coefficients from (a), are regressed against the critical temperature values, obtained from (c). Each data point in (d) is a species from a single elevation. Lines in (d) represent three theoretically different possible relationships between the temperature response and the species' critical temperatures. Solid black, no relationship; dashed blue, stronger response with low critical temperature; dotted red, stronger response with low critical temperature (From: Bishop *et al*. 2017; *Ecol*. *Entomol*. 42: 105–114).

C·I·B-affiliated postdoc Tom Bishop, with C·I·B Core Team Members Mark Robertson and collaborators, addressed these two knowledge gaps by sampling ants across a 1500 m elevational

gradient in southern Africa and estimating the upper (CTmax) and lower (CTmin) thermal tolerances of 31 and 28 species, respectively (Fig. 2). Ant abundances and soil temperatures were also recorded across the gradient over 6 years (Bishop *et al*. 2017; *Ecological Entomology* 42, 105–114).

They found that the average CT_{min} of the ants declined with elevation along with environmental temperatures. It was also found that the correlation between abundance and local temperature depended on the ant species' CT_{min}. The activity of species with a low CT_{min} was not constrained by temperature, whereas those with a high CT_{min} were limited by low temperatures. This study provides the first evidence that the thermal tolerances of ants are consistent with Brett's rule and Janzen's rule. A mechanistic link between physiology, behaviour and the environment was also demonstrated, which highlights that the ability of ants to deal with the cold may be a key, but often overlooked, factor that allows multiple ant species to succeed in an environment.

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 more generally are not ontologically separable from other 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.

UNDERSTANDING SUGAR LANDSCAPES AND POLLINATOR-MEDIATED INTERACTIONS IN PLANT COMMUNITIES

Pollinator-mediated interactions between plants can play an important role for the dynamics of plant communities. Pollination services depend on the abundance and the foraging behaviour of pollinators; these in turn respond to the availability and distribution of floral resources (notably nectar sugar). However, there is still limited understanding of how the 'sugar landscapes' provided by flowering plant communities shape pollinator-mediated interactions between multiple plant species and across different spatial scales. A better understanding of pollinator-mediated interactions demands an integrative approach to quantify different aspects of sugar landscapes and to investigate their relative importance for pollinator behaviour and plant reproductive success.

C·I·B Core Team Member Karen Esler and collaborators quantified such sugar landscapes from individual-based maps of shrub communities dominated by *Protea* species in the Cape Floristic Region. The 27 study sites of 4 ha each jointly comprise 127 993 individuals of 19 species. They analysed how rates of visitation by key bird pollinators and the seed set of plants respond to different aspects of sugar landscapes: the distribution of nectar sugar amounts, as well as their quality, taxonomic purity and phenology (Nottebrock *et al*. 2017; *Ecography* 40: 1129–1138).

The study found that pollinator visitation rates were strongly dependant on phenological variation of site-scale sugar amounts. The seed set of focal plants increased with nectar sugar amounts of

conspecific neighbours and with site-scale sugar amounts (Fig. 3). Seed set increased particularly strongly if site-scale sugar amounts were provided by plants that offer less sugar per inflorescence. These combined effects of the amount, quality, purity and phenological variation of nectar sugar show that nectar sugar is a common interaction currency that determines how multiple plant species interact via shared pollinators. The responses of pollinator-mediated interactions to different aspects of this interaction currency alter conditions for species coexistence in *Protea* communities and may cause community-level Allee effects that promote extinction cascades.

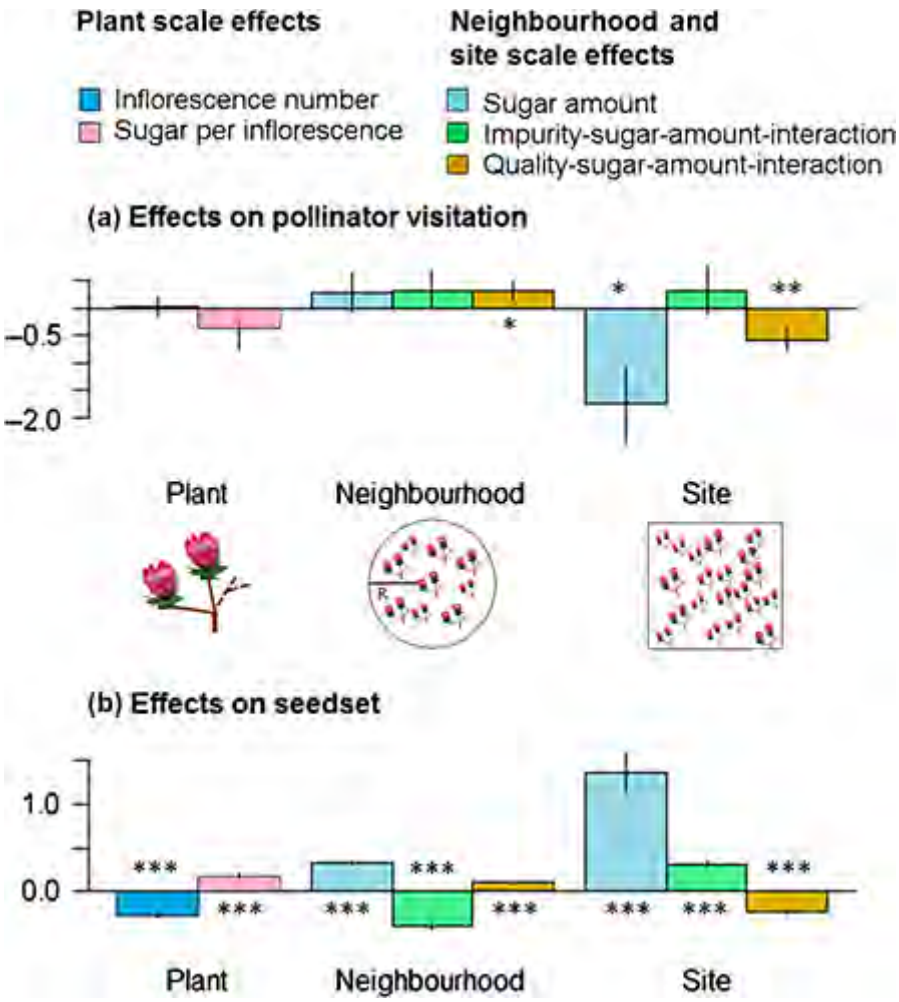


Figure 3. Effects of sugar landscapes at the scale of individual plants, neighbourhoods and sites on (a) pollinator visitation and (b) seed set per inflorescence. (From: Nottebrock *et al*. 2017; *Ecography* 40: 1129–1138).

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.

LEGUME–RHIZOBIUM SYMBIOTIC PROMISCUITY AND EFFECTIVENESS DO NOT AFFECT PLANT INVASIVENESS – INSIGHTS FROM INTRODUCED ACACIAS IN SOUTH AFRICA

The capacity of introduced plants to form mutualisms in their new ranges is a crucial ingredient for invasive success. The ability to fix atmospheric nitrogen plays an important role in the invasion success of legumes. Interactions between legumes and nitrogen-fixing bacteria (rhizobia) span a continuum of specialization, and promiscuous legumes are thought to have higher chances of forming effective symbioses in novel ranges.

C·I·B Core Team Members Jaco Le Roux and Cang Hui, with MSc student Jan-Hendrik Keet and other collaborators, sought further clarity on the relationships between introduced Australian acacias and bacteria. They hypothesized that widespread and highly invasive species will be more generalist in their rhizobial symbiotic requirements and will be more effective in fixing atmospheric nitrogen than more localized and less invasive species (Keet *et al*. 2017; *Annals of Botany*, 119, 1319–1331).

To test these hypotheses, they examined eight localized and 11 widespread acacia species using next-generation sequencing data for the nodulation gene nodC to compare the identity, species richness, diversity and compositional similarity of rhizobia associated with these acacias. Stable isotope analysis was also used to determine levels of nitrogen obtained from the atmosphere via symbiotic nitrogen fixation.

No differences were found in richness, diversity or community composition between localized and widespread acacias (Fig. 4). Widespread and localized acacias also did not differ in their ability to fix atmospheric nitrogen. However, for some species by site comparisons, significant differences in δ15N isotopic signatures were found, suggesting differential symbiotic effectiveness between these species at specific localities.

The results support recent findings that the diversity of root-nodule rhizobia and community composition do not differ between acacias that vary in levels of invasiveness. Differential invasiveness of acacias in South Africa is probably linked to attributes such as differences in propagule pressure, reasons for introduction (e.g. forestry vs. ornamental) and extent of plantings in the country.

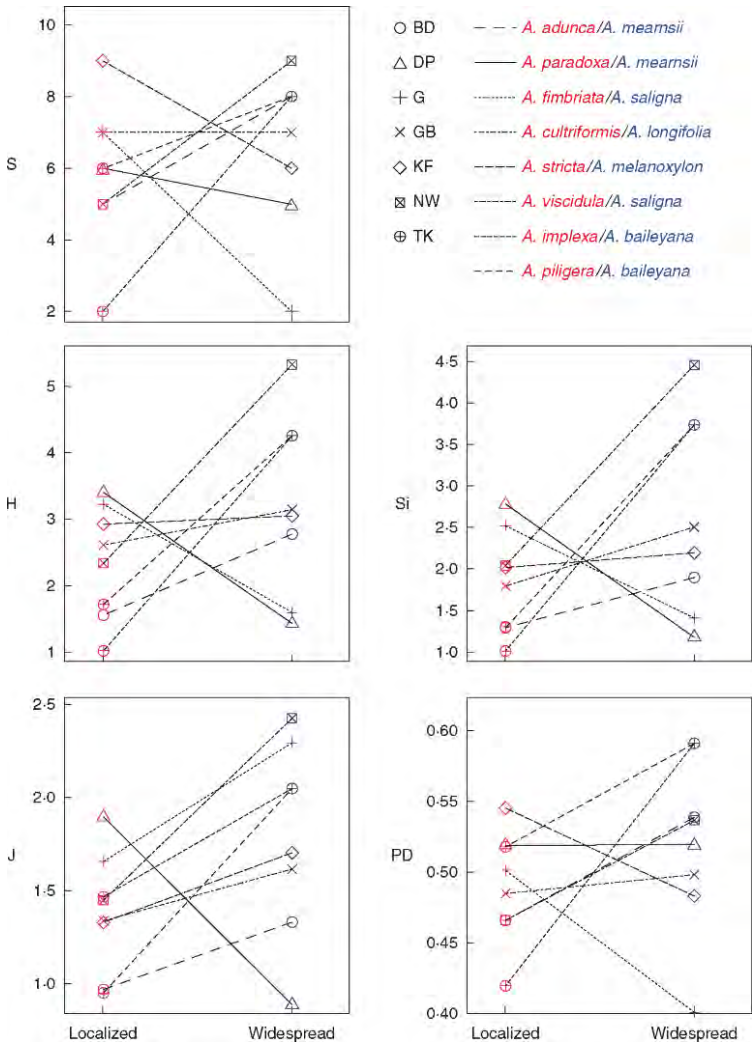


Figure 4. Diversity metrics (S, richness; H, Shannon diversity; Si, inverse Simpson diversity; J, evenness; PD, Faith's phylogenetic distance) for co-occurring widespread and localized acacia species pairs (lines) at different sites (symbols) (From: Keet *et al*. 2017; *Ann. Bot*. 119: 1319–1331).

ACACIA SEED BANKS ARE STILL ACCUMULATING IN THE PRESENCE OF BIOLOGICAL CONTROL AGENTS

The capacity of invasive alien plants to produce large numbers of propagules is a key factor that allows them to outcompete with native plants. Propagules are structures that can give rise to new plants such as cuttings, seeds or spores.

In South Africa, the seeds of invasive Australian *Acacia* species accumulate in the soil (in so-called 'seed banks'). These seed banks pose the greatest obstacle to the removal and management of these species. An arsenal of biological control agents, some released as long as 30 years ago, are an attempt to keep this seed production in check. However, despite these agents, dense stands of ant-dispersed invasive *Acacia* species continue to accumulate in the soil seed banks.

A study by C·I·B PhD student Matthys Strydom found that annual seed input of invasive Australian acacias is still high, despite the use of biological control agents.

Strydom and colleagues analysed soil samples from areas invaded by Australian *Acacia* species, long-leaved wattle (*Acacia longifolia*), golden wattle (*A. pycnantha*), black wattle (*A. mearnsii*) and Port Jackson willow (*A. saligna*) (Fig. 5). They found that the seed banks are generally large (>1000 seeds m^2) with 94% of the seeds viable. Previous research has shown that seed banks of similar size recruit seedlings at densities of 19 to 1200 seedlings m^2, and that as few as 10 seedlings per m^2 are needed to re-establish a closed-canopy stand of acacias.

The results of the study (Strydom *et al*. 2017; PLoS ONE 12(8): e0181763) have important implications for integrated control of *Acacia* species in South Africa and worldwide. It is proposed that seed banks can be managed using stem diameter to estimate potential seed-bank size. According to Strydom, 'Long term mechanical management, despite its higher cost compared to biological control, is likely required to effectively manage the seed banks of invasive Australian acacias'.

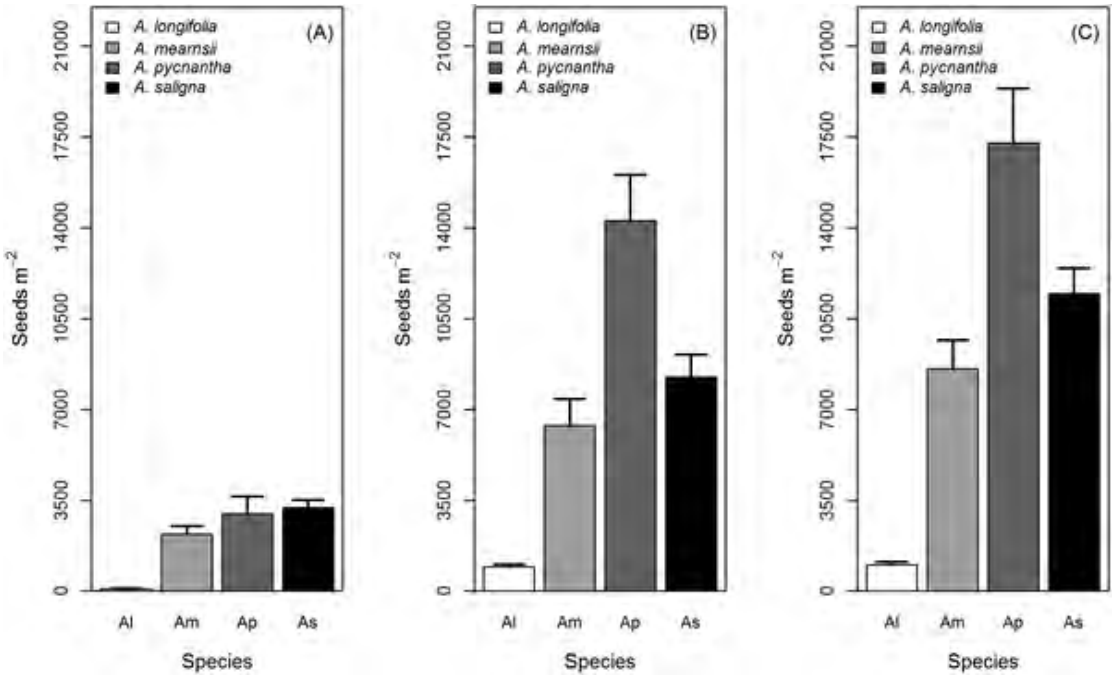


Figure 5. Seeds in the litter, soil and seed bank indicates the seeds surviving the pre- and post-dispersal phases. Average number of seeds per m^2 (+SE) in the litter (A), soil (B) and seed bank (litter + soil, C) of 4 ant-dispersed Australian *Acacia* species in the Western Cape of South Africa (From: Strydom *et al*. 2017; *PLoS ONE* 12(8): e0181763)

THE LEGACY OF ACACIA INVASIONS REMAINS IN THE SOIL LONG AFTER CLEARING

Native areas that are invaded by the invasive alien tree Port Jackson willow (*Acacia saligna*) can experience legacies in the soil that last several decades after invasive stands are cleared. This was

the finding of a study led by C·I·B PhD student Mlungele Nsikani. Understanding such legacies is crucial for planning restoration efforts.

The study explored the soil legacy effects of *A. saligna* in Cape Flats Sand Fynbos. Port Jackson willow is a nitrogen-fixing tree that has negative ecological impacts such as changing the soil chemistry of the areas it invades. It is often assumed that the negative impacts of invasive alien plant species will decline or disappear soon after their removal. This is unfortunately not the case because invasive alien plant species can leave legacy effects in the soil after their removal. Legacy effects are a specific type of effect where measurable changes in biological, soil chemical or physical conditions can be seen even after removal of the invader.

Soil was sampled in areas invaded by Port Jackson willow, where invasive stands had been removed, and from similar areas that have never been invaded. The soil was analysed for pH, carbon, nitrogen, available phosphorus, ammonium, nitrate and electrical conductivity.

Results showed that invasion by *A. saligna* changed overall soil characteristics, and especially resulted in elevated pH levels (Fig. 6). The removal of Port Jackson willow did not restore native soil characteristics. In particular, increased nitrate levels remained higher in previously invaded areas compared to invaded and un-invaded areas, even 10 years after removal of *A. saligna* stands (Nsikani *et al*. 2017; *Austral Ecology* 42: 880–889).

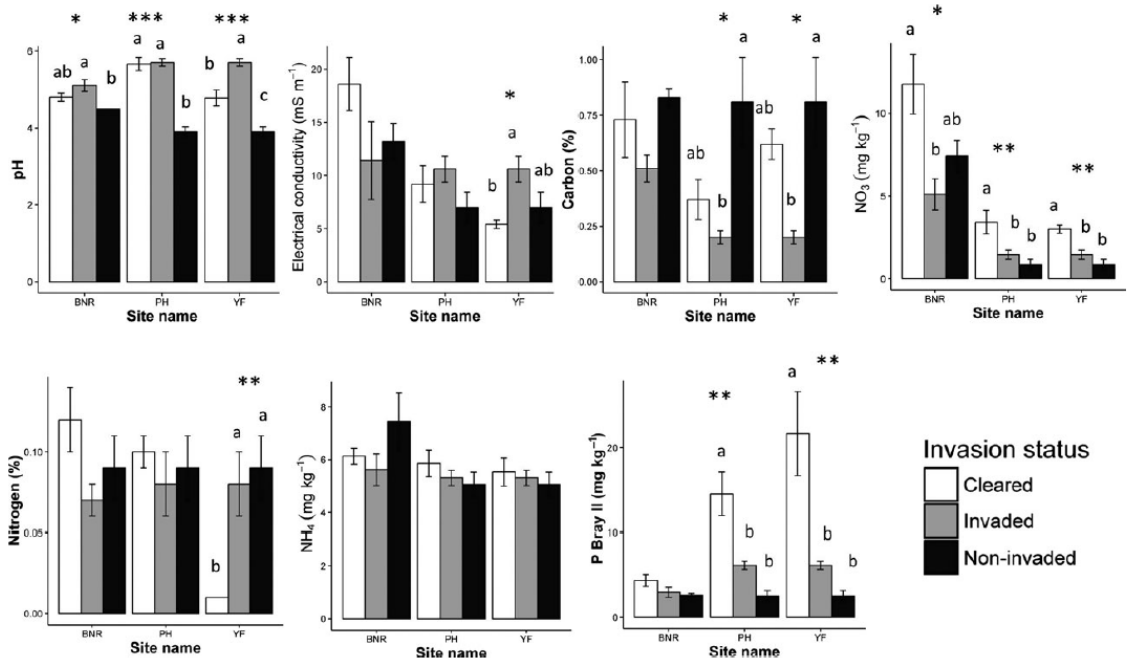


Figure 6. One-way ANOVA results of the different soil nutrients, pH and electrical conductivity in the different *Acacia saligna* invasion statuses at three study sites. Mean values of each soil nutrient in each study area with the same letter are not significantly different. Significance indicated in bold as: *P < 0.05; **P < 0.01; ***P < 0.001. BNR, Blaauwberg Nature Reserve; PH, Penhill; YF, Youngsfield. (From: Nsikani *et al*. 2017; *Austral Ecology* 42: 880–889).

'The remaining higher nitrate levels can facilitate the growth of other invaders which often out-compete native species' says Nsikani. He adds 'to improve restoration outcomes after clearing Port Jackson stands, the removal of secondary invaders and weedy native species should be at the top of the list. If this is not done, the goal of restoring native communities will remain elusive in most previously invaded areas'.

Ladybirds as a model group

Harmonia axyridis (Coleoptera: Coccinellidae; the harlequin ladybird) was introduced to Europe and the USA for the biological control of agricultural pests. It was also been unintentionally introduced to many parts of the world, including South Africa, where it has spread rapidly. To date it has established in four continents outside of its native range in Asia and it is considered a major invasive alien species with negative effects on native insect diversity, the food industry and human health.

Despite a large body of work on invasion ecology, many questions remain unanswered regarding the establishment mechanisms of invasive species and their interactions with natural enemies. Parasites (multicellular organisms that do not directly kill the host) could potentially play an important role in regulating host populations.

C·I·B Core Team Member Susana Clusella-Trullas worked with an international team of collaborators to review the parasites of *H. axyridis*, exploring their distributions and effects on host populations across the host's native and invasive range (Haelewaters *et al*. 2017; *BioControl* 62: 355–371). These parasites are: *Hesperomyces virescens* Thaxt. Fungi (Fig. 7), *Coccipolipus hippodamiae* (McDaniel and Morrill) mites, and *Parasitylenchus bifurcatus* Poinar and Steenberg nematodes.

Given the rapid spread and establishment of *H. axyridis* across different climates and regions, this species is a good model taxon for exploring processes and patterns of invasion biology. While some work has focused on traits that give this species a competitive advantage such as being a generalist top predator, much less research has explored the dynamics between this species and its natural enemies in invaded areas. Its large global range makes it a superb model system for exploring host-parasite dynamics across diverse climates and understanding how these relationships may have changed between the native and invaded regions. It also provides an opportunity to test theoretical expectations of co-evolution and community dynamics (e.g. the enemy release hypothesis).

In South Africa, the ectoparasitic fungus *Hesperomyces virescens* was detected on *H. axyridis* as well as a native ladybird, *Cheilomenes propinqua*, raising the question of whether the parasite shifted from the native to the invasive host or the other way around. The study of these host-parasite interactions is key to understanding the dynamics of this invasion but also to explore the potential regulatory role that natural enemies may have on this highly invasive species. This type of research may uncover strategies that can be implemented to control this species.

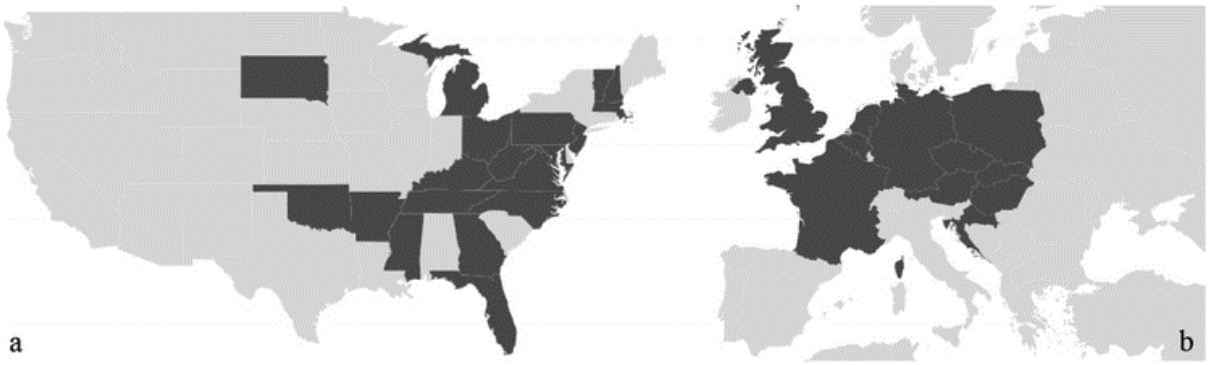


Figure 7. The distribution of *Hesperomyces virescens* parasitizing *Harmonia axyridis* in the USA (a) and Europe (b). Areas where the association is known are highlighted in black. (From: Haelewaters *et al*. 2017; *BioControl* 62: 355–371). This parasite has also been detected in Canada, Argentina, Ecuador, China and South Africa.

Xenopus laevis: a globally significant invader

The African clawed frog is a popular pet in many countries of the world, but traded animals do not originate from their native range in southern Africa. The surprising result from a recent paper by C·I·B Core Team Member John Measey suggests that nearly all animals imported into the USA were bred in China (Measey 2017; *Salamandra,* 53: 398-404) (Fig. 8). Interestingly, a significant number of frogs were also imported from Chile, possibly as the direct export of the invasive population there. Numbers imported from South Africa have dwindled to nothing over the last 15 years.

Frig. 8. Total live trade of African clawed frogs, *Xenopus laevis*, imported into the USA over the last 15 years. The thickness of the lines is proportional to the size of the trade (From: Measey 2017; *Salamandra* 53: 398-404).

Invasive populations of African clawed frogs generally reflect the mediterranean origin of their source population in South Africa's Western Cape. However, a recent study by John Measey and European INVAXEN collaborators on all invasive and native populations shows that the invasive population in France displays an important shift in its realized niche (Rödder *et al*. 2017; *Ecology and*

Evolution, 2017; 7: 4044–4058 doi:10.1002/ece3.3010). This suggests that the species has adapted to its local conditions and is no longer constrained by it historical distribution.

A new paper by C·I·B MSc graduate André de Villiers and John Measey using mark-recapture data shows that African clawed frogs move large distances overland (up to 2.4 km) within their native range (de Villiers & Measey 2017; *PeerJ,* 5:e4039 doi:10.7717/peerj.4039). The 3-year study found that 5% of frogs moved between 8 ponds in the study area of Kleinmond. This amount of movement may be so much that these frogs can no longer be considered a metapopulation. The really surprising result is the amount of movement between sites, and the animals that were moving.

The Cape platanna (*Xenopus gilli*) is not as well-known as its larger transcontinental invading sibling species, the African clawed frog (*X. laevis*). The former is restricted to a small area in the far southwest of the continent where it shares its remaining and highly disturbed habitat with its much larger sibling. The extent of the habitat disturbance is so large that the IUCN has considered this species to be threatened since the 1980s. The most recent assessment suggests that the Cape platanna is Endangered, but that the decline is being driven not so much by habitat loss as by hybridisation, competition and predation by the African clawed frog. Assessments of threats on the Red List most often result from discussions by teams of experts. Research at the C·I·B has clarified the nature of these threats.

It has been known since the 1970s that the Cape platanna hybridises with the African clawed frog, and it has long been thought that back crossing of these hybrids represent a genetic threat to the Cape platanna, so called introgression. C·I·B Core Team Member John Measey and C·I·B visiting fellow Ben Evans and his students from McMaster University in Canada compared samples of these two species from 1994 and 2014 to determine whether there have been any changes in the level of introgression over this 20-year period. They sampled two areas, one where the African clawed frog has been removed and another where they are left. Although hybrids of these two species were previously found in both areas, no evidence of introgression was detected. This suggests that although hybridisation is a threat to the already limited numbers of individuals which are not mating with the correct species, genetic introgression is not a substantial threat (Fig. 9) (Furman *et al*. 2017; *Scientific Reports*, 7(1):1091. doi:10.1038/s41598-017-01104-9).

These same two sites also formed the basis for another study which sought to determine the level of competition between these two species through their diet. In this study, John Measey, his students and collaborators at the Zoologisches Forschungsmuseum Alexander Koenig in Germany found that the diet from the two species overlapped almost entirely (Vogt *et al*. 2017; *PeerJ*, 5:e3130. doi: 10.7717/peerj.3130). Surprisingly, at one site the majority of the food of both these aquatic predators were the tadpoles of other amphibians. This form of anurophagy is more common in these frogs than previously reported. The researchers even found an example of the larger African clawed frog with a small Cape platanna in its stomach. The study showed that both competition and predation are important ways in which the African clawed frog impacts on the Cape platanna.

'Finding the smoking gun in the form of an ingested Cape platanna was really impressive' said Measey - 'We often speculate about these things, but it's rare to find examples. Now that we know that the impact of predation and competition is large, we can take steps to extend the programme of removing the large African clawed frog, thereby helping to conserve the Endangered Cape platanna.'

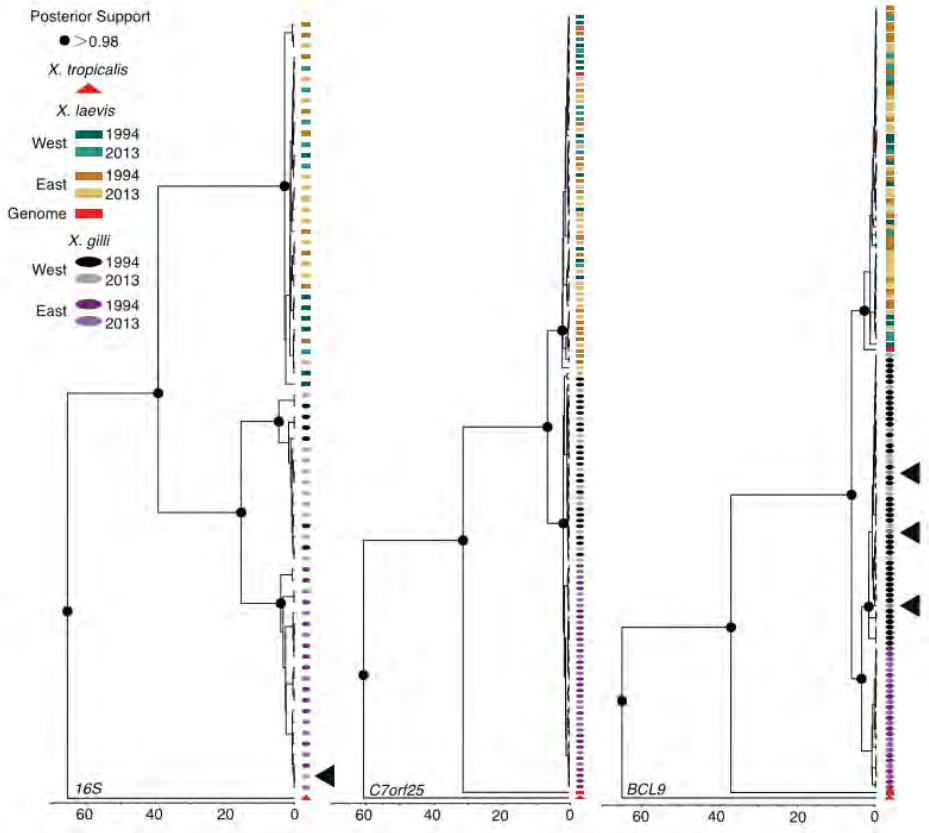


Figure 9. Representative gene trees that collectively provide no evidence of genetic exchange between *Xenopus gilli* and *X. laevis* (From: Furman *et al*. 2017; *Sci. Rep*. 7(1):1091. doi:10.1038/s41598-017-01104-9).

Invasions in urban areas

NON-NATIVE SPECIES IN URBAN ENVIRONMENTS: PATTERNS, PROCESSES, IMPACTS AND CHALLENGES

Although urban ecosystems are hotspots for biological invasions, the field of invasion science has given scant attention to invasion dynamics and the challenges facing managers in towns and cities. As in most parts of the world, biological invasions in urban ecosystems are attracting more attention. An increasing number of invasive species are becoming problematic in towns and cities, numerous ecosystem services are being affected, and complex conflicts of interest frequently complicate management attempts. Urban invasions were a major focus of research at the C·I·B in 2017. A highlight of the year in this regard was the publication of a special issue of *Biological Invasions* with 17 papers on the theme 'Non-native species in urban environments: Patterns, processes, impacts and challenges'. This issue explores urban-specific patterns, processes, impacts and challenges of

non-native species. It aimed to synthesize knowledge on invasion dynamics in urban ecosystems worldwide (Gaertner *et al*. 2017; *Biological Invasions* 19: 3461-3469) (Fig. 10).

The ten papers in the special issue that had C·I·B-affiliated authors dealt with the following themes and questions (C·I·B-affiliated authors in brackets):

- Ranking of invasive spread through urban green areas in the world's 100 most populous cities (Hui, Richardson)
- Small urban centres as launching sites for plant invasions in natural areas: insights from South Africa (McLean, Gallien, Wilson, Gaertner, Richardson)
- How do invasive species travel to and through urban environments? (Irlich, Faulkner, Gaertner, Wilson)
- Alien plants as mediators of ecosystem services and disservices in urban systems: a global review (Potgieter, Gaertner, Kueffer, Richardson)
- British plants as aliens in New Zealand cities: residence time moderates their impact on the beta diversity of urban floras (Pyšek)
- Understanding the influence of urbanization on invasibility: *Carpobrotus edulis* as an exemplar (Novoa, Le Roux)
- Does restricted access limit management of invasive urban frogs? (Vimercati, Davies, Hui, Measey)
- The potential range of *Ailanthus altissima* (tree of heaven) in South Africa: the roles of climate, land use and disturbance (Walker, Robertson, Gaertner, Gallien, Richardson)
- Does public awareness increase support for invasive species management? Promising evidence across taxa and landscape types (Novoa, Vimercati)
- Managing invasive species in cities: a decision support framework applied to Cape Town (Gaertner, Novoa, Richardson)

The special issue papers show that patterns and processes of urban invasions differ in many ways from invasions in other contexts, and that managing invasive species in cities has unique and increasingly complex challenges.

Progress in urban invasion science requires further work to: (1) address key limitations that hinder our understanding of invasion dynamics in cities; (2) clarify whether fundamental concepts in the field of invasion science are appropriate for urban ecosystems; (3) integrate insights from invasion science with those from the burgeoning literature on the Anthropocene biosphere, novel ecosystems, social-ecological systems, human-wildlife conflicts, urban green infrastructure, urban planning and design, and ecosystem services and disservices.

Figure 10. Schematic representation of the contributions of 17 papers in a special issue *of Biological Invasions* focussing on the elucidation of invasion science in the context of urban ecosystems. Contributions are categorized by their contribution with respect to historical perspectives; patterns and processes; impacts; and management and perceptions (From: Gaertner *et al*. 2017; *Biol. Invasions* 19: 3461-3469).

Agricultural pest insects as models for invasion science

UNDERSTANDING THERMAL LIMITS TO SURVIVAL AND ACTIVITY OF A MAJOR AFRICAN AGRICULTURAL CROP PEST

To understand a pest's geographic distribution, invasion potential and population dynamics it is critical to have information about its thermal limits to activity and survival. Many insects however have marked variation in these limits across developmental stages or may appear to have high thermal resistance when scored in the laboratory under extreme conditions. A team of C·I·B researchers tackled these issues for a major African agricultural crop pest, the false codling moth (*Thaumatotibia leucotreta*) to gain insight into when and where the pest may become invasive in the future and under which conditions, extreme weather may influence activity or survival of the pest in the field.

Research led by C·I·B Core Team Member John Terblanche has illustrated the importance of understanding several key sources of intrinsic variation in thermal limit estimates for the false codling moth, including developmental stage and the environmental rate of temperature change (Terblanche *et al*. 2017; *Physiological Entomology* 42: 379–388).

The team assessed functional upper and lower thermal limits of activity and survival in two life stages of the moth under a range of assay conditions in the laboratory. They also measured amounts of a key heat shock protein (HSP70) which is often associated with enhanced thermal tolerance in many other insect species, to potentially explain survival or activity limits detected in the thermal assays. However, this protein failed to explain the variation detected and suggests other cellular mechanisms may be more important in the case of this species.

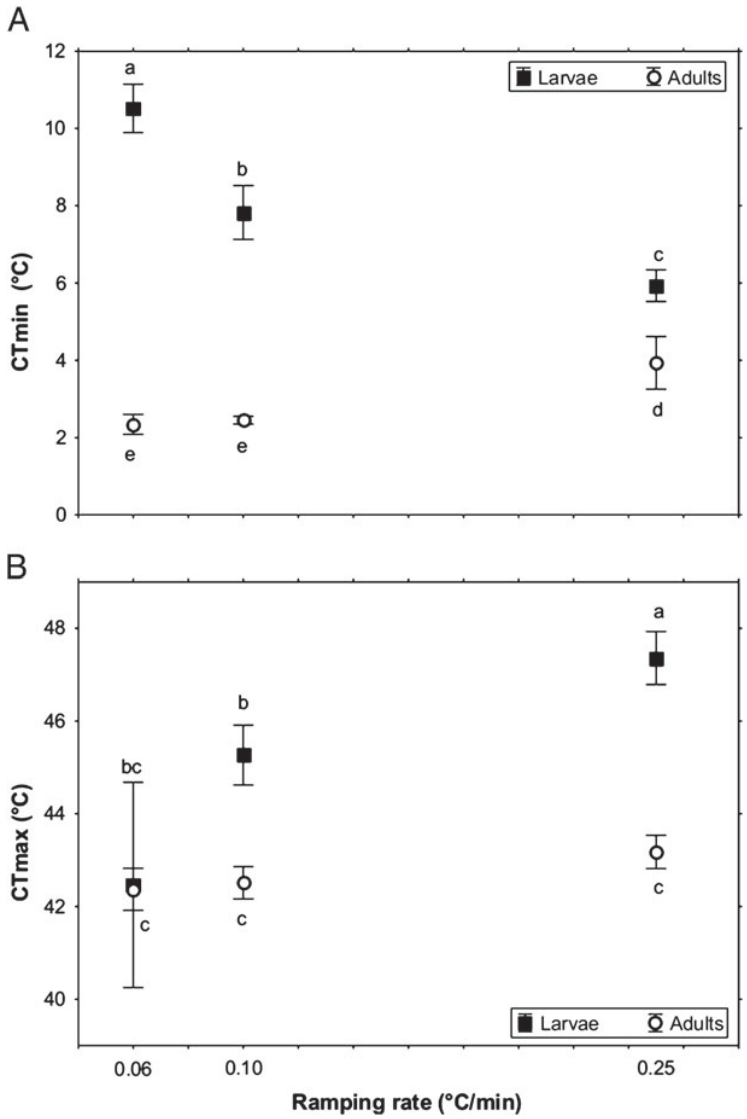


Figure 11. The effect of ramping rates on the mean critical thermal minima (CTmin) (A) and mean critical thermal maxima (CTmax) (B) in larvae and adults of the false codling moth, Thaumatotibia leucotreta. Error bars represent ±95% confidence intervals. Groups with different lowercase letters are significantly different (P<0.05) (From: Terblanche *et al*. 2017; *Physiol. Entomol*. 42: 379–388).

Larvae were found to survive across a wider range of thermal conditions than adults. By contrast, adults were more active across a wider range of conditions than larvae. Differences between the two main life-stages thermal tolerance were most pronounced under the slowest, ecologically-relevant ramping rates (0.06°C/min) for low temperature activity limits, but the opposite was found

for high temperature activity limits (Fig. 11). Thus, the methodological approach chosen in the lab could either hinder or enhance the detection of stage-related variation in thermal limits.

This study suggests that microclimates and insect abundance may need to be continuously monitored to better understand thermal tolerances in the field. This has immediate implications for forecasting invasion potential and population dynamics of this pest in the field. Terblanche explains, 'The immediate implications of this research for management are two-fold. First, we need to understand which microsites the insects are using and how they respond in the field to variation in weather. Second, temperature assessments need to simulate conditions of these specific microsites to forecast pest population dynamics and understand ecologically-relevant thermal limits to activity and survival.

1.2.4 Detection, demonstration, responses and remediation

UNRAVELLING INTRODUCTION PATHWAYS INVOLVING SHIPPING

Research conducted by C·I·B post-doctoral associate Katelyn Faulkner demonstrates that to reduce invasions, ships travelling along high risk routes should be targeted for inspections.

As ships move goods around the world, they unintentionally ferry invasive species to regions where they are not native. These new species arrive in the ships' ballast water — the water that ships take on board for stability. When the ships arrive in port, they discharge the ballast water, along with these unwanted hitchhikers. Many of these species establish in the new environment and have negative impacts there. Unfortunately, there are limited resources available to reduce these introductions, which means that priorities must be identified.

South Africa was used as a case study to evaluate the potential for ships to introduce species that will establish, and to determine whether there is variation across shipping routes. The authors used ship movement data and environmental matching techniques to estimate the number of species with the potential to establish that will be transported along each route to South Africa (Faulkner *et al*. 2017; *PLoS ONE* 12, e0173340. doi:10.1371/journal.pone.0173340).

The authors found that more alien species with the potential to establish are likely to be introduced to Durban than to other South African ports. One species that is not yet in South Africa but could be introduced to Durban through high risk shipping routes is the disease vector southern house mosquito, *Culex quinquefasciatus*.

Some shipping routes to South Africa will introduce more alien species with the potential to establish than others (Fig. 12). Routes from Asia, and in particular those from Singapore, pose a high risk to South Africa, but different routes pose a high risk to different South African ports. More alien species with the potential to establish are likely to be introduced to Durban than to South Africa's other large ports.

According to Faulkner, 'our results suggest that to reduce the number of invasive species introduced to South Africa through shipping, specific routes need to be targeted and a large portion of the available resources should be allocated to Durban. The identification of these management priorities is of particular relevance at the moment, as the International Maritime Organisation's Ballast Water Management Convention, which sets limits on the highest concentrations of various organisms that ships can have in their ballast water before discharging it, will enter into force in September this year.'

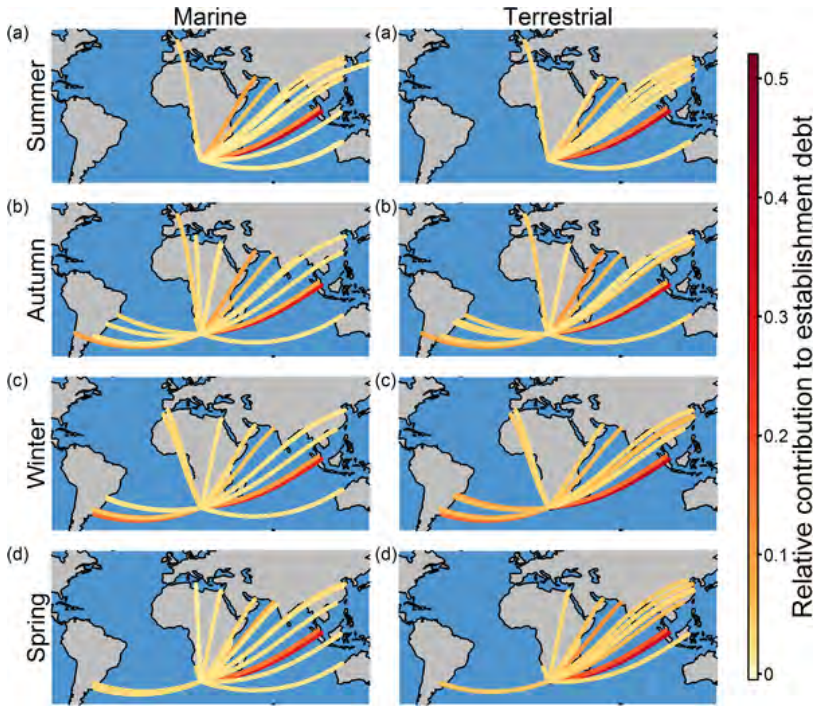


Figure 12. The twenty shipping routes from foreign ports, for each season, with the highest relative contribution to the marine and terrestrial establishment debt of Saldanha Bay (From: Faulkner *et al*. 2017; *PLoS ONE* 12: e0173340).

REASSESSING THE INVASION OF SOUTH AFRICAN WATERS BY THE EUROPEAN SHORE-CRAB

The European shore-crab *Carcinus maenas* has been known from South African waters since 1983. Despite this species' international reputation as a biological invader, its distribution in this region has only been considered by three outdated 'snapshot surveys.'

C·I·B PhD student Clova Jurk-Mabin and collaborators undertook the most comprehensive survey of the species to date to provide an update on the species' range and the first temporal assessment of its abundance and demographics (Mabin *et al*. 2017; *African Journal of Marine Science* 39: 259–267).

Along South Africa's Cape Peninsula and surrounding areas, *C. maenas* was absent from 12 intertidal sites surveyed, except for Sea Point, and no crabs were found during subtidal surveys along the open coastline. Subtidal harbour populations were recorded in the Cape Town harbours of Table Bay and Hout Bay (previously estimated as comprising approximately 164 200 and 6 500 individuals,

respectively). Table Bay was surveyed monthly for one year, using baited traps, crab condos and post-larvae settlement collectors, to assess size distributions and reproductive seasonality of the crab. Reproductive females were recorded throughout most of the year (Fig. 13).

Results suggest that the harbour populations could be targeted by control programmes, but provide no strong evidence to support the initiation of management action during a particular season. The lack of detection of post-larval settlement, even among well-established populations, suggests this will not be a useful monitoring tool for detecting incursions.

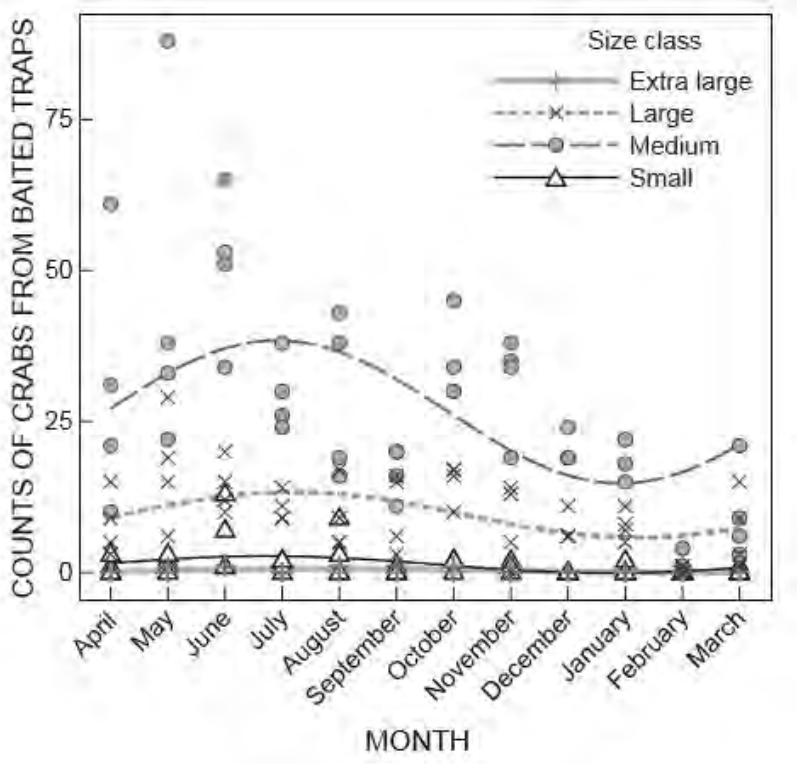


Figure 13. Seasonal patterns in abundance of *Carcinus maenas* in Table Bay, South Africa, among the different size classes captured using baited traps (From: Mabin *et al*. 2017; *Afr. J. Mar. Sci*. 39: 259–267).

THE SPREAD OF AUSTRALIAN REDCLAW CRAYFISH IN SOUTH AFRICA AND SWAZILAND

A study by C·I·B Post-doc Ana Nunes confirmed the presence of established and widespread populations of the Australian redclaw crayfish (*Cherax quadricarinatus*) in South Africa and Swaziland (Nunes *et al*. 2017; *PeerJ* 5:e3135 https://doi.org/10.7717/peerj.3135). This work also showed that, in 14 years, the species has spread more than 100 km from its point of first introduction. Considering the major impacts that alien crayfish have had on invaded ecosystems in many other countries, this is extremely worrying.

The Australian redclaw crayfish is native to Australia and was first reported in South Africa 2002, after accidentally escaping from an aquaculture farm in Swaziland. Despite initial reports of the

species in Swaziland and South Africa, no systematic survey had been carried out to determine their distribution, spread rate and population dynamics.

The study found that the species is now present in at least three large rivers (Komati, Mbuluzi and Usutu), two tributaries (Lomati and Mlawula rivers), and in several irrigation dams in Mpumalanga (Fig. 14). In the Komati River, the mean spread rate was 8 km/year downstream and 4.7 km/year upstream, whereas in Swaziland estimated downstream spread rate might reach 14.6 km/year. Individuals were generally larger and heavier closer to the introduction point, which might be linked to juvenile dispersal.

While the environmental impact of the redclaw crayfish in invaded habitats has yet to be determined, the possible introduction of this species into new catchments in South Africa is a matter of extreme concern, given its potential impacts on native biota, such as disease introductions or strong competitive interactions with native freshwater crustaceans.

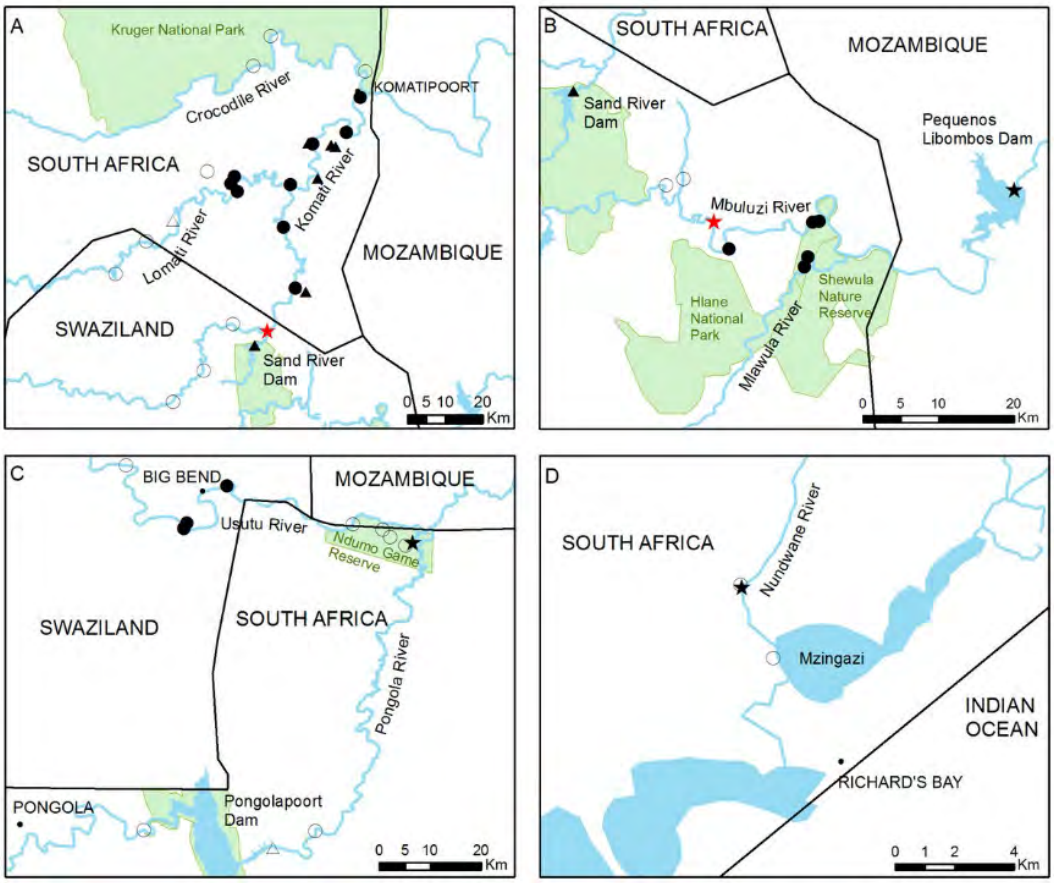


Figure 14. The four main study areas, with the 46 sampling sites surveyed to determine the distribution of *Cherax quadricarinatus* in southern Africa (From: Nunes *et al*. 2017; *PeerJ* 5:e3135 https://doi.org/10.7717/peerj.3135).

According to Nunes, 'Considering that established invasive crayfish populations are usually impossible to eradicate, the possibility of implementing management actions to control the spread

of crayfish populations in the international river systems studied here should be immediately discussed and coordinated between South Africa, Swaziland and Mozambique'.

BIOSECURITY REQUIRES IMPROVED IDENTIFICATION METHODS FOR ORNAMENTAL FISH

The ornamental fish trade has is worth tens of billions of USD but has been linked to more than 150 invasions by alien fishes. As a result, managing introductions via the pet trade is an important aspect of national biosecurity. South Africa is no exception, and fishes such as koi carp (Fig. 15), guppies and armoured catfishes often escape captivity and some have invaded freshwater ecosystems.

As the aquarium fish trade includes hundreds of species, identifying potential problem species at the point of entry is crucial. As most fishes are traded using common names, C·I·B alumnus Kerry-Ann Van der Walt together with C·I·B Core Team Member Olaf Weyl and collaborators from the South African Institute for Aquatic Biodiversity evaluated the accuracy of the common names used for aquarium fish in the ornamental fish trade by using a DNA barcoding approach together with morphological and visual identification.

Their assessment, based on sampling specimens of 185 different fish species from pet shops and traders, demonstrated that the use of trade names was not accurate. Identification of specimens was hampered by the inconsistent use of names, hybridisation and selection for different colour variants by the pet trade. Available genetic databases were also not sufficiently populated to identify more than half of the taxa sampled. On comparison with South Africa's permitted and prohibited species lists revealed that almost half of the specimens that were sampled were not listed. Two species were on the prohibited list for alien freshwater fish species.

Figure 15. The trade in ornamental fishes such as these koi carp is worth billions of USD annually (Photo: Olaf Weyl).

Because of inconsistencies in the identification of species, there is a considerable risk that invasive fishes will be imported into South Africa via the aquarium trade. For improved biosecurity, it is therefore imperative that live fish imports are screened for the presence of potentially invasive fishes. This requires the development of improved tools for detecting problematic species so that the risk of importing potentially invasive species are minimised.

THE EXTENT OF PLANT INVASIONS IN THE SERENGETI QUANTIFIED

Invasive plants are not widely recognised as a threat to the conservation of the African continent's protected areas. A recent study by C·I·B research fellow Arne Witt and Core Team Member Brian van Wilgen showed that more than 50 alien plant species have established naturalised populations in the iconic Serengeti-Mara ecosystem in Kenya and Tanzania. At least six of these pose serious threats to the ecosystem.

A survey was conducted between 2011 and 2016 to establish the extent to which alien plants had become established, and to identify those that posed the largest threats to the Serengeti-Mara (Fig. 16). Many species had been planted as ornamentals around tourist lodges, while some are spreading into the protected area from outside. Although current levels of invasion are low, there are six species, including cacti, mesquite trees (*Prosopis* spp.), triffid weed (*Chromolaena odorata*) and famine weed (*Parthenium*) that are present and have the ability to spread rapidly (Witt *et al*. 2017. *Koedoe* 59(1), a1426. https://doi.org/10.4102/koedoe.v59i1.1426).

Rapid spread would result in a serious reduction in the carrying capacity of the area's rangelands, decimating the hundreds of thousands of wildebeest, zebras and gazelles in the area, and seriously impacting on the tourist industry that relies on wildlife.

The study has recommended that all alien plants should be removed from tourist lodges and replaced with indigenous plants; and that control programmes be implemented to contain invasions where possible. The study also advocates the fullest possible use of biological control, as this offers the only real prospect of an affordable and sustainable solution to the problem in the long term.

'This is a serious problem that to date has not received the recognition and management attention that it deserves' said co-author van Wilgen. 'Failure to take rapid and effective measures to control spread would result in the possible demise of one of the natural wonders of the world, the annual wildebeest migration.'

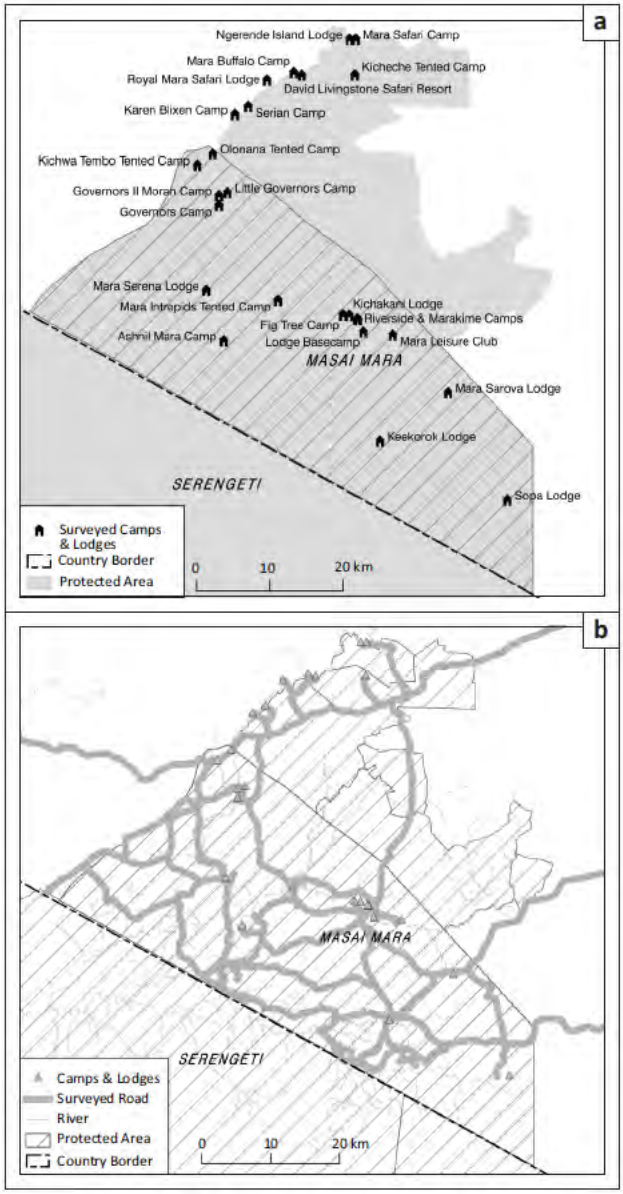


Figure 16. (a) Location of tourist nodes (lodges and other accommodation) in the Masai-Mara National Reserve and adjacent conservation areas that were surveyed for the occurrence of alien plant species and (b) roads in the area that were surveyed for the occurrence of alien plant species (From: Witt *et al*. 2017. *Koedoe* 59(1): a1426. https://doi.org/10.4102/koedoe.v59i1.1426).

EUCALYPTUS INVASIONS REDUCE BIRD DIVERSITY IN A RIPARIAN HABITAT

The zone between land and rivers or streams (riparian habitats) forms a small fraction of the landscape, but supports high levels of biodiversity in many regions of the world. Invasion of riparian habitats by alien plants has a major effect on the avifauna in fynbos ecosystems, which has implications for important services such as seed dispersal and pollination that birds provide in these ecosystems.

C·I·B-funded MSc student Joy Mangachena explored the extent of effects of the important riparian invader *Eucalyptus camaldulensis* (river red gum) on bird communities along the upper catchment of the Berg River in the Western Cape.. This Australian tree species is important for forestry and for the bee-keeping industry as a source of pollen and nectar in the dry season. Although the impacts of this invader on plant communities had been studied, little was known about its impacts on bird communities.

The study recorded 635 birds from 42 species in near-pristine sites (uninvaded) whereas sites invaded by *E. camaldulensis* had a lower diversity, with 507 birds from 26 species (Mangachena & Geerts 2017; *Ecological Research* 32: 667–676). Although alien trees are beneficial to a few generalist bird species, particularly those with a varied diet, important specialist bird species or those with a specialized diet are lost from invaded sites.

The study also found that frugivores (fruit-eating birds) showed reduced species richness and abundance while nectarivores (birds eating sugar-rich nectar) were entirely lost from invaded sites (Fig. 17) indicating that *E. camaldulensis* disrupts seed dispersal and pollination mutualisms. This study also found that in the sites examined, alien trees were not crucial nesting and roosting sites for raptors.

'This study justifies the current clearing of invasive alien plants through government-funded programmes,' said Mangachena, 'but it also highlights the importance of post-clearing studies to guide restoration activities. I hope that our findings will change the way that people view some invasive alien trees in our environment'

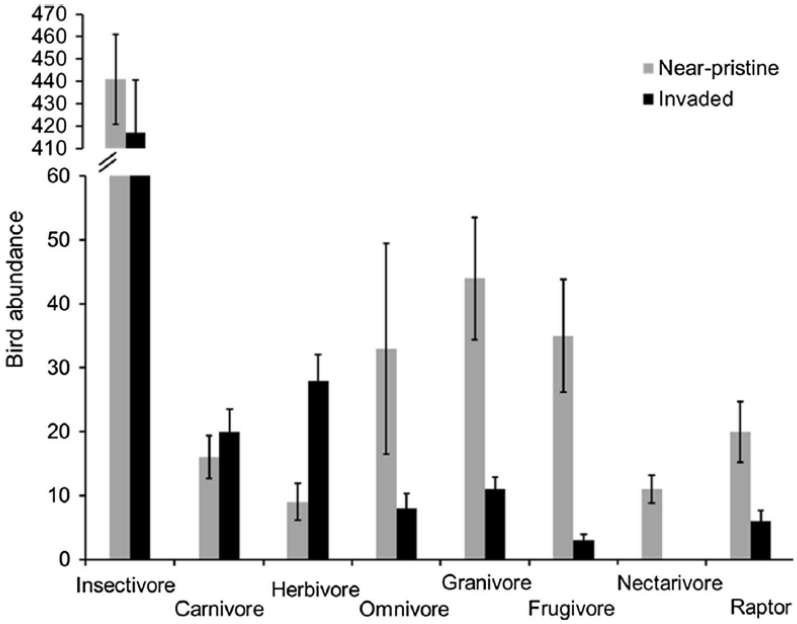


Figure 17. Numbers of individual birds recorded per feeding guild for near-pristine sites and sites invaded by *Eucalyptus camaldulensis* (From: Mangachena & Geerts 2017; *Ecol. Res*. 32: 667–676).

NATIONAL STRATEGIC FRAMEWORK FOR THE MANAGEMENT OF INVASIVE PLANTS IN SOUTH AFRICA: CACTACEAE AS AN EXEMPLAR

The rapid increase in the scale and complexity of problems associated with invasions calls for new, more strategic management approaches.

Several C·I·B team members collaborated with other members of the South African Cactus Working Group on a paper to develop a blueprint for the strategic management of a group of related invasive plant species, using cacti (family Cactaceae) as a case study (Kaplan *et al*. 2017; *Bothalia* 47(2), a2149. https://doi.org/10.4102/abc. v47i2.2149).

Cacti have had a long history in South Africa of socio-economic benefits, considerable negative environmental and socio-economic impacts, and a wide-range of management interventions. To guide the future management of cactus invasions, a national strategic framework was developed.

The overarching aim of this framework was to reduce the negative impacts of cacti to a point where their benefits significantly outweigh the losses. Four strategic objectives were proposed: 1) all invasive and potentially invasive cactus species should be prevented from entering the country; 2) new incursions of cactus species must be rapidly detected and eradicated; 3) the impacts of invasive cacti must be reduced and contained; and 4) socio-economically useful cacti (both invasive and non-invasive species) must be utilized sustainably to minimize the risk of further negative impacts.

There are currently 35 listed invasive cactus species in the country; 10 species are targeted for eradication and 12 are under partial or complete biological control. For some species (e.g. *O. ficus-indica* or *C. fulgida*), classical biocontrol control has been successful to a degree where species can potentially be removed from national alien and invasive species lists. We discuss approaches for the management of cactus species, their introduction and spread pathways and spatial prioritization of control efforts.

A thorough understanding of context-specific invasion processes and stakeholder support are needed when implementing strategies for a group of invasive species (Fig. 18). Insights from the strategic framework developed for Cactaceae will be helpful when developing frameworks for other plant groups.

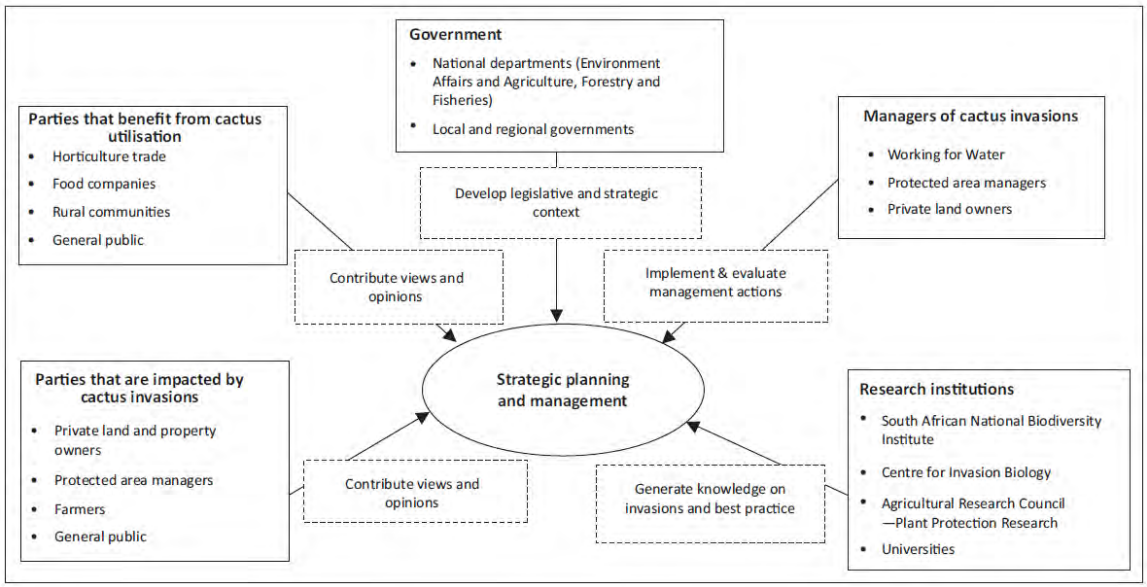


Figure 18. Stakeholder groups and their representative organisations involved in strategic planning and management of cactus invasions in South Africa (From: Kaplan et al. 2017; *Bothalia* 47(2): a2149. https://doi.org/10.4102/abc. v47i2.2149).

1.2.5 Global environmental change and ecosystem services

CONNECTING ECOSYSTEM SERVICES, DISSERVICES AND PLANT INVASIONS

Ecosystem services are the benefits to human wellbeing that result from the flows of energy, matter and information in ecosystems (e.g., drinking water, carbon sequestration, knowledge production). The outputs of ecosystems can also bring unpleasant, unwanted or harmful effects to human wellbeing (e.g., pollen allergies, plant roots damaging infrastructures, animal attacks to humans). These direct perceived or actual negative impacts on human wellbeing are termed ecosystem disservices.

The C·I·B was involved in the development of a new scheme for the classification of ecosystem disservices and a framework for integrating ecosystem services and ecosystem disservices for human wellbeing linked to ecosystem functioning with special reference to plant invasions (Fig. 19) (Vaz *et al*. 2017; *Ecosystem Services* 23: 94-107).

C·I·B-affiliated researchers David Richardson (C·I·B Core Team Member) and Christoph Kueffer (C·I·B research associate based at ETH Zurich, Switzerland), and researchers from several other institutions joined efforts to review examples from plant invasions worldwide in order to deal with current conceptual gaps underlying the ecosystem service-disservice dichotomy. They focussed on the value of ecosystem attributes and functions, the perception of the societal context on ecosystem benefits or nuisances, and the role of human management as a driver of ecosystem values.

The study suggests that ecosystem services and disservices can be valued through three main components: the ecological realm, the social realm, and the social-ecological interface. This account is based on three main assumptions: (1) the group of attributes and functions in a given ecosystem

(ecological realm) are intrinsically value-free; (2) the benefits or nuisances derived from ecosystems are, however, dependent on value attribution from individuals, groups of individuals and societies (social realm); and (3) because of the influence of human actions, services and disservices should not be perceived as static entities in dynamic ecosystems (social-ecological interface).

The authors propose the adoption of a management hierarchy as a useful tool for achieving the goal of sustainability, accounting for social and technological mechanisms to prevent, reduce or restore desirable levels of services, and to minimise the risk of or exposure to disservices.

For plant invasions, the authors emphasise that the invaders may provide benefits or nuisances in the social realm, without necessarily being considered beneficial or detrimental assets in the ecological realm. This is because people will value invasions differently, depending on available management options and on the capacity to use services or mitigate disservices provided by them, at certain cultural, geographical and temporal contexts.

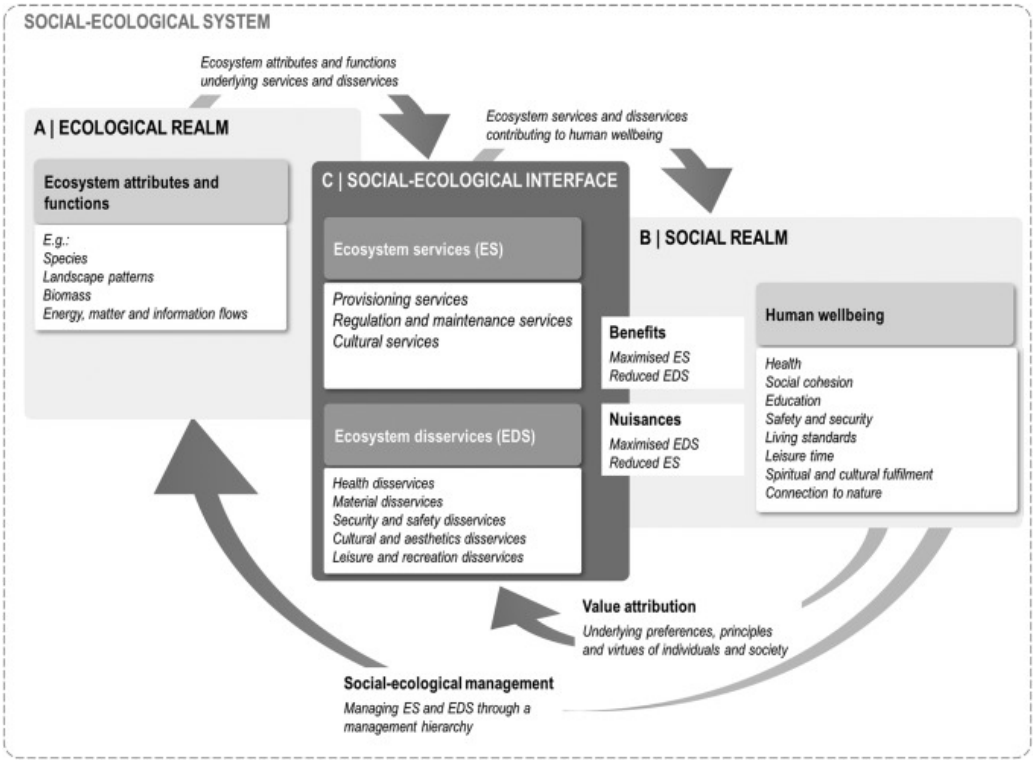


Figure 19. The framework proposed for addressing both ecosystem services (ES) and disservices (EDS), considering: (A) the ecological realm; (B) the social realm; and (C) the social-ecological interface. The framework assumes that the attribution of ES-EDS depends also on value attribution and social-ecological management (From: Vaz *et al*. 2017; *Ecosyst. Serv*. 23: 94-107).

'...we do not suggest that the benefits of ecosystems or biodiversity for human wellbeing should receive less attention or that nature conservation should be negotiated to justify unsustainable interventions on nuisances', says Ana Sofia Vaz, lead author of the paper. 'Rather, we hope that our approach helps the understanding of the valuing of ecosystem functioning, thereby expanding the

repertoire of actions to protect and sustainably manage invasions and the (dis-)services they provide'.

PROTECTED AREAS DEFEND WILDLIFE FROM INVASIVE ALIEN SPECIES

Nature reserves, national parks and marine protected areas have been proven to effectively shield native wildlife from the impacts of invasive species, according to a recent study by a team of international researchers, including C·I·B Associate Petr Pyšek. The research shows that despite their effectiveness, protected areas could be in danger in future, as climate change impacts the geographic distributions of increasing numbers of species (Gallardo *et al*. 2017; *Global Change Biology* 23: 5331–5343).

Invasive alien species often thrive at the expense of native wildlife. Until now, however, conservationists have lacked evidence of the role of protected areas area in mitigating against the threats of these species, such as competition for food, predation and diseases.

The team evaluated the current and future distributions of 100 of the most invasive terrestrial, freshwater and marine species in Europe. The team also assessed the threat that these animals pose to existing protected areas, when combined with the issue of climate change.

Results showed that only a quarter of the European protected areas established in the last century have so far been colonised by invasive alien species, even in cases where the conditions inside the protected areas was favourable for them. Fewer invasive alien species were found in protected areas with low levels of human activity, underlining the role played by humans in either deliberately or unintentionally helping the movement of invasive alien species.

However, the team warned that climate change has the potential to not only drive vulnerable species out of the current protected areas, but also to allow invasive species to colonise these areas more effectively, further increasing the pressure on native wildlife (Fig. 20). Alien species predicted to be particularly favoured by climate change include knotgrass (*Paspalum paspalodes*), the coypu (*Myocastor coypu*), the tree of heaven (*Ailanthus altissima*), and the American bullfrog (*Lithobates catesbeianus*), all of which were predicted to show a 20% expansion in range.

C·I·B Associate Pyšek says: 'We knew from previous research, including work done at the C·I·B, that protected areas provide an effective barrier against colonization by alien species. However, this study is the first assessment across multiple taxonomic groups of the resistance that such areas provide against biological invasions on a continental scale. This provides important further justification for safeguarding native biodiversity.'

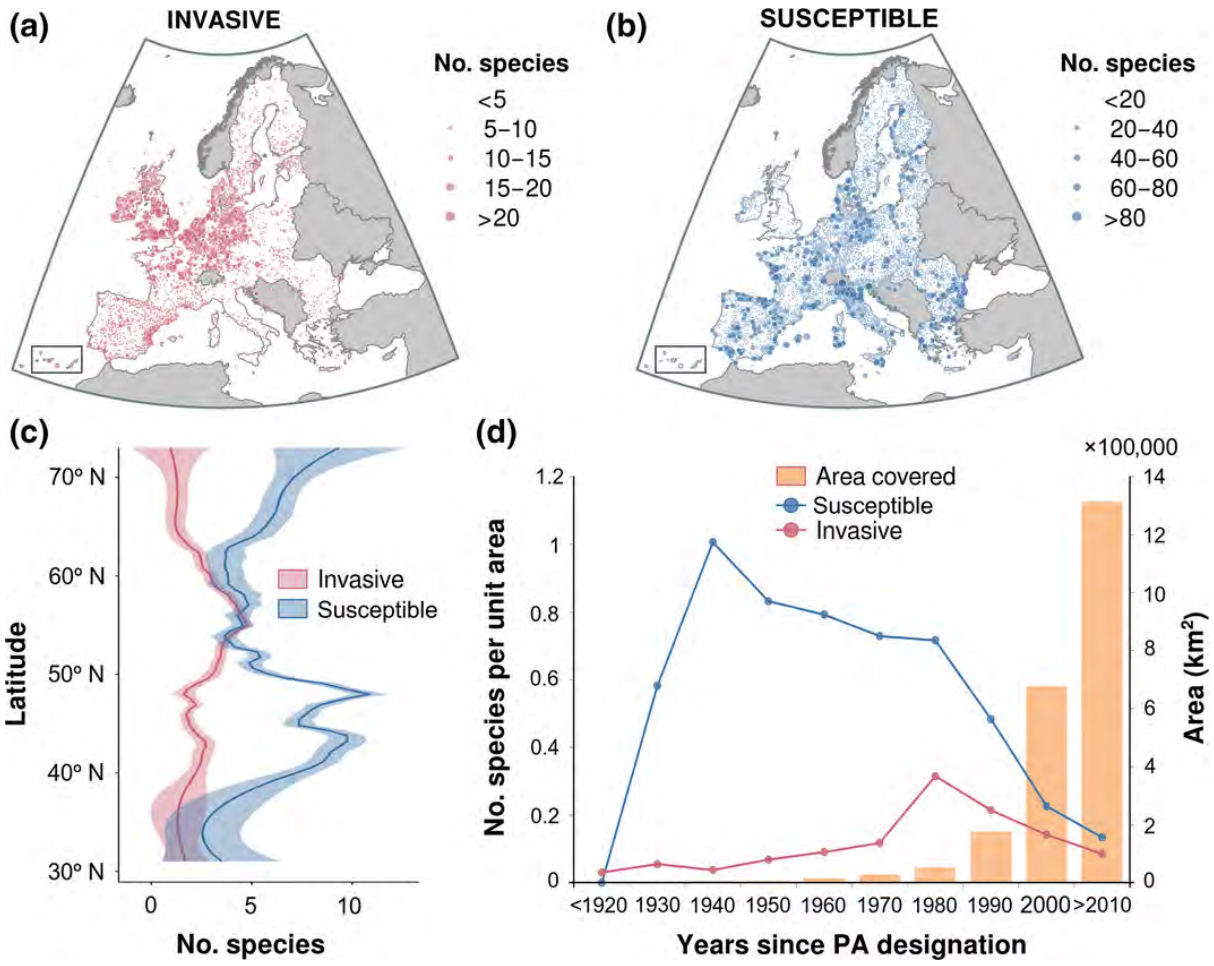


Figure 20. Spatial patterns of invasive and susceptible species within protected areas (PAs) in Europe. The size of bubbles represents the number of invasive (a) and susceptible (b) species currently known to occur in any of the 12,928 inland and 2,220 marine PAs evaluated (total N = 15,148) (From: Gallardo *et al*. 2017; *Global Change Biol*. 23: 5331–5343).

1.2.6 Human dimensions

CHALLENGES OF MANAGING PLANT INVASIONS ON PRIVATE LAND

In many parts of the world, privately-owned land provides a major challenge for regional and national strategies for dealing with biological invasions. This is because different land owners have different priorities, based on cultural factors, land-use priorities, and because policies and legislation relating to invasive species management is difficult to apply across multiple land-tenure systems.

Privately owned land provides major challenges for managers of plant invasions in the Cape Floristic Region where large-scale government-funded management initiatives are underway to reduce the extent of invasions in this region. Among the many challenges are the huge spatial extent of the invasions and difficulties in coordinating management efforts across large areas of invaded land in private ownership. Very little information is available on the success of privately-funded alien plant control initiatives.

A study by C·I·B MSc student Jacques van Rensburg investigated the emergence of problems with plant invasions in a privately owned farm in the Western Cape (van Rensburg *et al*. 2017; *South African Geographical Journal* doi: 10.1080/03736245.2017.1340187), and the effectiveness of efforts to reduce alien plant cover, the challenges faced, and the costs associated with long-term clearing operations on this farm (van Rensburg *et al*. 2017; *Transactions of the Royal Society of South Africa* 72: 207-216). The research focussed on Vergelegen Wine Estate in Somerset West.

The study showed that the cover of dense invasive plant stands declined by 70% over 10 years since management operations began, but that operations cost 3.6 times more than was originally estimated (ZAR 43.6 million vs 12.2 million respectively) (Fig. 21).

The challenges associated with managing invasive alien plants on private land are very similar to those faced on state-owned land, with the efficiency of management being constrained by multiple interacting environmental and socio-economic factors. However, success in managing invasive alien plants can be achieved by adhering to basic principles, including careful planning with clear achievable goals in mind, a commitment to stable long-term funding, and regular monitoring.

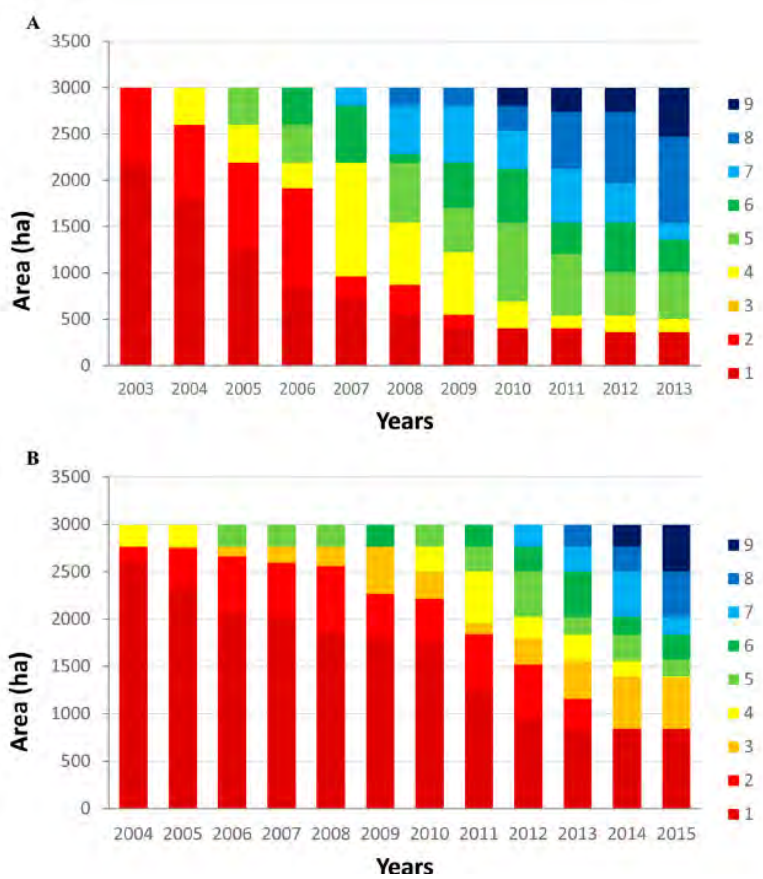


Figure 21. The planned and actual project flow through nine implemented management phases over 12 years at Vergelegen Wine Estate in the Western Cape. (A) The planned project flow from 2003 to 2013. (B) The actual management phases achieved between 2004 and 2015 (From: van Rensburg *et al*. 2017; *Trans. Royal Soc. S. Afr*. 72: 207-216).

Most private land owners cannot afford the substantial investment of resources that would be required to clear large stands of IAPs and to ensure that cleared areas are maintained to prevent re-invasion, and finding ways to fund this remains a major challenge.

PROGRESS TOWARDS GLOBAL NETWORKS IN INVASION SCIENCE

An international team, including several C·I·B researchers, including David Richardson (C·I·B Director), Petr Pyšek (C·I·B research associate) and Susan Canavan (C·I·B PhD student), developed a framework for the establishment of global networks between researchers, policymakers, and practitioners in invasion science (Fig. 22) (Packer *et al*. 2017; *Biological Invasions* 19: 1081–1096).

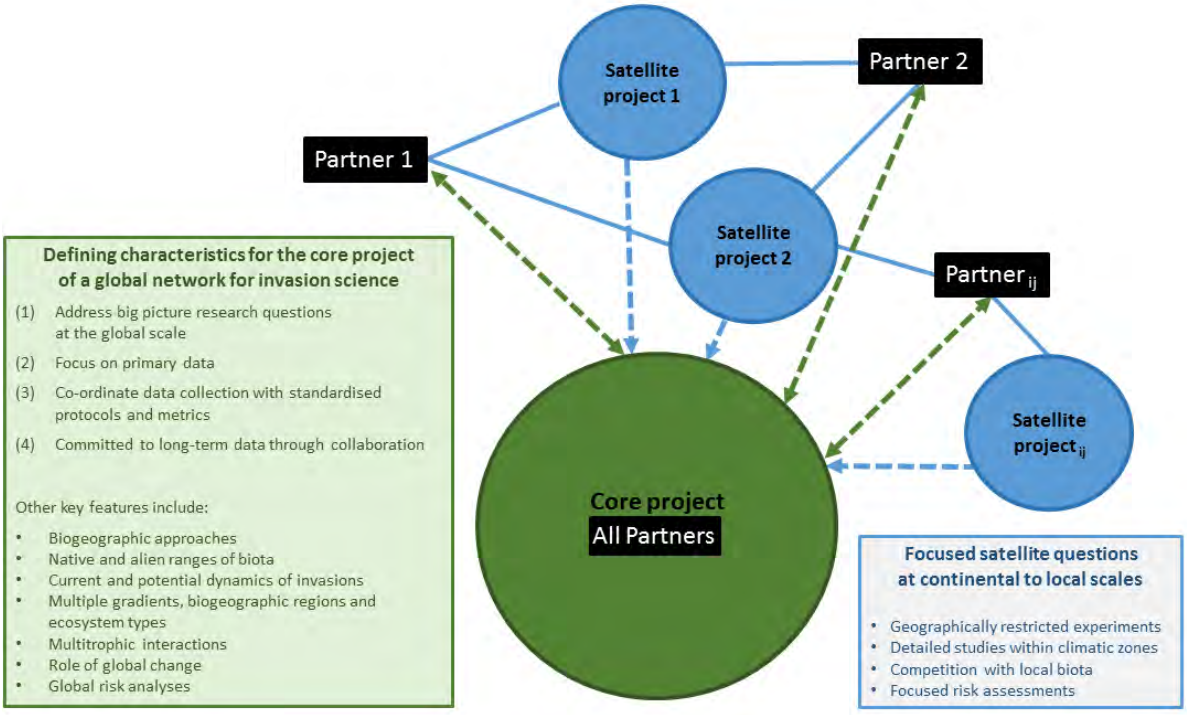


Figure 22. Structure of the proposed global network on invasive species: The core project (in green) involves all partners and addresses big-picture research questions at the global scale through: collection of primary data; use of standardized protocols and metrics; and commitment to long-term global data. Knowledge, and iterative global research questions, are generated by the core project and are exchanged (green arrows) with all partners through mutual dialogue. Satellite projects (in blue) that are performed by individual partners, or among partners, focus on questions that are biogeographically restricted to certain partner contexts or priorities (e.g., the competition of the focal taxa with a locally present congener, or addressing the effect of Mediterranean climates only). Satellite projects contribute (blue line) to the overall knowledge base within the core project; these inform the iteration of hypotheses and questions, some of which are addressed by other satellite projects (From: Packer *et al*. 2017; *Biol. Invasions* 19: 1081–1096).

One way to move towards studies that embrace a broader geographical context is through global networks. Global networks can provide better infrastructure for studies attempting to answer big-picture questions, especially those that address biogeographic questions. For example, trying to

understand the influence of climate-change, post-invasion adaption and evolution, environmentally influenced genetic traits, or species interactions associated with invasions, would all benefit greatly from this approach.

The authors suggest that a 'global network' should cover gradients (latitudinal and longitudinal from natural to human-dominated ecosystems) with nodes (partners and sites) spanning biogeographic zones over both hemispheres, and include at least three continents.

The paper also provides practical discussions surrounding the collection of data, coordination between researchers, development of protocols, and time-frames for long-term data collection.

'The formation of global networks offers a valuable tool to help study and understand biological invasions, which would otherwise be a challenge for research groups who often work in isolation,' said co-author Canavan. 'Global networks provide a collective capacity to better understand, predict and manage facets of biological invasions across multiple localities and geographic scales.'

TRADITIONAL MEDICINE MARKETS ARE NOT SAFE FROM INVADERS

Traditional medicine in South Africa is an amalgam of older local practices and a little, recent, 'spice' thrown in. The arrival of Indian labourers during the 19th century brought medical practices from the Indian subcontinent into South Africa. Many of these have been adopted to some extent by local medicinal practitioners. The results of this fusion can be seen in the modern *umuthi* trade where several alien plant species are sold in informal markets and *umuthi* shops in large urban centres.

C·I·B Core Team Member Marcus Byrne, along with University of the Witwatersrand's traditional medicine expert Vivienne Williams and student Ewa Wojtasik explored the viability of alien plants utilised in the South African umuthi trade (Byrne *et al*. 2017; *South African Journal of Botany* 109: 281-287). Because plants in the traditional medicine trade are often alien to South Africa the authors examined the viability of plant material sold at major markets in both Johannesburg and Durban (Table 2).

They discovered a total of 42 alien plants that are being traded as traditional medicine. Of these, 26 species were traded in the form of material with the potential to propagate (seeds, bulbs, tubers and live stems with roots). Twenty two of these species were found to be viable and capable of establishing new plants. Furthermore, seven of these plants are currently listed on the National Environmental Management: Biodiversity Act, which prohibits the trade of these species.

In many respects the umuthi trade mirrors the horticultural plant trade, in which a few hardy species are favoured simply because they are dependable; endure transport and storage to grow when correctly triggered. Whether the umuthi plants will escape from these markets remains to be seen. However, the elements of trade, including the large numbers of individuals involved, repeated

importations, transportation throughout the country, and persistence in the marketplace, all enhance the chances of plants establishing in new habitats.

Table 2. The identity and nature of invasive alien species sold for traditional medicine at retail outlets in South Africa and their viability as propagules. Only species sold as parts that have potential as propagules are listed. Viability was tested by germination of seeds and or a tetrazolium test, or by growth of vegetative parts such as tubers or rhizomes. Species in bold appear on the National Environmental Management: Biodiversity Act (NEMBA), National List of Invasive Species NEMBA. NEMBA and SUSPECT (Species under Surveillance – Possible Eradication or Containment Targets) status are given (From: Byrne *et al*. 2017; *S. Afr. J. Bot*. 109: 281-287).

Species name Unidentified species' vernacular names in inverted commas	Plant part	Viability test type and results				Species with viable propagules (a + b)	Sold in umuthi markets	Sold in umuthi shops	NEMBA category	Suspect status	Previously recorded in literature
		Germinated or grown (a)		Tetrazolium test (b)							
		Planted	% viable	Tested	% viable						
Acorus calamus	Rhizome	5	0	–	–	*	*				
Anacardium occidentale	Seeds	7	43	7	86	*		*		On list	
Anredera cordifolia	Tuber	5	100	–	–	*	*		1b		1
Brassica sp.	Seeds	20	90	20	80	*		*			
Bryophyllum delagoense	Stem	Live	100	–	–	*	*		1b		
Coix lacryma-jobi	Seeds	20	0	13	62	*	*	*			
Coriandrum sativum	Seeds	–	–	20	75	*		*			
Curcuma longa	Roots	10	0	–	–			*			
Eleutherine bulbosa	Bulb	5	60	–	–	*	*				
Foeniculum vulgare	Seeds	20	5	20	70	*	*	*		On list	
Hedychium gardnerianum	Rhizome	2	100	–	–	*	*		1b		
Helicteres isora	Fruit	>120*	0	20	10	*	*	*			
Macadamia sp.	Nut	–	–	11	100	*	*				
Opuntia ficus-indica	Cladode	Live	100	–	–	*	*		1b		1,3
Opuntia robusta	Cladode	Live	100	–	–	*	*		1b		
Pedilanthus tithymaloides	Stem	3	100	–	–	*	*				
Ricinus communis	Seeds	20	35	20	65	*	*	*	2		1,2,3
Sansevieria cylindrica	Stem	Live	100	–	–	*	*				
Sansevieria fasciata	Stem	Live	100	–	–	*	*				
Senna alexandrina	Seeds	20	50	44	16	*		*			
***Senna* sp.**	Seeds	20	40	–	–	*		*	All 1b		3
Terminalia chebula	Seeds	30	0	19	0			*			
Unidentified: 'inderjow'	Seeds	20	0	20	5	*		*			
Unidentified: 'Indian pearls'	Seeds	20	0	20	0			*			
Unidentified: 'kamal kachi'	Seeds	20	0	9	56	*		*			
Unidentified: 'girmalasing'	Seed pods	20	0	20	0			*			
Species totals	26	19	15	14	11	22	15	15	7	2	

The question thus arises as to what the appropriate response is to a discovery of this nature. Prohibition or regulation is unlikely to be successful in the near future, given the numerous pressures on borders and their control. However, voluntary regulation has proven very successful in halting the sale of invasive alien plants in the South African horticultural industry. Public education, especially through schools, is likely to be a useful tool for raising awareness of these plants, particularly because invasive species feature in the curriculum of grade-11 learners. Clearly, further engagement with stakeholders is called for.

'More scientific research is needed to determine the exact importation routes and quantities of plant parts being traded as umuthi', says Byrne. He adds 'informal markets arising from newer immigrant groups, such as the Chinese, who moved into Africa more recently, should not be overlooked. Ultimately, assessments of alien plant movements within these channels will also indicate the extent of this practice, allowing us to decide how much of a problem this ancient human behaviour really is.'

2 Education and training

2.1 Objectives

Our research takes place mainly through post-graduate and emerging researcher (post-doc) training. It is thus crucial that the Education and Training Key Performance Area incorporates excellence and equity. Thus, the C·I·B aims not only to develop science capacity in South Africa, but also to produce cohorts of graduates who excel and are increasingly representative of South Africa's population.

2.2 Progress

We received 43 applications for bursaries and post-doctoral fellowships in 2017. Of these, 20 were accepted for some level of funding. Together with our existing students and post-docs who were continuing their work from 2016 and earlier, this made up a total of 71 students and 13 post-docs supported in 2017. In 2017, 46% of C·I·B students (excluding post-docs) were black and 70% were female. Many students and most post-docs brought their own independent funding with them, demonstrating the power of the DST-NRF grant in leveraging other funding for the Centre

2.2.1 Equity

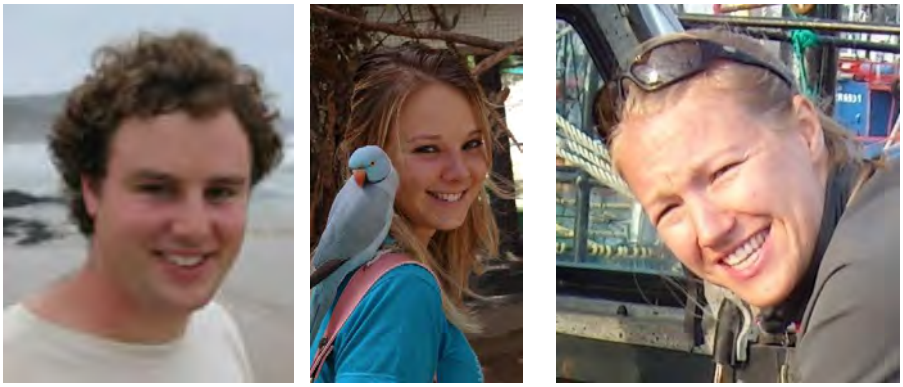
Our criteria for student and post-doc support are:

- 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 (especially WfW, SANBI and conservation agencies)
- Synergies and co-funding with SANBI and SARChI Chair bursary schemes
- Spread among C·I·B Core Team Members, universities and freshwater, marine and terrestrial environments
- History of C·I·B Core Team Member productivity.

The C·I·B core management team also considers student and post-doc applications in the context of the support structures within a research group and provides advice and support to Core Team Members on how matters can be arranged to support students and to help ensure their success. In turn, Core Team Members are expected to solicit applications from good students, to take on these students for training, to create an inclusive and well-supported post-graduate student training environment and to provide additional mentorship where necessary. No students are funded unless the C·I·B management is satisfied that appropriate supervisors, facilities, and mentoring opportunities exist.

2.2.2 Doctoral graduates in 2017

Six C·I·B students completed their PhDs during 2017 and graduated or will do so early in 2018.



Left to right: Stuart Hall, PhD graduate, Stellenbosch University; Genevieve Diedericks, PhD graduate, Stellenbosch University; Clova Jurk-Mabin, PhD graduate, Stellenbosch University

Savannah Nuwagaba, PhD graduate, Stellenbosch University; Koebraa Peters, PhD graduate, Stellenbosch University; Saachi Sadchatheeswaran, PhD graduate, University of Cape Town.

2.2.3 Awards to students and post-docs

Ingrid Minnaar (PhD candidate, Stellenbosch University) won first prize in **SAASTA's 2016/2017 Young Science Communicator's Competition** for her article on an agricultural pest insect titled 'The harlequin ladybird: The bad side of a cute beetle'. The second prize was awarded to another C·I·B student, Marike Louw (MSc candidate, Stellenbosch University) for her article on acoustic monitoring of a group of extremely cryptic frogs, the moss frogs (genus *Arthroleptella*) called 'Listen up! Eaves-dropping on Cape Peninsula endemics'.

Ingrid Minnaar also won Young Entomologist of the year at the **Symposium on the Management of Biological Invasions in South Africa** held as part of the Combined Congress of the Entomological and Zoological Societies of Southern Africa held at the CSIR International Convention Centre Pretoria, South Africa. CSIR, Pretoria 3-7 July 2017. At the same meeting, Blair Cowie (PhD candidate, Wits University) won the award for best student presentation in the PhD category for his talk on the highly effective biocontrol agent, Parthenium beetle: 'A dirty agent: photosynthetic response of

Parthenium hysterophorus to defoliation by the leaf-feeding beetle *Zygogramma bicolorata*'. Mr Cowie also won awards for his poster and talk at the University of the Witwatersrand's Cross Faculty Graduate Symposium (25-26 October 2017).

The **C·I·B student travel awards** were presented to the masters and doctoral student who presented the best speed talk of the conference. the winners received an award of R30 000 to spend on travel to a conference, course or lab visit. The winners were:

- **PhD:** Lubabalo Mofu, Rhodes University/SAIAB (supervisor: Olaf Weyl); runner up: Dianah Kutama, Stellenbosch University (supervisor: Susana Clusella-Trullas)
- **Masters:** Natasha Kruger, Stellenbosch University (supervisor: John Measey); runners up: Mmatsawela Ramahlo, University of Pretoria (supervisor: Chris Chimimba) and Sophia Turner, Stellenbosch University (supervisor: Karen Esler).

Marike Louw used her award from the 2016 Annual Research Meeting to present a poster at the *Ecology Across Borders* meeting in Ghent, Belgium, during December 2017. She then travelled to St. Andrews University, Scotland, where she presented her MSc work at the Centre for Research into Ecological & Environmental Modelling (CREEM) and discussed her analyses with Prof. David Borchers. Marike also won the best student speaker award at the 2017 Fynbos Forum.

Catherine Vise facilitated two meetings of the Vhembe Biosphere Reserve Invasive Species Network during 2017, and also presented the results of her surveys at the C·I·B ARM and the VBR Invasive Species/Greater Mapungubwe Network meeting. Ms Vise is collaborating with SANParks through the Greater Kruger Management Plan, where she is now on a Task Team through which she has set up a Levhuvhu River IAP Task Team that includes both SANParks and Government stakeholders.

2.2.4 Student support workshops

Another new initiative in 2017 was a set of interactive self-development workshops presented for students and post-docs in two centres (students from other universities could travel at their own cost to attend). The workshops were a response to the observations that students' performance is sometimes hampered by challenges that are not purely academic. These challenges create anxiety and stress which limit the students' performance ability. The Up Your Game interactive small group sessions aimed at equipping students and post-docs with pro-active coping skills and abilities to manage themselves better within the different spheres of life. The aim is that this will enhance the students' abilities to perform well within their academic endeavours and beyond. The workshops included the following themes:

- Motivation, Strengths, Resilience, Goals
- Lifestyle & Performance
- Winning habits – Relationship with money, Relationship with time
- Winning habits – Raise the performance bar, Time suckers & solutions
- Communication

- Life strains – Managing stress, anxiety, depression

Altogether, 22 students and post-docs attended the sessions in Pretoria and Stellenbosch.

Figure 23. Students who attended the 'Up Your Game' workshop in Pretoria in June 2017.

Using the overwhelmingly positive and constructive feedback from the 2017 workshops, this initiative has been developed into an integrated Student Support Programme starting in 2018. The expanded programme will consist of an 'On Boarding Camp' for new students and post-docs to be held in the Western Cape in February (with student travel costs supported by the centre), a mid-year workshop for established and new students, and ongoing 'Touching Base' interactions through the year for C·I·B students and post-docs across the country. All interactions are confidential and are voluntary on the part of the students and post-docs.

2.2.5 Science communication workshops

In 2017 we initiated our 'Bridging the Gap' science communication workshops funded through our NRMP collaborative training project. Two workshops were hosted in Stellenbosch and Pretoria for students and post-docs. The workshops were facilitated by Jive Media (Robert Inglis and his team), and entailed training in public speaking and popular writing. Twenty-seven C·I·B members from honours to post-doctoral level attended the hands-on practical workshops. Feedback from the participants was good. One commented: 'Wow, I learnt so much, I feel like I have undergone a paradigm shift in terms of communicating my science effectively. Thank you very much'. We hope to continue the workshops annually in collaboration with NRMP.

Figure 24. Participants in the science communication workshop held in Stellenbosch.

2.2.6 Under-graduate training initiatives

Invasion Ecology third year course (Stellenbosch University)

The C·I·B team at Stellenbosch University presents a third-year undergraduate course in invasion ecology, which covers key aspects of invasions, including transport vectors and pathways, propagules, evolution of invaders, trends in numbers of invaders, disturbance, modelling the geographical spread of invasive species, establishment success: the influence of biotic interactions, ecological processes and the spread of alien species, impacts of invasive species and management is invasions. Lectures were given by Jaco Le Roux, David Richardson, John Measey and Florencia Yannelli (C·I·B post-doc). The students also toured the quarantine facilities at the ARC-PPRI biological control research facility, saw examples of biocontrol and interacted with biocontrol experts. As part of their practical training, students were expected to execute a research project in groups of 4 to 5 students. Their research findings were then written up as a final report in manuscript format. Forty-eight students enrolled for the course in 2017.

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

Table 3. The current whereabouts of a selection of our recent graduates (2013-2017)

Name	Level completed	Institution	Current affiliation	Sector
Coetzee, Bernard	PhD	UP & SU	African Ecology & Conservation Semester Program in South Africa, Organisation for Tropical Studies, Kruger NP	NGO
Davies, Andrew	PhD	UP	Post-doc, Global Ecology Labs, Carnegie Science, Washington	Academic / Research
Dredge, Brendon	Masters	SAIAB/Rhodes	Kwandwe Private Game Reserve, Grahamstown	Private sector / consultancy
Ebrahim, Zishan	Masters	SU	Biodiversity Data Scientist, SANParks Cape Research Centre	Government / implementing agencies
Fill, Jennifer	Post-doc	SU	University of Florida, School of Forest Resources & Conservation, Gainesville, USA	Academic / Research
Gaertner, Mirijam	Post-doc	SU	Professor, Nürtingen-Geislingen University, Germany	Academic / Research
Greve, Michelle	Masters	SU	Lecturer, Department of Plant and Soil Sciences, UP	Academic / Research
Janion-Scheepers, Charlene	Post-doc	SU	PDP post-doc, Iziko Museums of SA, Cape Town	Government / implementing agencies
Le Roux, Pete	Post-doc	SU	Lecturer, Department of Plant and Soil Sciences, UP	Academic / Research
Lyons, Candice	PhD	SU	Researcher: Biological Control of Invasive Weeds, Plant Protection Research Institute, ARC	Government / implementing agencies
Mokhatla, Mohlamatsane	PhD	SU	SANParks Social Ecology Unit, Garden Route	Government / implementing agencies
Munyai, Caswell	PhD	UniVen	Lecturer, UKZN	Academic / Research
Nunes, Ana	Post-doc	SU	Content editor: Invasive Species Compendium and Pro, CABI, Wallingford, UK	NGO
Rahlao, Sebataolo*	PhD	SU	Director: Biological Invasions, SANBI	Government / implementing agencies
Ruwanza, Sheunesu*	PhD	SU	Lecturer, Dept. Environmental Management, University of Venda	Academic / Research
Strydom, Matthys	PhD	SU	Academic Manager, Academy for Environmental Leadership	Private sector / consultancy
Tererai, Farai	PhD	SU	Deputy Director, Working for Wetlands, DEA-NRMP	Government / implementing agencies
Zengeya, Tsungai*	PhD	UP	Reporting Coordinator, National Status Report, SANBI	Government / implementing agencies

*Appointed as a C·I·B Core Team Member during 2017

2.2.8 Demographic breakdown of students and post-doctoral associates

Table 4. Demographic breakdown of students and post-doctoral associates

	No.	%
All supported students	**71**	**100**
Academic level		
Honours/4th year B. Agric.	11	16
Masters	30	42
PhD	30	42
Gender		
Male	21	30
Female	50	70
Student demographics		
Black	33	46
White	38	54
Funding level		
Full	16	23
Partial	15	21
Independent	40	56
Citizenship		
South African	61	86
Foreign	10	14
Ministerial targets for country of origin:		
South Africa	61	86
SADC	1	1
Rest of Africa	3	4
Rest of World	6	8

	No.	%
All supported post-doctoral associates	**13**	**100**
Gender		
Male	4	31
Female	9	69
Student demographics		
Black	0	
White	13	100
Funding level		
Full	2	15
Partial	1	8
Independent	10	77
Citizenship		
South African	3	23
Foreign	10	77
Ministerial targets for country of origin:		
South Africa	2	15
SADC	0	0
Rest of Africa	0	0
Rest of World	11	85

3 Networking

3.1 Objectives

The C·I·B continues to encourage a variety of approaches to scientific excellence, and facilitate networking among its members and with like-minded individuals and organizations in South Africa and abroad. In consequence, networking forms a critical component of the C·I·B's work. The Visiting Fellows programme will remain an important way to maintain and develop partnerships, particularly in the international sphere.

3.2 Progress

3.2.1 Agreements with partner institutions

Figure 25. Partner organisations of the C·I·B (memoranda of understanding signed) include TNC?

3.2.2 Developing new partnership

The C·I·B is developing a partnership with The Nature Conservancy (Cape Town), which is establishing a water fund to ensure that key catchments are cleared on invasive alien plants which restrict water supply to the large dams that supply the Cape Town metropole. Water funds have been implemented successfully in many countries and this is a very exciting initiative for South Africa.

3.2.3 Interaction with peers

British Ecological Society Bulletin article

The C·I·B was invited to prepare an article on its operations for the British Ecological Society's newsletter, Features section. The C·I·B commissioned freelance journalist Engela Duvenage to write

the article titled 'Science for society at South Africa's Centre for Invasion Biology'. The resulting eight-page spread was published in July issue of the Bulletin and included views and experiences from several students, Core Team Members and partners, as well as the Iimbovane outreach project, showing how capacity building, collaboration and networking have contributed to the C·I·B's success.

Fellowship Programme

Only one visiting fellow was appointed in 2017, **Dr Philipp Lehmann** (Stockholm University, Sweden), who will visit early in 2018. After several very busy years hosting fellows, we focused on consolidating the outcomes of past fellowships. Several papers were published from **Prof. James Vonesh's** very successful Fulbright fellowship in 2015 and 2016.

Llewellyn Foxcroft worked with C·I·B fellow **Prof. Paul Downey** (2015, University of Canberra, Institute for Applied Ecology) to update the dataset created during Downey's visit, and draft a manuscript on *assessing and refining the use of strategic adaptive management for invasive species management in SANParks* (Foxcroft).

Visiting research fellow **Prof. Sven Bacher** (2016) prepared a manuscript on the Socio-Economic Impact Classification for Alien Taxa with Core Team Member Sabrina Kumschick, which was accepted for publication in the journal *Methods in Ecology and Evolution*. Kumschick is co-supervising Lara Volery, one of Bacher's PhD students, on a project dealing with impact assessment for alien mammals. Prof. Bacher invited Dr Kumschick to present a keynote talk at a workshop on 'Biological Invasions – Challenges for Science and Society in September 2017. Prof. Bacher and Dr Kumschick co-authored a paper on the worst European invaders that has been accepted for publication in the journal *Biological Invasions*. Core Team Member John Wilson also worked with Prof. Bacher on Socio-Economic Impact of Alien Taxa Classification Scheme. Prof. Bacher is working with PhD student Mlungele Nsikani and Core Team Member Brian van Wilgen on a paper addressing re-establishment of proteas after acacia invasions.

John Wilson worked with **Dr Bethany Bradley** (2016) on a project looking at how introduction dynamics versus human-mediated dispersal versus natural spread might be seen in broad-scale distribution patterns. Following Bethany Bradley's visit to South Africa, she has started a project on assessing alien plants with EICAT in collaboration with Sabrina Kumschick.

Brian van Wilgen continues work on several papers initiated as a result of **Dr Arne Witt's** fellowship here in May 2016 (Witt is with CABI, Nairobi). Marcus Byrne met with C·I·B fellow Arne Witt to discuss biocontrol of *Opuntia engelmannii* in Kenya. CABI has since contracted the University of the Witwatersrand, and Marcus Byrne's research group will screen biocontrol agents of *O. engelmannii* for use in Kenya and South Africa.

Jaco Le Roux worked on a review/synthesis paper with C·I·B fellow **Prof. Scott Carroll** (2016), that is in an advanced stage and should be ready for submission in 2018.

4 Information brokerage

4.1 Objectives

Information brokerage will continue to be a core component of the C·I·B's business. The Iimbovane Outreach Project is the primary outreach and community interaction activity undertaken by the C·I·B, but we have a range of other outreach and science communication activities. Further information brokerage takes place via the dissemination of knowledge through primary scientific literature, the hosting of scientific meetings, scientific books, popular publications, print media, radio and television, and web resources. The C·I·B will continue to make use of the full range of information brokerage mechanisms at its disposal, recognizing that as an essential part of the knowledge economy, it must serve society at a broad range of levels.

4.2 Progress

4.2.1 Workshops hosted

Invasion syndromes – moving towards generalizations in invasion science

In November 2017 the C·I·B 2017 hosted an international workshop on 'Invasion syndromes – moving towards generalizations in invasion science'. The workshop was coordinated by former C·I·B post-doc Ana Novoa. Its main aim was to discuss the advantages and disadvantages of focusing on functional or taxonomic groups when studying biological invasions from theoretical and practical points of view. The workshop was attended by 29 researchers from 7 countries other than SA. The C·I·'s annual workshops held in the same week as the C·I·B Annual Research Meeting have become an important entry on the calendar for invasion researchers around the world.

4.2.2 Joint SACEMA-CIB Workshop: Practical integration of invasion biology and epidemiology

The workshop was coordinated by Nick Ogden (visiting fellow at SACEMA from the National Microbiology Laboratory, Public Health Agency of Canada), Sabrina Kumschick and Juliet Pulliam (Director, SACEMA). Participants spent three days discussing the parallels between epidemiology (specifically emerging infectious diseases) and biological invasions. A review paper is being produced as an outcome of the workshop.

4.2.3 Popular article series in The Conversation Africa

The C·I·B published a series of five articles in the online magazine *The Conversation* (https://theconversation.com/africa/topics/invasive-species-series-39958) co-ordinated by Core Team Members John Measey and Sarah Davies. The articles summarised publications from the special issue of the journal *Bothalia: African Biodiversity and Conservation* and the C·I·B's work in support of the National Status Report on Biological Invasions in South Africa. These articles created considerable interest from the public who engaged by leaving comments at the end of the text. Explaining why South Africa should keep out the worst invasive species, newly appointed C·I·B Core Team Member Tsungai Zengeya expanded on the different ways that invasive species are known to impact South Africans, and how to prioritise action to deal with them. This article in particular

resulted in robust discussions on and off the website which helped to inform members of the public and policy makers alike.

4.2.4 C·I·B podcast series

In 2016 we initiated, under leadership of senior researcher John Measey, a podcast series focusing on our research outputs and showcasing two or more researchers talking about their research. In 2017 a podcast on biological invasions research was published following the Annual Research Meeting (available on Sound Cloud: https://soundcloud.com/user-374791551)

4.2.5 Team events

Annual Research Meeting

The C·I·B's Annual Research Meeting was attended by about 150 people, including almost all of the Centre's Core Team, associates, staff, students, post-docs, our International Science Advisers and many representatives from our partner organizations. C·I·B Director opened the meeting with a review of achievement of the Centre for the year. Keynote lectures were presented by Dr Sebataolo Rahlao (Director, Biological Invasions, South African National Biodiversity Institute), Ms Becky Cudmore (Manager, Asian Carp Program, Fisheries and Oceans Canada) and Dr Jane Catford (University of Southampton, UK). Dr Rahlao provided an overview of the recently completed national status report on biological invasions in South Africa. Ms Cudmore gave a fascinating account of her involvement in the implementation of the large programme that is underway to manage Asian Carp in the Canadian Great Lakes. Dr Catford's presentation focussed on the challenges in understanding introduced species and their impacts. The rest of the meeting was devoted to presentations by some of the Centre's MSc and PhD, arranged in themed 'Pods' facilitated by post-docs. The aims of the Annual Research Meeting are to showcase the Centre's research and to provide opportunities for interactions among members of the C·I·B team and with our partners.

Table 5: Student presentation session topics at the Annual Research Meeting; sessions were coordinated by C·I·B post-doctoral associates

Topic	Coordinator
Pod 1: The invasion biology toolbox - methods to identify drivers and impacts of invasive species	Dr Heidi Hirsch
Pod 2: From impacts to successful management	Dr Laure Gallien
Pod 3: Managing invasive species: tools for each invasion step	Dr Sanet Hugo
Pod 4: Looking at the nuts and bolts for a mechanistic understanding of invasion success	Dr Wolf Saul
Pod 5: On the trail of alien plants: impacts on flora, fauna and people	Dr Raquel Garcia
Pod 6: 50 shades of green: Analysing the human dimensions of invasion ecology	Dr Florencia Yannelli

Figure 26. Team members, staff and guests and at the Annual Research Meeting held at Stellenbosch University (9-10 November 2017)

The C·I·B international science advisors, Prof. Laura Meyerson (University of Rhode Island, USA) and Dr Piero Genovesi (ISPRA Institute for Environmental Protection and Research, Italy, and Chair of the IUCN SSC Invasive Species Specialist Group), submit a review of the Centre's science programme for the Steering Committee each year. In 2017, the science advisors commented:

> '…The exciting transformative research presented at the annual meeting included both applied and theoretical work by post-doctoral fellows and graduate students (and their advisors) from South Africa and from many other countries around the world… The C·I·B has also worked very hard to provide both personal and professional development opportunities for graduate students and post-doctoral fellows. Based on the quality of the research that we witnessed during the ARM meeting, it is readily apparent that they are succeeding in producing high quality and well-trained invasion biologists in South Africa and beyond that are poised to become global leaders…In addition to research and training, a particularly important aspect of the work that C·I·B does is information brokerage and outreach both with the public and with other centers of excellence in South Africa. This work with public stakeholders and researchers from other disciplines is critical and will promises to facilitate breakthroughs in both management and research…The C·I·B has is leading the world in the field of invasion biology and to interrupt the impressive momentum that the C·I·B has achieved would significantly reduce the leverage of the investments to date.'

Mid-year Core Team get together

The 2017 mid-year Core Team meeting was held in Pretoria during the ESSA & ZSSA combined conference (3-7 July 2017). Although several Core Team Members were not able to attend, three of the new Core Team Members, Sebataolo Rahlao (SANBI), Tsungai Zengeya (SANBI) and Thabiso Mokotjomela (ECPTA) were present, and the informal occasion was an important introduction and orientation for them as new members of the team.

4.2.6 Iimbovane Outreach Project

In 2017, the Iimbovane Outreach Project continued working closely with Grade 10 learners and educators of the Western Cape Education Department. The Iimbovane team visited the project's partnership schools three times in the year during which the learners received classroom lessons and assisted with field investigations. Besides the school-based events, the Iimbovane team also hosted a number of workshops for learners from the partnership schools. The July school holiday saw two 5-day workshops on the Stellenbosch University campus. The workshop taught the attendees about biodiversity in terrestrial and freshwater ecosystems, biodiversity as indicators of environmental health, biodiversity loss and invasive species. Training was made fun and was done through interactive activities and practical investigations whereby learners were involved in sampling, data collection and analysis. A major component of the workshops also included the training in basic computer skills whereby learners used MS PowerPoint and Excel to present their findings. Iimbovane hosted a further series of 1-day workshops for a group of Grade 10 Life Science learners from the Umyezo Wama Apile Combined School (Grabouw), Weltevrede Secondary School and Luhlaza Secondary School. The morning session took the learners to a nearby nature reserve where they learned and applied biodiversity monitoring and sampling techniques. The afternoon session focussed on microscope work whereby learners were expected to use a scientific key to identify the insects collected earlier in the day. These 5-day and 1-day workshops were attended by 152 learners. Feedback from learners attending workshops highlights the value of taking learners for one day away from their environment and by showing them how scientists work in an academic setting.

"*I learn about the different types of species (alien species). I also learn about invasive species. I have also learned the different types of plants in the botanical garden*." (Learner from Emil Weder Secondary School in Genadendal)

"*When we went to the river I got to see animals that I didn't think existed. The water was cold, but it tasted nice. We checked the speed of the river, its length, all things I haven't done before."* (Learner from Emil Weder Secondary School in Genadendal)

"*We walked to the Jan Marais Nature Reserve and did a study on ants under rocks and inside tree stumps. Our group used the vacuum to suck up all the ants etc. Afterwards we went to the lab to identify the species of ants we caught. To see such amazing sights of ants under the microscope was fun*." (Learner from Weltevrede Secondary School in Wellington)

Figure 27. Learners from Luhlaza Secondary School using Peter Slingsby's recent publication 'Ants of Southern Africa' during an Iimbovane workshop.

4.2.7 SciFest Africa

From 11 to 14 March, the Iimbovane team attended SciFest Africa – South Africa's largest national science festival – where they facilitated a series of eight workshops. The workshops, titled 'Awed by Ants' were hands-on and interactive, making it open to visitors of all ages. The Iimbovane team introduced attendees' eyes to the world of ants, teaching them about their importance and ecology, and was happy by the response of the learners, who were all very receptive. "*I want to be an ant-ologist when I grow up*!" exclaimed one enthusiastic boy. This lead to discussions on myrmecology (the study of ants), how to become a myrmecologist and what their job is. The older learners were taught how to use a microscope and to identify an ant by its morphological traits. The younger learners were also taught how to use a microscope, then asked to draw a number of ants provided to them – thus teaching them about ant morphology and taxonomy.

4.2.8 Working with younger learners

The Iimbovane team also expanded their reach by working with groups of younger learners. Eleven intrepid pupils from Touwsrivier Primary School's Science and Maths Club (Touwsrivier) joined Iimbovane for a short workshop on ant diversity and classification. The pupils ranged in age from twelve to fourteen. Learners were introduced to the anatomy of ants and it was explained how scientists used the parts of the ant to classify them into species. The exciting part came when the pupils were shown how to use a microscope. Five distinct ant species were provided. They were given the task of describing them, drawing them and giving them each a name, based on their description of it. At the end of the activity, a group discussion was had on each species, whereby the pupils described their ants to the group and pointed out characteristics unique to each ant species.

Figure 28 (a). The Grade 10 learners form Gerrit du Plessis Secondary School experiencing a touch of taxonomy with Iimbovane, right from their own classroom, using mini microscopes to ID ants.

Figure 28 (b). Act like an ant! Learners pose after a successful workshop introducing the wonderful world of ants, one of the workshops Iimbovane held at SciFest Africa 2017.

4.2.9 Cape Leopard Trust workshop

The Iimbovane Outreach Project also joined forces with the Cape Leopard Trust and hosted a workshop for 14 enthusiastic girls. The girls were given a background to Iimbovane's work, and were taught about the importance of ants in the Fynbos ecosystem.

4.2.10 Take a Girl Child to Work Day

On the 25 May 2017, ten learners from the Luhlaza Secondary School (Kayelitsha) visited the C·I·B and Iimbovane as part of the Cell C Take a Girl Child to Work Day. The day's activities allowed learners to see the variety of roles within an academic institution. They learned a lot about the importance of women in biological sciences and also met women in professions such as post-doctoral students, senior researchers and lecturers, and management staff. The day also included a tour of the campus and the Stellenbosch University library.

4.2.11 Ants of southern Africa – the ant book for all

Peter Slingsby, author of the first ever guidebook on ants of Southern Africa generously donated 50 copies of this guidebook to Iimbovane as a token of appreciation for the project's efforts in raising awareness of biodiversity science. The donation will be used as an educational resource during workshops and field excursions to introduce learners to the full diversity of the species.

Iimbovane was also represented at both local and international conferences in 2017. At the annual Fynbos Forum, Iimbovane Technical Assistant (Outreach) Sophia Turner, commented on pathways to improved biodiversity education, using Iimbovane as a case study. Iimbovane was also represented at the World Environmental Education Congress in Vancouver, Canada. The focus of this presentation was on the effectiveness of a citizen science project, such as Iimbovane, in environmental education.

4.2.12 EnviroKids magazine issue

In 2017, the Iimbovane team together with the Wildlife and Environmental Society of South Africa (WESSA) have put together an issue of the *EnviroKids* magazine, themed 'Understanding alien plants and animals in South Africa'. This issue tackled the history of how invasive alien species arrive from other places and what it means when they invade. The content of EnviroKids support the national curriculum and serve as educational resource for learners, parents and teachers.

Figure 29. The Iimbovane team compiled a full issue of EnviroKids magazine devoted to invasive species

4.2.13 Web-based services

Information Retrieval and Submission System

The CIB's Information Retrieval and Submission System (IRSS) holds 2466 items, including publications and data sets from long- and short-term projects. These are broken down as follows:

- Core Team research outputs [1968]
- Datasets and theses [185]
- Long-term research projects [95]
- Student and post-doc research outputs [218].

The IRSS is accessible to anyone who has registered on the system (open access, D-Space) and is administered in-house by the C·I·B's Database Manager.

Table 6. Social media and web site statistics

<table>
<tr><td>Instrument</td><td>Number of interactions</td></tr>
<tr><td>Information retrieval and submission system (https://ir.sun.ac.za/cib/)</td><td>297 items were submitted to the IRSS during the reporting year</td></tr>
<tr><td>Web page (www.sun.ac.za/cib)</td><td>22 063 unique visitors (up 4% from the previous year)
35 720 unique page views

<table><tr><td>CONTINENT</td><td>VISITS</td></tr><tr><td>Africa</td><td>13 694</td></tr><tr><td>Europe</td><td>2 940</td></tr><tr><td>North America</td><td>2 206</td></tr><tr><td>Asia</td><td>1 181</td></tr><tr><td>Oceania</td><td>977</td></tr><tr><td>Unknown</td><td>592</td></tr><tr><td>South America</td><td>431</td></tr><tr><td>Central America</td><td>42</td></tr></table></td></tr>
<tr><td>C·I·B – Facebook (centreforinvasionbiology)</td><td>878 likes (~followers) in total
55 posts
880 viewers per post (average)

Posts that received the most attention:
10 Feb: The fall armyworm arrives in SA [2697]
24 Feb: CIB members collaborate to build capacity in river rehab monitoring [1951]
8 May: Australian redclaw crayfish quickly spreading in SA and Swaziland [2240]
8 Aug: A novel system for ranking and comparing the impacts of invasive species [1930]
11 Aug: Eucalyptus invasions reduce bird diversity in a riparian habitat [2313]
18 Aug: CIB study finds that Port Jackson invasions impact soil long after removal [2392]
26 Sept: Acacia seed banks can accumulate in the presence of biological control agents [2366]
15 Nov: Being mycorrhizal is important for the persistence and spread of alien plants [2369]</td></tr>
<tr><td>C·I·B – Twitter (@invasionscience)</td><td>2243 total Tweets
113 photos and videos
538 followers (48% Male and 52% Female)</td></tr>
<tr><td>Iimbovane – Facebook (iimbovaneoutreachproject)</td><td>316 page likes
22 posts
10 379 people reached (almost double that of the previous year)

<table><tr><td>Female</td><td>61%</td></tr><tr><td>Male</td><td>39%</td></tr><tr><td>Largest age group</td><td>18-24</td></tr></table></td></tr>
</table>

4.2.14 Media highlights

In 2017, the C·I·B's research was reported on in both local and international media. The complete list of media mentions can be viewed in the Media Interactions section of the report (page A-40); however, there are a few highlights that deserve special mention.

A paper by former C·I·B 4th year (BAgric) student, Alistair Galloway, and Core Team Members, Karen Elser and Mirijam Gaertner, received wide media attention. The study, which was published in the *South African Journal of Botany*, explored the restoration of fynbos after the felling of pine plantations. The paper has led to several articles in the media and featured in *Farmer's Weekly* and *The Times*, and on online news sites including *Science Daily, Times Live* and *SA Forestry*. The research was further publicised through an interview with Galloway on *Radio Sonder Grense* and *Smile FM*.

In 2017, several C·I·B Core Team Members contributed articles to the online news platform *The Conversation Africa* as part of a series on invasive species. C·I·B Core Team Members, John Measey and Sarah Davies' article focussed on the movement of frog species in southern Africa. This was based on their research article published in *Bothalia: African Biodiversity and Conservation*. An article by C·I·B Core Team Member, Sabrina Kumschick, and Reuben Keller, highlighted the importance policy development and monitoring for management of invasions in developing countries. An article by Core Team Member, Susanna Clusella-Trullas, discussed the impact of invasive plants on animal diversity and was based on research published in the scientific journal *Bothalia: African Biodiversity and Conservation*.

A paper by C·I·B Core Team Member, Brian van Wilgen and colleagues, led to a popular science article in *Water Wheel* and an interview with John Maytham on *Cape Talk Radio*. The research, which assessed the invasive alien plant control operations in the Kruger National Park over several decades, was published in the open access journal *Neobiota*.

The C·I·B's involvement in the development of the first national status report on biological invasions in South Africa has led to media exposure. An article discussing the purpose of the report appeared in the popular magazine, *Water Wheel*, and newspaper articles appeared in the *Sunday Weekend Argus* and *Saturday Star*.

In August 2017, the Iimbovane Outreach team collaborated with Wildlife and Environment Society of South Africa (WESSA), to produce a special issue of the *EnviroKids* magazine dedicated to biological invasions in South Africa. The magazine included articles about the history of how aliens arrive from other places and what it means when they invade, highlighting certain examples of plants and animals, to career profiles of current invasion scientists. *EnviroKids* support the national curriculum and serve as educational resource for learners, parents and teachers.

Research published by C·I·B Post doc, Ana Nunes, has led to a comic and a popular article in *Farmers' Weekly*. The research, which investigated the rapid spread of the invasive Australian redclaw crayfish

(*Cherax quadricarinatus*) in South Africa's eastern aquatic ecosystems, was published in the scientific journal *PeerJ*.

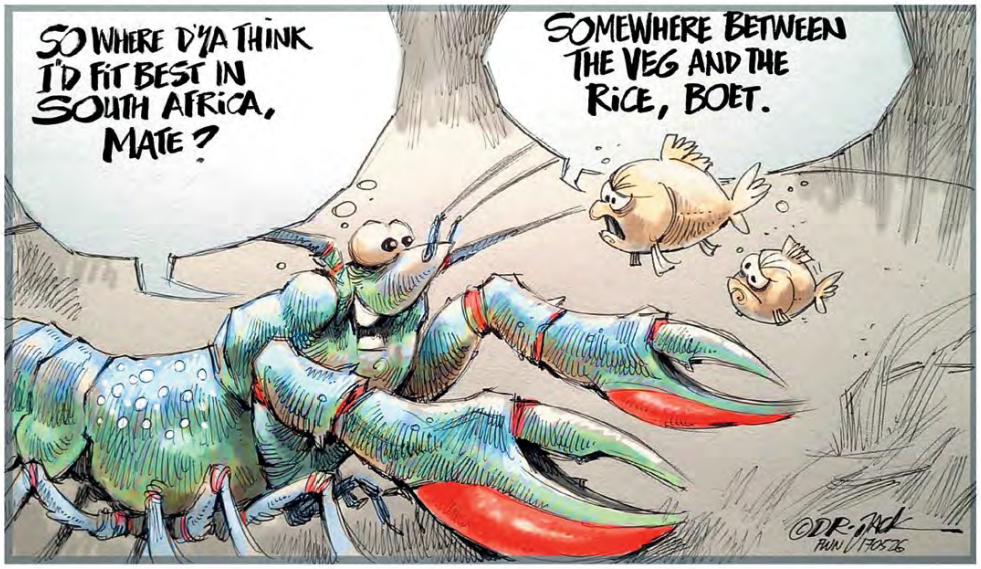


Figure 30. The cartoon, based on the C·I·B's research on the invasive Australian redclaw crayfish (*Cherax quadricarinatus*), that was published in the popular magazine *Farmers' Weekly*.

5 Service provision

5.1 Objectives

The C·I·B strives to be valued for its excellent, evidence-based, reliable, affordable and impartial service and 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.

Many of the Centre's members provide inputs to policy and management guidelines on a regular basis. Several Core Team Members work closely with initiatives of DEA, and in particular their Natural Resource Management Programmes. Our collaboration with SANBI ensures inputs at all levels to SANBI's Invasive Species Programme. Dr Sabrina Kumschick works closely with DEA and SANBI to develop best-practice methods of risk assessment for invasive species.

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 NEMBA). As part of soliciting input, a workshop was held in May 2016 that led to this special issue of 19 papers in the journal *Bothalia: African Biodiversity and Conservation* (published in 2017). The linking of the symposium, journal special issue and status report provided an integrated process towards involving the full range of researchers and implementers in the process.

Papers in the special issue focused on key pathways, taxa, areas, and evaluations of interventions, specifically the movement of taxa between South Africa and neighbouring countries; the dispersal pathways of amphibians; a review of alien animals; a report on changes in the number and abundance of alien plants; in-depth reviews of the status of invasions for cacti, fishes, fungi and grasses; an assessment of the impact of widespread invasive plants on animals; reviews on invasions in municipalities, protected areas and sub-Antarctic Islands; assessments of the efficacy of biological control and other control programmes; and recommendations for how to deal with conflict species, to conduct scientific assessments and to improve risk assessments. These papers confirm that South Africa is an excellent place to study invasions that can provide insights for understanding and managing invasions in other countries (Wilson *et al*. 2017; Bothalia 47, a2207, DOI: 10.4102/abc.v47i2.2207). The draft status report was published for comment in May 2017 and finalised late in 2017.

C·I·B team members contributed to the report in various capacities – as writers, reviewers and data contributors: Core Team Members Llewellyn Foxcroft, Charles Griffiths, John Measey David Richardson and Tamara Robinson-Smythe; research associates Pat Holmes and David Le Maitre; C·I·B post-doctoral associates Jennifer Fill, Ross Shackleton and Giovanni Vimercati.

5.2.2 Risk analysis guidelines

The risk analysis framework developed is intended for the structured and transparent assessment of evidence for the listing of alien and invasive species under national regulations, and is as such recommended by the Alien Species Risk Analysis Review Panel, and the DDG of DEA. It may be incorporated into the regulations as an official guideline for risk analyses.

This report constitutes the first comprehensive attempt to assess the status of biological invasions across all aspects of the problem at a national level. The report is based on information from a range of sources, including inputs from experts and practitioners, atlas data, published scientific papers and theses, and management records from government agencies. Draft versions of the report were sent out to a wide and representative range of interested parties in two rounds of review, which resulted in the inclusion of additional information.

The report concludes by providing a list of policy-relevant messages distilled from the assessment, which should be considered when formulating environmental policies for the country as a whole. Besides expanding on the points described above, it is noted that it should be imperative to improve management efficiency, given the substantial economic and social consequences that would be associated with a failure to adequately address the problem of biological invasions. This will require difficult choices and trade-offs to be made, including the need to practice conservation triage by focusing effort on priority species and areas.

5.2.3 Invasive species survey in Kruger and Mapungubwe National Parks

Two of the core conservation zones in the Vhembe Biosphere Reserve are Mapungubwe National Park and the northern sections of Kruger National Park (KNP). The northern region of KNP had previously not been surveyed at a fine spatial scale and for all alien species. Cathy Vise, C·I·B-affiliated PhD student (based at the University of Venda), in partnership with KNPs new monitoring team, carried out an extensive survey recording numerous species. The survey forms part of the baseline data needed for improving management planning and future monitoring in the northern region of KNP.

The full list of service provision activities can be found on page A-44.

6 Gender impact of the Centre's work

Women make up 23% of the Core Team and 43% of the research associate network of the Centre. All the hub staff are women, and the all-woman Iimbovane team is a strong role model for aspiring young scientists at secondary school level. Females made up 70% of our students, and 69% of our post-doctoral associates in 2017. The C·I·B makes a concerted effort to provide an inclusive and friendly yet professional environment where all individuals feel comfortable and are able to be productive and grow. These efforts include a range of training events and academic meetings where capacity building and training takes place. Women consistently perform well in our annual presentation awards (in 2017, four out of the five award-winners were women). Two women students were awarded the top science communication prizes at SAASTA's 2016/2017 Young Science Communicator's Competition. In 2017, we initiated a series of support workshops for C·I·B students and post-docs, with the aim of improving the level of preparedness of all students entering the C·I·B and make the Centre a more 'student-ready' institution. Workshops were held in Pretoria and Stellenbosch and will be expanded to include UniVen in the next reporting year.

7 Return on investment

This section has been added at the request of the Steering Committee.

7.1 Why South Africa cannot do without a Centre for Invasion Biology

Excerpt from the Sustainability Plan of the C·I·B (revision published October 2017):

Invasions by alien species are a growing environmental problem worldwide. A recent assessment listed over 2000 invasive species in South Africa, and the number continues to grow as new species are deliberately or accidentally introduced, and as already introduced species become naturalized. Invasive species have serious negative impacts on the ecosystems that they occupy, reducing ecosystem services and threatening the livelihoods of rural people. For example, the combined impacts of invasive plants on surface water runoff have been estimated at between 1.4 and 2.4 billion m^3 per year in South Africa. If no action is taken, reductions in water resources are set to rise further to between 2.6 and 3.2 billion m^3 per year, about 50% higher than estimated current reductions. Reducing the amount of water lost to invasive plants is one of the environmental needs and interventions identified in South Africa's Water Research, Development, and Innovation (RDI) Roadmap: 2015-2025.

Impacts on livestock production are growing exponentially as more rangelands are invaded. Predictions are that the capacity of some rangelands to produce livestock could drop by as much as 75% if invasions reach their full potential. The economic consequences of these invasions are huge. One study estimated that, at levels of invasion in 2010, invasive plants caused economic losses of over R 6 500 million every year, mostly for losses of water runoff, but also in reduced livestock production from invaded rangelands, and reduced income from biodiversity-related goods and services.

Problems associated with biological invasion have been growing steadily over the past few decades, and are in an exponential growth phase. Monitoring of invasive plants in South Africa has shown that 172 new invasive species were recorded between 2006 and 2016, bringing the total number of invasive plant species in natural and semi-natural habitats to 773. Those already here have also spread further and now occupy 50% more area than they did in the year 2000. The DST's 10-year Global Change Research Plan (published in 2008) identified invasive species as the second largest threat to biodiversity after direct habitat transformation.

In attempting to reduce the costs associated with alien species, the South African government alone has spent more than R10 billion on control measures over the past 20 years (excluding contributions by other sectors of society). C·I·B research has identified the factors that can lead to successful control, but these lessons are not yet widely applied, partly because of the shortage of trained personnel. The effort and resources required for successful control are routinely under-estimated. C·I·B research has shown that in South Africa the actual costs of managing invasive plants have been between 1.5 and 8.6 times higher than initial budget estimates. These findings point to a lack of appreciation or understanding of the complexity and costs of effectively managing invasive species.

Biological invasions are a significant and growing problem that needs to be professionally managed if the negative consequences are to be avoided. C·I·B research is needed to understand the drivers of alien species spread and impact, and people must be trained to provide the capacity to manage the problem. Links must be built between organizations that conduct research and those that develop and implement management strategies and policies, to ensure the effective two-way flow of information on problems and solutions.

A permanent Centre for Invasion Biology is crucial for facilitating focussed research that draws on international best practice, and that forges partnerships across the country between academic institutions, science councils, conservation entities and government departments at local, provincial and national levels. Without a clear focus on all aspects of the complex problem of biological invasions, the knowledge and capacity to address this significant problem will not keep pace with demands, with serious environmental and economic consequences for the country (see Table 1).

Table 7. South Africa without the C·I·B

Scenario	Related policy objectives not met
Invasive species increase their negative impacts on ecosystems; ecosystem services and livelihoods are compromised	DST's Global Change Strategy (Theme 2B)
Rangelands are overrun by invasive plant species, impacting rural livelihoods	Conservation of Agricultural Resources Act (CARA), 1983 (Act No 43 of 1983)
Water lost to invasive species increases, affecting development in rural and urban areas	SA's Water Research, Development, and Innovation Roadmap (2015-2025)
Scarce government funds are increasingly spent on management of preventable invasions and disaster management	Reduced budget available for research & innovation, thereby affecting DST's budget

Scenario	Related policy objectives not met
Reduced flexibility to respond to climate change, expanding invasions, and interactions between these elements of global change.	Reduced information & support for DST's 1st Biennial Report to Cabinet on the State of Climate Change Science & Technology in SA (Recs. 1 and 2)
No distributed national network of invasion scientists providing a focus for capacity and policy consultation	Reduced ability to implement Convention on Biological Diversity, SANBSAP
Reduced numbers of PhDs trained to supply SA's knowledge economy	DST's target of 5 000-6 000 PhDs per year is harder to meet
Absence of an honest broker to interpret scientific data on invasive organisms to public, government, policy makers & NGOs	Cross-cutting impacts on efficiency and accuracy of policy formulation
No influence on SADC regional partners to reduce cross-border invasions	Broad impacts on South Africa's international relations with neighbouring states as SA is both a donor and a recipient of introduced and invasive organisms.

Maintaining a permanent Centre for Invasion Biology is in line with several key government initiatives, including the DST's 10-year Global Change Research Plan (2008) and DEA's National Biodiversity Research & Evidence Strategy (2015-2025) (2016). South Africa is a signatory to the Convention on Biological Diversity (CBD). Compliance with the CBD is achieved through South Africa's National Biodiversity Strategy and Action Plan 2015 – 2025 (SANBSAP). Invasive species are recognized as a key pressure on biodiversity and initiatives required to manage invasions appear throughout SANBSAP.

South Africa is a world leader in invasion science. The country is a superb natural laboratory for studying many aspects of invasion science, and South African researchers have developed numerous innovative solutions to problems associated with biological invasions.

In summary, a permanent Centre for Invasion Biology is essential to maintain the momentum of delivering 'invasion science for society', thereby responding to global change by protecting and using our geographical advantage.

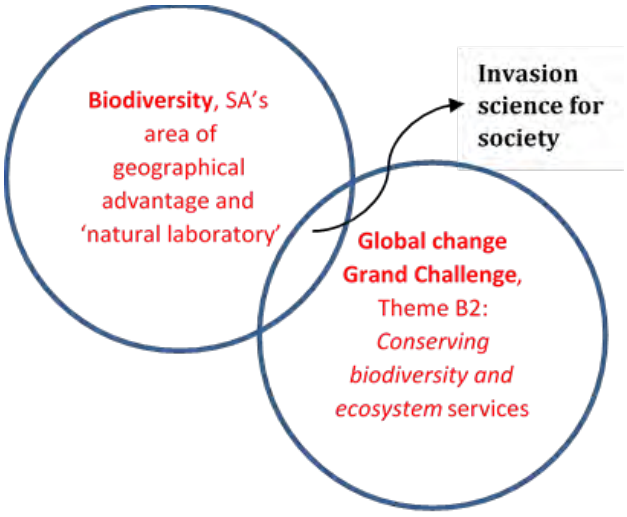


Figure 31. Conceptual model of how the C·I·B fits into DST's plans and strategies

7.2 Return on the investment since 2004

The C·I·B plays a driving role in initiating and sustaining cutting-edge scientific research (almost all of which involves student training) on biological invasions in South Africa. Biological invasions have the potential to curtail commercial as well as subsistence agricultural production and in fact are already influencing livelihoods (see https://www.youtube.com/watch?v=IKkZHY6z0vg). By supporting the government and private sector agencies working on invasive species management, from expanded public works programmes (DEA-NRMP), to evaluating biological control programmes, to identifying theoretical challenges and opportunities, such as the parallels between biological invasions and emerging infectious diseases, **the Centre is working towards better management of invasive species in South Africa and its neighbouring countries**.

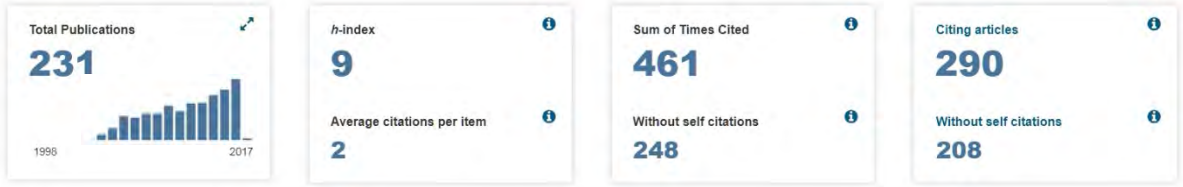
One of the biggest impacts the Centre can have on the management of biological invasions in the southern African region, is in **building capacity in invasive species research**. Our graduates are valued, as shown by a high employment rate within the sector. C·I·B alumni work in a wide range of agencies in SA and abroad. Since 2004, a total of 125 masters and PhD students have completed their degrees with us, and we have hosted 50 post-doctoral associates, many of whom are employed in higher education institutions worldwide (62%). Most masters graduates are employed in private sector firms and consultancies (23%) or government and implementing agencies (15%); 24% go on to study for PhDs. A full quarter of PhD graduates (25%) are employed in government and implementing agencies, while 44% go on to research careers or post-docs. A selection of information on our alumni is shown in Section 2.2.8. (Career development).

The C·I·B is a **partner to several government institutions** mandated to manage invasive species, including the national environmental authority, DEA, principally, though not exclusively, through its NRMP directorate (formerly Working for Water) and provincial environmental and conservation agencies (e.g. CapeNature in the Western Cape and the Department of Agricultural and Rural Development in Gauteng) and local authorities (eThekwini and City of Cape Town). SANParks and SANBI, both affiliates of DEA, are also key partners, allowing the Centre to identify connections between research and implementation and gain valuable input to student training, field work opportunities and project ideas from SANParks and SANBI staff. Through these partnerships the C·I·B supports scientists working in these organisations, promotes coordination of research into invasive species and provides a forum for interaction and career development of young researchers and practitioners once they graduate. Advice given by team members changes management practice, and aids policy development.

The C·I·B is one of the most **productive scientific research groups** in South Africa, and has contributed substantially to the country's international science profile through over 1560 peer-reviewed publications since its establishment in 2004.

2004-2017:

2017 only:



Since its inception, the Centre has hosted at least one international workshop per year. Products from the workshops have taken the form of a book, and several special issues and collections of papers as shown below.

Box 1: Scientific products that have emerged from CIB workshops

- Special issue of *South African Journal of Botany* on 'Riparian vegetation management in landscapes invaded by alien plants: insights from South Africa' [Vol. 74, Issue 3; 14 papers; 2008].
- Special issue of *Diversity and Distributions* on 'Human-mediated introductions of Australian acacias – a global experiment in biogeography' [Vol. 17, issue 3; 21 papers; 2011].
- Special issue of *Biological Invasions* on 'Tree invasions – patterns & processes, challenges & opportunities' [Vol. 16, issue 3; 17 papers; 2014]
- Special issue of *Biological Invasions* on 'Drivers, impacts, mechanisms and adaptation in insect invasions' [Vol. 8, issue 4; 14 papers; 2016]
- Special issue of *AoB PLANTS* from international workshop on 'Evolutionary dynamics of tree invasions' [13 papers; 2017]
- Special issue of *Bothalia: African Biodiversity and Conservation* on 'Assessing the status of biological invasions in South Africa' [Vol 47, No 2; 20 papers; 2017]
- Special issue of *Biological Invasions* on 'Non-native species in urban environments: Patterns, processes, impacts and challenges' [Vol. 19, No 12; 18 papers; 2017]
- Richardson, D.M. (2011). *Fifty years of invasion ecology. The legacy of Charles Elton*. Wiley-Blackwell, Oxford. 456 pp, ISBN 978-1-4443-3586-6
- Special issue of *Diversity and Distributions on* 'Fifty years of invasion ecology – the legacy of Charles Elton' [Vol. 14, Issue 2; 29 papers; 2008
- A special issue initiated by Ross Shackleton during his post-doc will appear later this year in *Journal of Environmental Management* on 'Social invasion biology'. [In progress; scheduled for publication in mid-2018]

In addition, the C·I·B has published a special issue of *Quest* magazine, as well as many articles in *The Conversation*, among other popular outlets.

At the Annual Research Meeting in November 2017, the C·I·B's International Science Advisors commented "The Center for Invasion Biology continues to maintain its status as the world leader in invasion biology research, graduate education and management. The global impact of the research carried out at CIB is confirmed by the number of students from all over the world choosing the center for their education and research."

The C·I·B **plays a leading role in determining policy and practical implementation**, and has participated in the production of the regulations under Chapter 5 of NEMBA, led the National Strategy on Biological Invasions, and played a pivotal role in the first National Status Report on Biological Invasions produced by SANBI in 2017. Internationally, the C·I·B has led the development and implementation of indicators of biological invasion in support of the Convention on Biological Diversity through the work of former Core Team Member and research associate Melodie McGeoch. This work produced three indicators for monitoring invasions at national level, and a database of information in support of the indicators (2006-2010), as well as a country guide to identifying and prioritising invasive alien species and pathways in support of Aichi Target 9 (part of the Convention on Biological Diversity's Strategic Plan). Numerous other products and interactions of the Centre have supported decision-makers.

The Centre has been substantially involved in the development and implementation of a classification scheme for alien taxa according to their impacts (the Environmental Impact Classification for Alien Taxa, EICAT), which was adopted by the IUCN as an official tool to be used for the conservation of biodiversity, alongside the Red List of Threatened Species (https://www.iucn.org/theme/species/our-work/invasive-species/eicat). Furthermore it aids the achievement of Aichi Target 9 of the Strategic Plan for Biodiversity 2011-2020 of the Convention on Biological Diversity (CBD) and Target 15.8 of the Sustainable Development Goals (SDGs), which call for the prioritisation of invasive alien species for prevention, eradication or control.

Furthermore, with collaborators from SANBI and SANParks, Core Team Member Sabrina Kumschick developed a Risk Analysis Framework for the evidence-based listing and regulation of alien species under the NEMBA Alien and Invasive Species Regulations. This framework is currently used to assess species already listed under the regulations to provide the evidence base for their listing.

Furthermore, Dr Kumschick has been instrumental in the set-up and running of the Alien Species Risk Analysis Review Panel, which provides a scientific review of suggestions for listing, delisting and changes to the listing status of NEMBA regulated alien species, and reviews the risk analyses that accompany import permit applications as a service to the Department of Environmental Affairs.

The C·I·B hosts outreach for learners in science and environmental studies, **playing a crucial role in teacher support and providing a role model for learners who wish to enter scientific careers** (see Iimbovane section). The project encourages learners to be agents of change in their communities by equipping them with broad skills in the scientific method, exposure to learning in environments

outside their school grounds. Iimbovane is the major outreach instrument of the Centre, but is complemented by a range of other interventions such as citizen science projects (e.g. ice plants (*Carpobrotus* spp.), invasive toads in Cape Town), science festivals and career expos.

The investment by DST-NRF of c. ZAR 10 million per annum provides **financial leverage for a wide national and international network** that has gained international and national recognition beyond the value of the investment itself. The C·I·B is known and respected at the highest levels of decision-making on biological invasions, and its advice is sought-after. Sixty two percent of C·I·B-affiliated students are funded independently of the DST-NRF grant (2017 figures), while the Centre leverages a further 30% to 50% from the DST-NRF grant (2013-2017).

8 Governance and organisational structure

8.1 Steering Committee

The Steering Committee is an advisory structure created to guide the advancement of the Centre. In brief, it advises on objectives and approves the Strategic Plan, Annual Business Plans, budgets and projections presented by C·I·B management. It must discuss and resolve matters of policy that relate to the CoE and approve the Annual Progress Report prior to submission to the NRF. It makes recommendations to the NRF concerning the progress of the Centre and assists in the promotion of, and lobbying for support for, the CoE to facilitate achievement of its objectives and advises on resourcing.

Table 8. The Steering Committee of the C·I·B in 2016

Name	Affiliation	Role
Prof. Eugene Cloete	Vice-Rector, Research, Innovation and Postgraduate Studies, Stellenbosch University	Chair; ex officio
Prof. David Richardson	Director, C·I·B, Stellenbosch University	Ex officio
Prof. Louise Warnich	Dean, Faculty of Science, Stellenbosch University	Ex officio
Dr Makobetsa Khati	Executive Director, Research Chairs and Centres of Excellence (RCCE) Programme	Funder representative
Prof. Laura Meyerson	Professor, Natural Resources Science, University of Rhode Island, USA	Science advisor*
Prof. Piero Genovesi	Head of Wildlife Service, ISPRA Institute for Environmental Protection and Research, and Chair of the IUCN SSC Invasive Species Specialist Group, Italy	Science advisor*
Dr Wendy Annecke	General Manager, Cape Research Centre, SANParks Scientific Services	Social science advisor
Prof. John Donaldson	Director, Applied Biodiversity Research Division, SANBI	Industry representative
Prof. Paul Skelton	Emeritus Professor, SAIAB and Rhodes University	Industry representative
Mr Ahmed Khan	Natural Resources Management Programmes, Department of Environmental Affairs	Industry representative
Prof. Michael Somers	Associate Professor, Centre for Wildlife Management, University of Pretoria	Core team representative
Dr Sarah Davies	Deputy Director, C·I·B, Stellenbosch University	Ex officio, staff rep.

*The Science Advisors do not attend Steering Committee meetings but give their input each year by (1) attending the ARM, (2) adjudicating the student and post-doc presentations at the ARM and awarding the student prizes, and (3) providing a report on their view of the C·I·B's science programme.

8.2 Core Team Members

Core Team Members are full-time researchers located in a range of South African institutions, including universities, national regulators and other research organisations. Core Team Members conduct research, train students and undertake outreach in biological invasions towards the goals of the CoE. The composition of the Core Team comes under regular review by the C·I·B Steering Committee.

Table 9. C·I·B Core Team Members in 2017

Name	Institution	Race	Gender	% Time spent working in CoE (estimated)	NRF rating
Prof. David Richardson	SU	W	M	100	A1
Dr Sarah Davies	SU	W	F	100	Not rated
Prof. Marcus Byrne	Wits	W	M	20	C1
Prof. Chris Chimimba	UP	B	M	25	C1
Prof. Susana Clusella-Trullas	SU	W	F	50	C1
Prof. Colleen Downs	UKZN	W	F	5	C2
Prof. Karen Esler	SU	W	F	15	C1
Prof. Stefan Foord	UniVen	W	M	10	C2
Dr Llewellyn Foxcroft	SANParks	W	M	20	C2
Prof. Cang Hui	SU	B	M	40	B2
Dr Sabrina Kumschick	SU	W	F	90	Not rated (applied)
Prof. Jaco Le Roux	SU	W	M	50	Y1
Dr John Measey	SU	W	M	100	C2
Dr Thabiso Mokotjomela*	ECPTA[#]	B	M	n/a	Not rated
Dr Sebataolo Rahlao*	SANBI	B	M	n/a	Not rated
Prof. Mark Robertson	UP	W	M	40	C2
Dr Tammy Robinson-Smythe	SU	W	F	50	C2
Dr Sheunesu Ruwanza*	Univen	B	M		Not rated
Prof. Michael Somers	UP	W	M	10	C1
Prof. Peter Taylor	UniVen	W	M	10	B3
Prof. John Terblanche	SU	W	M	10	B2
Prof. Olaf Weyl	SAIAB	W	M	20	B3
Prof. John Wilson	SANBI	W	M	80	B3
Dr Tsungai Zengeya*	SANBI	B	M	n/a	Y2
Emeritus core team members:					
Prof. Charles Griffiths	UCT	W	M	10	B3
Prof. Brian van Wilgen	SU	W	M	100	B1

*These members joined during the year and will come on board in full from January 2018.

[#]Eastern Cape Parks and Tourism Agency

8.3 Research associates

The C·I·B's research associates are individuals working within academic and non-academic organisations who are expert or interested in matters related to biological invasions. The research associate network allows the Centre to extend its influence outside the academic sphere, and to draw on the expertise of a diverse range of skilled personnel. In some cases, the Centre's support for research associates also contributes to research capacity development and keeps us in touch with our growing alumnus of graduates and former post-doctoral associates, some of whom occupy influential positions in partner organisations.

Table 10. C·I·B research associates in 2017

Full Name	Affiliation
Dr Mhairi Alexander	Lecturer, School of Science and Sport, Department of Applied Bioscience and Zoology, University of the West of Scotland, UK
Prof. Tim Blackburn	Chair of Invasion Biology, Centre for Biodiversity and Environment Research in Department of Genetics, Evolution and Environment, University College London, UK.
Dr Ryan Blanchard	Ecologist and Senior Researcher, Natural Resources and Environment, CSIR
Dr Jane Carruthers	Private
Prof. Franz Essl	Senior Scientist, Biodiversity and Nature Conservation, Environment Agency Austria; and Professor, Division of Conservation Biology, Vegetation Ecology and Landscape Ecology, University of Vienna, Austria
Dr Sjirk Geerts	Lecturer, Dept. Conservation and Marine Sciences, Cape Peninsula University of Technology
Prof. Jan Gilliomee	Research associate, Dept. Botany and Zoology, Stellenbosch University
Dr Patricia Holmes	Biodiversity Management Branch, Environmental Resource Management, City of Cape Town
Ms Ulrike Irlich	Urban Expert: Biodiversity and Ecosystem Management, ICLEI - Local Governments for Sustainability – Africa; Africa Secretariat
Dr Michelle Jackson	Research associate in freshwater ecology at Imperial College London, UK
Dr Charlene Janion-Scheepers	PDP post-doctoral associate, Department of Entomology, Iziko South African Museum, Cape Town
Dr Martine Jordaan	Scientific Technician, CapeNature Scientific Services
Dr Jesse Kalwij	Senior Researcher, Institute for Ecosystem Research -- Geobotany, Kiel University, Germany
Prof. Christoph Kueffer	Senior Scientist, Institute of Integrative Biology, ETH Zurich, Switzerland
Dr David Le Maitre	Principal Scientist, Natural Resources and Environment, CSIR
Prof. Melodie McGeoch	School of Biological Sciences, Monash University, Australia
Mr Dave Pepler	Private
Prof. Petr Pyšek	Department of Invasion Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Czech Republic
Prof. Anthony Ricciardi	Professor, Redpath Museum, McGill University, Montréal, Canada
Dr Nicola van Wilgen	Global Change Scientist, Cape Research Centre, South African National Parks
Dr Darragh Woodford	Senior Lecturer, Department of Animal Plant and Environmental Sciences, University of the Witwatersrand

8.4 Staff employed by the C·I·B

8.4.1 Staff development

C·I·B support staff attended training courses based on their Personal Development Plans, which form part of the Personnel Plan of the Centre. In 2017, three staff members attended courses in their areas of work, including CHEC courses on the Higher Education sector (Karla Coombe-Davis), and training for personal assistants (Lorraine Cilliers and Rhoda Moses). Our laboratory and fieldwork managers (Erika Nortje, Megan Mathese and Suzaan Kritzinger-Klopper) routinely attend first aid and fire safety courses arranged by our host Department (Botany and Zoology) to keep their certifications valid.

The table below shows all staff who are employed or hosted by the Centre.

Table 11: C·I·B staff in 2017

Name	Institution	Position	Race	Gender
Support staff				
Ms Lorraine Cilliers	SU	PA to the Director	W	F
Ms Karla Coombe-Davis	SU	Database Manager	W	F
Dr Sarah Davies	SU	Deputy Director	W	F
Ms Dorette Du Plessis	SU	Chief Technical Officer: Outreach	W	F
Ms Megan Mathese	SU	Molecular Laboratory Manager	B	F
Ms Suzaan Kritzinger-Klopper	SU	Senior Technical Officer	W	F
Ms Christy Momberg	SU	Management Assistant	W	F
Dr Elrike Marais	SU	Project Manager	W	F
Ms Rhoda Moses	SU	Administrative Assistant	B	F
Ms Londiwe Msomi	SU	Education Outreach Officer	B	F
Ms Erika Nortjé	SU	Laboratory Manager	W	F
Ms Sophia Turner	SU	Iimbovane Technical Assistant	W	F
Ms Mathilda van der Vyver	SU	Administrative Officer	W	F
Ms Monica Leitner[#]	UP	Technical Officer & Admin. Assistant	W	F
Academic staff				
Prof. David Richardson	SU	Distinguished Professor (Botany & Zoology) and Director of the C·I·B	W	M
Dr Sabrina Kumschick	SU (funded by SANBI)	Risk Analysis Researcher, C·I·B	W	F
Dr John Measey	SU	Senior Researcher, C·I·B	W	M
Prof. Brian van Wilgen	SU (funded by SANBI & CABI)	Professor (Botany & Zoology)	W	M
Prof. John Wilson	SANBI (hosted by SU)	Invasive Species Scientist, SANBI	W	M

[#]Position supported 50:50 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 information.

9 Stage progress

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

Timeframes

The pending Gate review (Gate 6) shall take place during February or March 2019

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

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

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.

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

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

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 2018 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

The CoE shall submit a Statement of Compliance by no later than March 2019 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 2016 will be signed off at the Steering Committee meeting on 29 March 2018

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

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

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

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).

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

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

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

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

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

Number of patents ≥ 1

2015: 0

2016: 0

2017: 0

Number of peer reviewed publications ≥ 85 on average per annum

2015: 178

2016: 201

2017: 216

Number of peer reviewed publications ≥ 2 with an impact rating of ≥ 15 on average per annum

2015: 2

2016: 1

2017: 4

Number of peer reviewed publications ≥ 20 with an impact rating of ≥ 4.0 on average per annum

2015: 33

2016: 36

2017: 47

Number of national conference presentations ≥ 30 on average per annum

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

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

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

Number of international conference presentation ≥ 10 on average per annum

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

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

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

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'.

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).

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.

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).

10 Conclusion

2017 was a very successful year for the C·I·B in terms of all our Key Performance Areas. On the research front, our publication output was exceptional (216 papers in peer-reviewed journals, two books, and 10 chapters in edited volumes). In education and training, we supported 71 students and 13 post-docs. There were many highlights pertaining to networking, information brokerage and service provision. A big highlight of the year was our work with SANBI that resulted in the completion of the National Status Report on Biological Invasions in South Africa – the first such report globally. It is important to note that besides the report, a large volume of crucial information was generated that will be useful to our partner organizations. Our students and post-docs also benefitted substantially from the many discussions and workshops associated with the status report.

Uncertainty about funding for the Centre's activities after 2019 is a major concern and is hampering the development and expansion of productive partnerships to address the increasingly vexing challenges associated with biological invasions in South Africa.

Appendices

A.1. Outputs

Research

Books

Carruthers, J. (2017). *National Park Science: A Century of Research in South Africa*. Cambridge University Press, UK. 548 pp, ISBN: 9781107191440.

Hui, C. and Richardson, D.M. (2017). *Invasion Dynamics*. Oxford University Press, Oxford, UK. 336 pp, ISBN: 9780198745334.

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Products, artefacts and patents

None in 2017

Conferences attended

International plenary/keynote addresses

Richardson, D.M. 2017. A global historical perspective on invasion science. 'Life on the loose: Species invasion and control', Australian Academy of Science Annual Symposium, Canberra, Australia. May 2017 (Richardson)

Taylor, P. J. 2017. Afromontane small mammals feel the heat: impact of taxonomy and climate change on extinction risks and determination of conservation status. AfroMont_Mt Kilimanjaro Mountain Research Conference. Moshi, Tanzania. February 2017 (Taylor)

Taylor, P. J. 2017. How resilient are bats to anthropogenic change? Land use effects on insectivorous bat ensembles in commercial and small holder agricultural landscapes in Limpopo, South Africa. Southern African Bat Conference. UCT, Cape Town, October 2017 (Taylor)

Taylor, P. J. 2017. The New Age of mammal species discovery: 'taxonomic anarchy' or an inconvenient truth for conservation? Invited guest lecture at the Paris Museum of Natural History, Paris, Sept 2017 (Taylor)

Terblanche, J.S. 2017 Mechanisms and responses of insects to climate stress. SIP 2017: 16th Symposium on Insect-Plant Interactions, Tours, France. (invited keynote lecture)

Wilson, J. R. 2017, Monitoring and reporting on plant invasions at a country level. 14th International Conference on the Ecology and Management of Alien Plant Invasions, Lisbon, Portugal, 4–8 September 2017 (Wilson).

National plenary/keynote addresses

Downs, C.T. 2017. The importance of curiosity in birding. Birdlife SA AGM, Plenary address, April 2017 (Downs).

Esler, K.J., Sandberg, R., Bond, W., Allsopp, N. 2017. Searching for signs of extinction debt. 43rd Annual Conference of South African Association of Botanists, Cape Town. January 2017 (Esler).

Foxcroft, L.C. 2017. Biological invasions in South African National Parks. South African National Parks Honorary Rangers INDABA, South Africa. May 2017 (Foxcroft).

Measey, J. 2017. 101 ways to conserve frogs: from numbers to decisions. Plenary talk for Statistics in Ecology, Environment and Conservation Student Symposium: 4 May 2017 (Measey).

Van Wilgen, B.W. 2017. South Africa's first National Status Report on Biological Invasions Combined congress of the Entomological and Zoological Societies of South Africa, Pretoria (van Wilgen).

Weyl, O.L.F., van der Walt, J.A., Impson, N.D., Jordaan, M.S., Woodford, D.J. (2017). Is native fish restoration in headwater streams as easy as removing alien fish? South African Society of Aquatic Scientists Conference, Boksburg, South Africa. June 2017 (Weyl).

International oral contributions

Bloomer, P., Miller, S.M., Somers, M.J., Harper, C.K., Funston, P.J. and Davies-Mostert, H. 2017. Fenced and fragmented: Genetic management of carnivore metapopulations in South Africa. 12th International Mammalogical Congress Perth, Western Australia, July (Somers)

Clusella-Trullas, S. 2017. Buffers and amplifiers: behavioural thermoregulation as a key moderator of climate change impacts. 9th Integrative Society for Zoological Sciences, Xining, China, 27-31 August. (Invited speaker – symposium titled 'Biological buffers and the impacts of climate change' Buckley L., Du W.-G., Huey R.B.)

Esler, K.J., Sandberg, R., Bond, W., Allsopp, N. 2017. Fragmentation effects and extinction debt in South African Fynbos. XIV MEDECOS & XIII AEET meeting, Seville, Spain, 31 January – 4 February 2017 (Esler)

Esler, K.J., Abrahams, B., Sitas, N., Le Maitre, D. 2017. Exploring scenario and modelling approaches in an ecosystem service based initiative to clear invasive alien plants – the case of Working for Water in South Africa. VII World Conference on Ecological Restoration, Foz do Iguassu, Brazil, 28 August – September 1 (Esler). *Note: This paper was presented in a Symposium entitled: The use of scenarios and models in ecological restoration, proposed and organized by Karen Esler and Jean-Paul Metzger*

Foord, S.H. Landuse change in savannas disproportionally reduces functional diversity of invertebrate predators at the highest trophic levels: Spiders as an example. 30th European Congress of Arachnology, August 20 – 25, 2017, University of Nottingham, UK (Foord)

Foxcroft, L.C., van Wilgen, N., Baard, J. and Cole, N. 2017. Biological invasions in South African National Parks. 15th Annual International Savanna Science Networking Meeting, Skukuza, March 2017 (Foxcroft).

Grant J.S., Mauda, E.V., Seymour, C.L., Munyai, T.S., Dippenaar-Schoeman, A.S. and Foord, S.H. Phylogenetic and functional perspectives on □-diversity: the case of spiders and ants along elevations. 4th Conference of the Asian Society of Arachnology, August 9 – 13, 2017, Chongqing, China (Foord)

Hirsch, H., Impson, F.A.C., Kleinjan, C., Richardson, D.M., Le Roux, J.J. 2017. POPBIO2017. Population biology in a changing world. 30th Conference of the Plant Population Biology Section of the Ecological Society of Germany, Austria and Switzerland. Halle, Germany, May 2017. (Le Roux)

Hulme, P. E., Brundu, G., Carboni, M., Dehnen-Schmutz, K., Dullinger, S., Early, R., Essl, F., González-Moreno, P., Groom, Q. J., Kueffer, C., Kühn, I., Maurel, N., Novoa, A., Pergl, J., Pyšek, P., Seebens, H., Tanner, R., Touza, J. M., van Kleunen M., & Verbrugge, L. N. H. (2017) Integrating invasive species policies across ornamental horticulture supply-chains to prevent plant invasions. International Conference on the Ecology and Management of Alien Plant Invasions, Lisbon, Portugal, 4–8 September 2017 (Novoa)

Kumschick, S. 2017. Alien species classification according to impact magnitude: filling the gaps. Workshop on Biological Invasions – Challenges for Science and Society. Fribourg, Switzerland, September 2017 (Kumschick)

Kumschick, S. 2017. Alien species classification according to their impact. Neobiota: 10th international conference on biological invasions. Lisbon, Portugal, September 2017 (Kumschick)

Marneweck, D.G., Druce, D.J. and Somers, M.J. 2017. Dispersal patterns affecting pack formation and breeding success in a monogamous and social carnivore, the African wild dog (*Lycaon pictus*) 12th International Mammalogical Congress Perth, Western Australia, July (Somers)

Mukarugwiro, J.A., Newete, S., Adam, E., Byrne, M. 2017. Mapping distribution of water hyacinth in Rwanda using multispectral remote sensing imagery. 37th international Symposium on Remote Sensing of Environment. Tswane, South Africa, May 2017 (Byrne)

Novoa, A., Canavan, S., Richardson, D.M., Shackleton, R. & Wilson, J.R. (2017) When can we make generalizations in invasion science? International Conference on the Ecology and Management of Alien Plant Invasions, Lisbon, Portugal, 4–8 September 2017.

Richardson, D.M. 2017. Invasion science: progress and challenges. Annual Conference of the Ecological Society of America (symposium on 'Advances in Biodiversity and Ecosystem Science: Building on the Work of Harold A. Mooney), Portland, Oregon. August 2017 (Richardson)

Rodríguez, J., Novoa, A., Thompson, V., Cordero-Rivera, A., Richardson, D.M. & González, L. (2017) Novel interactions between *Carpobrotus edulis* and invertebrate species in the native and non-native range. International Conference on the Ecology and Management of Alien Plant Invasions, Lisbon, Portugal, 4–8 September 2017 (Novoa)

Shackleton, R., Bennett, B., Estevez, R., Fisher, A., Kull, C., Larson, B., Marchante, E., Marchante, H., Novoa, A., Potgieter, L., Richardson, D.M., Shackleton, C., Witt A. & Vaz S. (2017) Factors driving people's knowledge and perceptions of invasive species. International Conference on the Ecology and Management of Alien Plant Invasions, Lisbon, Portugal, 4–8 September 2017.

Taylor, P. J. 2017. Valuation of biological control in commercial macadamia orchards in a tropical landscape. Connecting biodiversity and improving human livelihood beyond boundaries – a global perspective, September 2017, Linde, Germany (Taylor)

Weyl, O.L.F., Hargrove, J., Allen, M.S., Woodford, D. (2017). One man's pest is another's trophy. 147th Annual Meeting of the American Fisheries Society, August 2017. (Weyl)

Weyl, O.L.F., van der Walt, J.A., Impson, N.D., Jordaan, M.S., Woodford, D.J. (2017). Non-native fish eradication facilitates the rapid recovery of native stream fishes in the Cape Fold ecoregion, South Africa. 50th Anniversary of the Fisheries Society of the British Isles Conference, Exeter UK. July 2017. (Weyl)

Woodford, D.J., Chakona, A., Ellender, B.R., van der Walt, K-A., van der Walt, J.A., Weyl, O.L.F. (2017). The importance of network discontinuity in the ecology and conservation biology of African headwater stream minnows. 5th Biennial Symposium of the International Society for River Science, Hamilton, New Zealand. November 2017 (Weyl).

National oral contributions

Abels, T., Byrne, M.J., Witkowski, E. & Strathie, L. 2017. Establishment of the biological control agent, *Zygogramma bicolorata*, on *Parthenium hysterophorus* in South Africa: Is soil moisture important? 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, Oral, speed talk, July 2017

Adlam, A., Chimimba, C., Alexandre, M. & Woodborne, S. 2016. Are Debshan headwater streams refugia against invasive fish species. 8th Oppenheimer De Beers Group Research Conference. De Beers Corporate Headquarters, Johannesburg, October 2017

Alujevic K., Logan M., Streicher J., Clusella-Trullas S. 2017. The evolution of complex phenotypes in lizards: can multiple physiological functions be optimized at the same time? Responses to changing environments symposium. The Entomological Society of Southern Africa and the Zoological Society of Southern Africa. Pretoria, South Africa, July 2017.

Becker, F. Altwegg, R., Measey, J., Slingsby, J., Tolley, K.A. 2017. Estimating the global population size of a species that is hard to find: The case of Rose's mountain toadlet. 13th conference of the Herpetological Association of Africa, January 2017.

Bloy, L., Hannweg, B., Dallas, H., Weyl, O.L.F. 2017. An assessment of whether thermal tolerance is a driving factor of non-native fish invasion fronts. 2017 ZSSA Conference, CSIR Conference Centre, Lynwood, South Africa, July 2017.

Bloy, L., Hannweg, B., Dallas, H., Weyl, O.L.F. 2017. The thermal preference and tolerance of the endangered Eastern Cape redfin, *Pseudobarbus afer*. 2017 SASAQS Conference, OR Tambo Conference Centre, Birchwood Hotel, Boksburg, South Africa, June 2017.

Canavan, S. 2017. Bamboos in South Africa: prospects, perceptions and management. Grassland Society of South Africa (GSSA) 52nd Annual Congress. May 2017. Wits Rural Facility, Limpopo.

Canavan, S. & Visser, V. 2017. Invasion syndromes of grasses. Model Groups Workshop. Stellenbosch, November 2017.

Canavan, S. 2017. The history and current status of bamboos in South Africa. Mine Land Rehabilitation and Phytoremediation Workshop. Melrose, Johannesburg, July 2017.

Cowie, B., Strathie, L., Goodall, J., Witkowski, E., Byrne, M.J. & N. Venter, N. 2017. A dirty agent: Photosynthetic response of *Parthenium hysterophorus* to defoliation by the leaf-feeding beetle *Zygogramma bicolorata*. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, Oral, speed talk, July 2017.

Cowie, B.W., Witkowski, E.T.F., Byrne, M.J., Strathie, L.W., Goodall, J.M. & Venter, N. 2017. A dirty agent: Photosynthetic response of *Parthenium hysterophorus* to defoliation by *Zygogramma bicolorata*. Symposium on the management of biological invasions in South Africa – Pretoria, *awarded best speed presentation of Symposium, July 2017.

Cowie, B.W., Witkowski, E.T.F., Venter, N. & Byrne, M.J. 2017. Biological control of bugweed: New insights and future prospects for South Africa. 8th Wits Cross Faculty Graduate Symposium – Johannesburg, *awarded best flash talk and poster for the science faculty as well as the entire symposium, October 2017.

Cowie, B.W., Witkowski, E.T.F. & Byrne, M.J. 2017. The nutrient effect: a recipe for success in the biocontrol of Parthenium hysterophorus using *Zygogramma bicolorata*? Centre for Invasion Biology: Annual Research Meeting, Stellenbosch, November 2017.

Dlamini, P., Zachariades, C., Downs, C.T. 2017. The effect of frugivorous birds on seed dispersal and germination of the invasive Brazilian pepper tree (*Schinus terebinthifolius*) and Indian laurel (*Litsea glutinosa*). ZSSA Pretoria, July 2017.

Foord, S.H. & Dippenaar-Schoeman, A. 2017. Spider diversity increases with elevation on an isolated mountain in an arid savanna of southern Africa. 12th African Arachnological Colloquium, Goudini, South Africa, January 2017.

Foord, S.H., Munyai, T.C. 2017. Habitat, aspect and elevation interact to affect the relative roles of turnover and nestedness in explaining ant beta diversity across the Soutpansberg. Combined Congress of the Entomological and Zoological Societies of Southern Africa held at the CSIR International Convention Centre Pretoria, South Africa. CSIR, Pretoria, July 2017.

Foord, S.H., Mauda, E., Dippenaar-Schoeman, A., Munyai, C. 2017. The future of spiders and ants on an ancient mountain: substituting space for time and replicating space in time. 8th Oppenheimer De Beers Group Research Conference, De Beers Corporate Headquarters, Johannesburg, October 2017.

Frehse, F., Weyl, O.L.F., Vitule, J. 2017. Evaluation of fish colonization and use of artificial habitats in a Brazilian reservoir using different sampling methods. 2017 SASAQS Conference, OR Tambo Conference Centre, Birchwood Hotel, Boksburg, South Africa, June 2017.

Hannweg, B., Bloy, L., Marr, S.M., Weyl, O.L.F. 2017. Association between an artificial and a natural habitat of the Eastern Cape redfin minnow. 2017 ZSSA Conference, CSIR Conference Centre, Lynwood, South Africa, July 2017.

Hannweg, B., Bloy, L., Marr, S.M., Weyl, O.L.F. 2017. Behaviour and habitat association of *Pseudobarbus afer* in the Swartkops River System, South Africa. 2017 SASAQS Conference, OR Tambo Conference Centre, Birchwood Hotel, Boksburg, South Africa, June 2017.

Howard, A., Chimimba, C., Monadjem, A. & MacFadyen, D. 2017. Seasonal Chiropteran diversity and abundance across habitat types on Wakefield Farm, Natal Midlands, KwaZulu-Natal Province, South Africa. 8th Oppenheimer De Beers Group Research Conference. De Beers Corporate Headquarters, Johannesburg, October 2017.

Hugo, S., Altwegg, R., Bellingan, T., Weyl, O.L.F. 2017. New methods for analysing species communities: multivariate modelling and Bayesian ordination. 2017 ZSSA Conference, CSIR Conference Centre, Lynwood, South Africa, July 2017.

Hugo, S., Bellingan, T., Weyl, O.L.F. 2017. Keiskamma aquatic invertebrate communities: new multivariate modelling methods. 2017 SASAQS Conference, OR Tambo Conference Centre, Birchwood Hotel, Boksburg, South Africa, June 2017.

Foxcroft, L.C., Novoa, A., Le Roux J.J. 2017. Below-ground impacts of selected invasive alien plants in Kruger National Park, South Africa. 44th Annual Research Symposium on the Management of Biological Invasions in Southern Africa, Pretoria, July 2017.

Galloway, A.D., Holmes, P.M., Gaertner, M., Esler, K.J. 2017. The impact of pine plantations on fynbos above-ground vegetation and soil seed bank composition. Fynbos Forum, Swellendam, July – August 2017.

Hall, S., Holmes, P.M., Gaertner, M., Esler, K.J. 2017. Implications for management of lowland fynbos ecosystems resulting from restoration experiments in Cape Flats Sand Fynbos. Fynbos Forum, Swellendam, July – August 2017.

Ihlow, F., Courant, J., Secondi, J., Herrel, A., Rebelo, R., Measey, J., Lillo, F., De Villiers, F.A., De Busschere, C., Backeljau, T., Rödder, D. 2017. Impacts of climate change on the global invasion potential of the African clawed frog *Xenopus laevis*. 13th conference of the Herpetological Association of Africa, January 2017.

Keet, J-H., Hui, C., Ellis, A.G., Le Roux, J.J. 2017. Legume-rhizobium symbiotic promiscuity and effectiveness do not affect invasiveness. 43rd Annual Conference of South African Association of Botanists (SAAB), Stellenbosch, South Africa, January 2017.

Khosa, D., Marr, S.M., Wasserman, R.J., Weyl, O.L.F. 2017. The extent of black bass distribution in South Africa. 2017 ZSSA Conference, CSIR Conference Centre, Lynwood, South Africa. July 2017. (Weyl)

Khosa, D., Marr, S.M., Wasserman, R.J., Weyl, O.L.F. 2017. Using angler data to map the extent of black bass distribution in South Africa. 2017 SASAQS Conference, OR Tambo Conference Centre, Birchwood Hotel, Boksburg, South Africa, June 2017.

Kral, M., Chimimba, C. & Robinson, M. 2017. Small mammal landscape corridor usage in a fragmented grassland ecosystem in Mpumalanga Province, South Africa. Combined Congress of the Entomological and Zoological Societies of Southern Africa. CSIR International Convention Centre, Pretoria, South Africa, July 2017.

Kumschick, S. 2017. Risk assessment in invasion biology. Workshop on Moving toward practical integration of invasion biology and disease modelling for understanding, predicting, monitoring and studying emerging vector-borne diseases. Stellenbosch, South Africa, October 2017.

Kumschick, S., Wilson, J.R.U., Foxcroft, L.C. 2017. A risk analysis framework for the listing of alien species under regulations. Joint Congress of the ESSA and ZSSA, Pretoria, South Africa, July 2017.

Kruger, N., Du Preez, L.H. Measey, J. 2017. Parasite introduction to the endangered western leopard toad: Spill-over or spill-back? 13th conference of the Herpetological Association of Africa, January 2017.

Le Granje, A., Brettschneider, H., Chimimba, C.T. & Bastos, A.D.S. 2017. Anaplasmataceae in indigenous commensal rodents (Rodentia: Muridae and Nesomydidae) from Gauteng Province, South Africa. Combined Congress of the Entomological and Zoological Societies of Southern Africa. CSIR International Convention Centre, Pretoria, South Africa, July 2017.

Louw, M., Turner, A., Slingsby, J., Altwegg, R., Borchers, D., Stevenson, B., Measey, J. 2017. Densities of *Arthroleptella lightfooti* across the Cape Peninsula: preliminary results from acoustic spatial capture-recapture. 13th conference of the Herpetological Association of Africa, January 2017.

Louw, M., Measey, J. 2017. Listen up! Eavesdropping on a Cape Peninsula Endemic. Fynbos Forum, Swellendam, August 2017.

Louw, M., Turner, A., Slingsby, J., Altwegg, R., Borchers, D., Stevenson, B., Measey, J. 2017. Estimating calling population densities of *Arthroleptella lightfooti* using acoustic spatial capture-recapture. Fynbos Forum 2017, Swellendam, August 2017.

Louw, M., Turner, A., Slingsby, J., Altwegg, R., Borchers, D., Stevenson, B., Measey, J. 2017. Estimating calling population densities using acoustic spatial capture-recapture. Combined Congress of the Entomological and Zoological Societies of Southern Africa, Pretoria, July 2017.

Marlin, D., Smit, E. & Byrne, M.J. 2017. Host-preference of the beetle *Diorhabda carinulata* on invasive and indigenous *Tamarix* spp. (Tamaricaceae) in South Africa. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, July 2017.

Marr, S.M., Bellingan, T.A., Bloy, L., Dalu, T., Esler, K.J., Foord, S.H., Hannweg, B., Hugo, S., Mofu, L., Rajkaran, A., Roux, H., Shelton, J.M., Vine, N.G., Weyl, O.L.F. 2017. Training the next generation of aquatic scientists through full immersion field exposure to river research and monitoring methods. 2017 SASAQS Conference, OR Tambo Conference Centre, Birchwood Hotel, Boksburg, South Africa, June 2017.

Marr, S.M., Ellender, B.R., Woodford, D.J., Alexander, M.E., Wasserman, R.J., Ivey, P., Zengeya, T., Weyl, O.L.F. 2017. Evaluating invasion risk for freshwater fishes in South Africa. 2017 ZSSA Conference, CSIR Conference Centre, Lynwood, South Africa, July 2017.

Matthews, T., Measey, J. 2017. Who croaked? What the fossil frog bones say. 13th conference of the Herpetological Association of Africa, January 2017.

Mbonani, S., Newete, S., Marlin, D., Venter, N. & Byrne, M.J. 2017. A comparison of plant vigour between Tamarix species and hybrids and their susceptibility to *Opsius stactogalus* in South Africa. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, Oral, speed talk, July 2017.

Mudau, P., Byrne, M.J. & D. Marlin. 2017. Suitability of *O. engelmannii* as a host of Las Cruces and 'stricta' biotypes of *Dactylopius opuntiae*. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, Oral, speed talk, July 2017.

Measey, J., Stevenson, B., Scott, T., Altwegg, R. Borchers, D. 2017. Counting chirps: Acoustic monitoring of cryptic frogs. 13th conference of the Herpetological Association of Africa, January 2017.

Minnaar, I.A., Hui C., Clusella-Trullas S. 2017. Plasticity of traits of competing invasive and native ladybirds in a changing environment. Annual research symposium on the management of biological invasions in Southern Africa. The Entomological Society of Southern Africa and the Zoological Society of Southern Africa. Pretoria, South Africa, July 2017.

Minnaar I., le Roux J., Hui C., Clusella-Trullas S. 2017. Thermal adaptation of the harlequin ladybird, Harmonia axyridis, to variable environments: a multigenerational experiment. Responses to changing environments symposium. The Entomological Society of Southern Africa and the Zoological Society of Southern Africa. Pretoria, South Africa, July 2017.

Mofu, L., Woodford, D.J., Wasserman, R.J., Weyl, O.L.F. 2017. Assessing the relative impact potential of successfully introduced fishes in man-made aquatic Environments. 2017 ZSSA Conference, CSIR Conference Centre, Lynwood, South Africa, July 2017.

Mofu, L., Woodford, D.J., Wasserman, R.J., Weyl, O.L.F. 2017. Using functional responses to assess relative impact potential of successfully introduced fishes in man-made aquatic environments. 2017 SASAQS Conference, OR Tambo Conference Centre, Birchwood Hotel, Boksburg, South Africa, June 2017.

Mokhatla, M.M., Rödder, D., Measey, J. 2017. Modelling current and future distributions of three African anurans representing different functional groups: An ecophysiology modelling approach. 13th conference of the Herpetological Association of Africa, January 2017.

Molekoa, L., Newete, S., Byrne, M.J. & Adams, E. 2017. Hyperspectral Remote Sensing to discriminate between *Tamarix* species and their hybrids in South Africa. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, Oral, speed talk, July 2017.

Mukarugwiro, J.D., Newete, S., Adam, E. & Byrne, M.J. 2017. Mapping distribution of water hyacinth in Rwanda using multispectral remote sensing imagery. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, Oral, speed talk, July 2017.

Musengi, K., Klein, H. & Byrne, M.J. 2017. Reproductive performance of the 'stricta' biotype of *Dactylopius opuntiae* on *Opuntia* hosts. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, Oral, speed talk, July 2017.

Nanni, I, Canavan S, Lalla R. 2017. Bamboo: an asset to the economy or liability to biodiversity? Symposium of Contemporary Conservation Practice. KwaZulu-Natal, November 2017.

Nsikani, M.M. 2017. *Acacia saligna*'s soil legacy effects: what do they do and for how long? Fynbos Forum, Swellendam, July – August 2017.

Ramulifho, P.A., Foord, S.H., Rivers-Moore, N.A., Dallas, H.F. 2017. A conceptual framework towards more holistic freshwater conservation planning through incorporation of stream connectivity and thermal vulnerability. Symposium of contemporary conservation practice 2017. Howick, November 2017.

Rebelo, A.D., Measey, J. 2017. Frog Olympics: Exploring the locomotory ecomorphology of the pyxicephalid radiation in southern Africa. 13th conference of the Herpetological Association of Africa, January 2017.

Robertson, M.P., Bishop, T.R., Newman, S.A., de Jong, G., Parr, C.L., van Rensburg, B.J. 2017. Elevation gradients: natural laboratories to better understand diversity patterns and processes. Combined congress of the Entomological and Zoological Societies of Southern Africa, Pretoria, July 2017.

Rödder, D., Ihlow, F., Courant, J., Secondi, J., Herrel, A., Rebelo, R., Measey, J., Lillo, F., De Villiers, F.A., De Busschere, C., Backeljau, T. 2017. Global realized niche divergence in the African clawed frog *Xenopus laevis*. 13th conference of the Herpetological Association of Africa, January 2017.

Saccaggi, D.L., Collett I., Wilson, J.R., Terblanche, J.S. 2017. Arthropod pests, agricultural trade and South Africa's biosecurity. Combined conference of the ESSA & ZSSA, Annual Research Symposium on the Management of Biological Invasions in Southern Africa. CSIR, Pretoria, South Africa, July 2017.

Senoge, N. and Downs, C.T. 2017. Use of communal roost counts for population estimates of the invasive Common Myna. ZSSA Pretoria, July 2017.

Taylor, P.J. Grass, I., Alberts, A. J., Joubert, E. Tscharntke, T. 2017. Ecosystem services provided by bats in macadamia orchards in South Africa. Symposium of Contemporary Conservation Practice, Howick, November 2017.

Taylor, P.J., Goodman, S., MacDonald, A., Cotterill, W., Stoffberg, S., Kearney, T. Monadjem, A., Schoeman, M. C., Richards, L. 2017. Integrative taxonomy resolves species limits and identification of cryptic small rhinolophid bats in Southern Africa, with the description of two new species from Mozambique. 2017 Combined Congress of the Entomological and Zoological Societies of Southern Africa CSIR International Convention Centre, Pretoria, July 2017.

Terblanche, J.S. (2017). Manipulating insect performance. Mass Rearing of Insects Workshop; University of Stellenbosch, South Africa. November 2017.

Thorp, C.J., Vonesh, J.R. & Measey, J. 2017. The relative tadpole vulnerability of *Xenopus* tadpoles to *X. laevis* predators. 13th conference of the Herpetological Association of Africa, January 2017.

Turner, A.A., Measey, J., Tolley, K.A. 2017. Frog metapopulation dynamics in the Western Cape. 13th conference of the Herpetological Association of Africa, January 2017.

Van Wilgen, B.W. 2017. The effectiveness of alien species control measures in South Africa. 14th National Biodiversity Planning Forum, Skukuza, June 2017.

Vimercati, G., Davies, S.J., Measey, J. 2017. Never underestimate your opponent: Adaptive phenotypic response in a recent amphibian invader. 13th conference of the Herpetological Association of Africa, January 2017.

Veldtman, R, Nethavhani, Z. & Foord, S.H. 2017. Mopane worm harvesting in Limpopo Province and underlying Ecological Infrastructure. 14th National Biodiversity Planning Forum 20–23 June 2017, Nombolo Mdhluli Conference Centre, Skukuza, June 2017.

Venter, N., Cowie, B., Witkowski, E., Snow, G. & Byrne, M.J.. 2017. The amphibious invader: Water hyacinth's physiological strategy to survive stranding and drought events. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, Oral, speed talk, July 2017.

Venturi, G., Duncan, F., King, A. & M.J. Byrne. 2017. Thermal imaging and feeding damage of the biological control agent, *Cornops aquaticum*, on water hyacinth. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, Oral, speed talk, July 2017.

Wasserman, R.J., Alexander, M.E., Dalu, T., Ellender, B., Kaiser, H., Weyl, O.L.F. 2017. Using functional responses to quantify interaction effects among predators. 2017 SASAQS Conference, OR Tambo Conference Centre, Birchwood Hotel, Boksburg, South Africa. June 2017.

Wilson, J. R. 2017. Monitoring invasions and incursion response. Practical integration of invasion biology and epidemiology. Joint Workshop of the SACEMA-CIB Workshop. October 2017.

Wilson, J.R. and National Status Report Team (2017). Proposed indicators for assessing the status of biological invasions (2017) 14th National Biodiversity Planning Forum, Skukuza, June 2017.

Wilson, J. R., Gaertner, M., Richardson, D. M., Rahlao, S., van Wilgen, B. W. 2017. Reporting on the state of plant invasions in South Africa. 43rd Annual Conference of the South African Association of Botanists, Cape Town, January 2017.

International posters

Hirsch, H., Impson, F.A.C., Kleinjan, C., Richardson, D.M. & Le Roux, J.J.: Molecular ecology of invasive Australian silver wattle, *Acacia dealbata*, in South Africa. 30th Conference of the Plant Population Biology Section of the Ecological Society of Germany, Austria and Switzerland, 2017.

Hulme, P.E., Brundu, G., Carboni, M., Dehnen-Schmutz, K., Dullinger, S., Early, R., Essl, F., González-Moreno, P., Groom, Q.J., Kueffer, C., Kühn, I., Maurel, N., Novoa, A., Pergl, J., Pyšek, P., Seebens, H., Tanner, R., Touza, J.M., van Kleunen, M. and L.N.H. Verbrugge. Integrating invasive species policies across ornamental horticulture supply-chains to prevent plant invasions. EMAPI, Lisbon, Portugal, September 2017.

Louw, M., Turner, A., Slingsby, J., Altwegg, R., Borchers, D., Stevenson, B., and Measey, J. Assessing the use of Acoustic Spatial Capture Recapture (aSCR) to study populations of the Cape Peninsula moss frog *Arthroleptella lightfooti*. Joint Annual Meeting: Ecology Across Borders with BES, GFO, NECOV & EEF, Ghent, December 2017.

Mohanty, N.P., Measey, G.J., Sachin, A., Selvaraj, G. and Vasudevan, K. 2017. Using key informant surveys to reliably and rapidly estimate the distributions of multiple insular invasive species. Island Invasives Conference 2017, Dalhousie Building, University of Dundee, Scotland, July 2017.

Novoa, A., Canavan, S., Richardson, D.M., Shackleton, R. and Wilson, J.R.U. When can we make generalizations in invasion science? EMAPI, Lisbon, Portugal, September 2017

Potgieter, L.J., Gaertner, M., O'Farrell, P.J. and Richardson, D.M. Public perceptions of urban plant invasions – an ecosystem service perspective. Ecology and Management of Alien Plant Invasions. EMAPI, Lisbon, Portugal, September 2017.

Rodríguez, J., Novoa, A., Thompson, V., Cordero-Rivera, A., Richardson, D.M. and González, L. Novel interactions between *Carpobrotus edulis* and invertebrate species in the native and non-native range. EMAPI, Lisbon, Portugal, September 2017

Shackleton, R., Bennett, B., Estevez, R., Fisher, A., Kull, C., Larson, B., Marchante, E., Marchante, H., Novoa, A., Potgieter, L., Richardson, D.M., Shackleton, C., Witt, A. and S Vaz. Factors driving people's knowledge and perceptions of invasive species. EMAPI, Lisbon, Portugal, September 2017.

National posters

Burness, A., Williams, V., Byrne, M.J. 2017. The richness, diversity, viability and escape potential of alien medicinal plant species introduced into South Africa by the largest immigrant groups. 44th Annual Research Symposium on the Management of Biological Invasions, CSIR International Conference Centre, Pretoria, South Africa, 4 – 6 July. Poster.

Cowie, B.W., Witkowski, E.T.F., Venter, N. & Byrne, M.J. 2017. Bugweed Biocontrol: new insights and future prospects. Combined Congress of the Entomological and Zoological Societies of Southern Africa, Pretoria, July 3-7.

Gumede, T., and Downs, C.T. (2017). Dietary preference of the common myna, an invasive alien bird in South Africa. ZSSA, Pretoria, July 2017.

Le Granje, A., Brettschneider, H., Chimimba, C.T. & Bastos, A.D.S. (2017). Bartonella prevalence and diversity in commensal and wild populations of *Mastomys coucha* (Rodentia: Muridae) from South Africa. Combined Congress of the Entomological and Zoological Societies of Southern Africa. 3-7 July 2017. CSIR International Convention Centre, Pretoria, South Africa.

Nelufule, M., Taylor, P.J., Vise, C., Madden, M., Linden, V., Mphethe, V., Kingston, T., Venter, S.M. 2017. Surviving in a harsh environment: bats, water & baobabs in the dry Limpopo Valley. 8th Oppenheimer De Beers Group Research Conference 17-18 October 2017, De Beers Headquarters, Johannesburg.

Ramulifho, P.A., Foord, S.H. Environmental Flow Requirements and response of macro-invertebrate populations in the Luvuvhu river basin. ESSA and ZSSA combined congress 2017. Pretoria, July 3-7, 2017.

Ramulifho, P.A., Foord, S.H., Rivers-Moore, N.A., Dallas, H.F. Variability analyses of long-term flow and water temperature regimes in the Luvuvhu River Catchment (LRC). 14th International Water Association Specialist Conference on watershed and river basin management. Skukuza, October 9-11, 2017.

Thwala, T. and Foxcroft, L.C. Mapping and monitoring of alien invasive plants in Kruger National Park. 44th Annual Research Symposium on the Management of Biological Invasions in Southern Africa, CSIR, Pretoria, July 2017.

Turnbull, M., Chimimba, C. & Jansen van Vuuren, B. (2017). Comparing genetic patterns in native and introduced species. Combined Congress of the Entomological and Zoological Societies of Southern Africa. 3-7 July 2017. CSIR International Convention Centre, Pretoria, South Africa.

Education and training

Students supported by the Centre in 2017

Name	Citizenship	Institution	Race	Gender	Status	Funding
B Sc (Hons.) / 4th year B Agric.						
Mr Lee-Roy Arendse	South Africa	Stellenbosch University	Coloured	M	Completed	Full
Ms Nasiphi Bitani	South Africa	University of KwaZulu-Natal	Black	F	Completed	Independent
Ms Icky Chauke	South Africa	University of Venda	Black	F	Completed	Full

Name	Citizenship	Institution	Race	Gender	Status	Funding
Ms Bianca Hagen	South Africa	Stellenbosch University	White	F	Completed	Independent
Mr David Kesner	South Africa	Stellenbosch University	White	M	Completed	Independent
Ms Lindelani Makuya	South Africa	University of Pretoria	Black	F	Completed	Partial
Ms Mancha Ramotjiki	South Africa	University of Venda	Black	F	Completed	Full
Ms Megan Reid	South Africa	Rhodes University	White	F	Completed	Independent
Ms Nokubonga Thabethe	South Africa	University of KwaZulu-Natal	Black	F	Completed	Partial
Ms Nicole Voster	South Africa	Stellenbosch University	White	F	Completed	Partial
Ms Staci Warrington	South Africa	Stellenbosch University	White	F	Completed	Independent
Masters						
Mr Luca Afonso	South Africa	Stellenbosch University	White	M	Current	Independent
Ms Patricia Begwa	South Africa	University of the North West	Black	F	Completed	Independent
Ms Lesley Bloy	South Africa	Rhodes University	White	F	Current	Partial
Ms Liana de Araujo	South Africa	Stellenbosch University	White	F	Current	Full
Ms Debbie Du Preez	South Africa	Nelson Mandela University	White	F	Completed	Independent
Ms Thobeka Gumede	South Africa	University of KwaZulu-Natal	Black	F	Completed	Independent
Ms Nicolene Hellstrom	South Africa	Stellenbosch University	White	F	Dismissed	Independent
Ms Catherine Keanly	South Africa	Stellenbosch University	White	F	Current	Partial
Ms Dianah Kutama	South Africa	Stellenbosch University	Black	F	Current	Full
Ms Marike Louw	South Africa	Stellenbosch University	White	F	Current	Full
Mr Nkoliso Magona	South Africa	Stellenbosch University	Black	M	Completed	Independent
Ms Ndivhuwo Maligana	South Africa	University of Pretoria	Black	F	Current	Full
Mr Phil McLean	South Africa	Stellenbosch University	White	M	Completed	Partial
Ms Ella Elizabeth Morran	South Africa	Stellenbosch University	White	F	Current	Independent
Ms Puseletso Motsomane	South Africa	University of Pretoria	Black	F	Current	Partial
Mr Takalani Nelufule	South Africa	University of Pretoria	Black	M	Current	Partial
Mr Vhutali Nelwamondo	South Africa	University of Pretoria	Black	M	Resigned	Partial
Ms Khensani Nkuna	South Africa	Stellenbosch University	Black	F	Current	Independent
Ms Sinazo Ntsonge	South Africa	Rhodes University	Black	F	Completed	Independent
Ms Elizabeth Opperman	South Africa	Stellenbosch University	White	F	Completed	Full
Ms Mmatsawela Ramahlo	South Africa	University of Pretoria	Black	F	Current	Full
Ms Anneke Schoeman	South Africa	University of the North West	White	F	Current	Full

Name	Citizenship	Institution	Race	Gender	Status	Funding
Mr Cavin Shivambu	South Africa	University of Pretoria	Black	M	Current	Independent
Ms Thabang Sibiya	South Africa	Stellenbosch University	Black	F	Pending overtime	Independent
Ms Lisa Skein	South Africa	Stellenbosch University	White	F	Level upgraded	Full
Ms Kirstin Stephens	South Africa	Stellenbosch University	White	F	Current	Full
Mr Thomas Stielau	South Africa	University of Cape Town	White	M	Pending overtime	Independent
Ms Marliese Truter	South Africa	University of the North West	White	F	Current	Full
Ms Sophia Turner	South Africa	Stellenbosch University	White	F	Current	Partial
Ms Georgina Wilson	South Africa	University of Pretoria	White	F	Completed	Independent
PhD-upgraded from Masters						
Mr Brent Abrahams	South Africa	Stellenbosch University	Coloured	M	Current	Full
Ms Susan Canavan	Ireland	Stellenbosch University	White	F	Current	Independent
Mr Mlungele Nsikani	Zimbabwe	Stellenbosch University	Black	M	Current	Independent
Mr Stuart Hall	South Africa	Stellenbosch University	White	M	Completed	Independent
PhD						
Ms Karla Alujevic	Croatian	Stellenbosch University	White	F	Current	Independent
Mr Antoine Bahizi	Rwanda	Stellenbosch University	Black	M	Pending overtime	Independent
Ms Maria Castillo	Chile	Stellenbosch University	White	F	Current	Independent
Mr Chad Cheney	South Africa	Stellenbosch University	White	M	Pending overtime	Independent
Mr Blair Cowie	South Africa	University of the Witwatersrand	White	M	Current	Independent
Ms Genevieve Diedericks	South Africa	Stellenbosch University	White	F	Completed	Independent
Ms Patricia Duncan	South Africa	Stellenbosch University	White	F	Current	Independent
Ms Rolanda Julius	South Africa	University of Pretoria	Coloured	F	Pending overtime	Independent
Ms Clova Jurk-Mabin	United Kingdom	Stellenbosch University	White	F	Completed	Partial
Mr Dumisani Khosa	South Africa	Rhodes University	Black	M	Current	Partial
Ms Natasha Kruger	South Africa	Stellenbosch University	White	F	Current	Partial
Ms Sandra MacFadyen	South Africa	South African National Parks	White	F	Pending overtime	Independent
Ms Thabitha Maimela	South Africa	University of Pretoria	Black	F	Current	Partial
Ms Ingrid Ané Minnaar	South Africa	Stellenbosch University	White	F	Pending overtime	Independent
Mr Lubabalo Mofu	South Africa	Rhodes University	Black	M	Current	Partial
Mr Nitya Mohanty	India	Stellenbosch University	Indian	M	Current	Independent

Name	Citizenship	Institution	Race	Gender	Status	Funding
Mr Mohlamatsane Mokhatla	South Africa	Stellenbosch University	Black	M	Pending overtime	Independent
Ms Jeanne Mukarugwiro	Rwanda	University of the Witwatersrand	Black	F	Current	Full
Ms Savannah Nuwagaba	Ugandan	Stellenbosch University	Black	F	Completed	Independent
Ms Koebraa Peters	South Africa	Stellenbosch University	Coloured	F	Completed	Independent
Mr Luke Potgieter	South Africa	Stellenbosch University	White	M	Current	Independent
Ms Davina Saccaggi	South Africa	Stellenbosch University	White	F	Current	Independent
Ms Saachi Sadchatheeswaran	Canada	University of Cape Town	Coloured	F	Completed	Independent
Ms Lisa Skein	South Africa	Stellenbosch University	White	F	Current	Full
Ms Catherine Vise	South Africa	University of Venda	White	F	Current	Independent
Mr Thozamile Yapi	South Africa	Rhodes University	Black	M	Current	Independent

*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

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 Thomas Bishop	United Kingdom	University of Pretoria	White	M	Current	Independent
Dr Katelyn Faulkner	South Africa	University of Pretoria	White	F	Current	Independent
Dr Jennifer Fill	USA	Stellenbosch University	White	F	Resigned	Independent
Dr Laure Gallien	France	Stellenbosch University	White	F	Current	Full
Dr Raquel Garcia	Portugal	Stellenbosch University	White	F	Current	Full
Dr Heidi Hirsch	Germany	Stellenbosch University	White	F	Current	Independent
Dr Sean Marr	South Africa	South African Institute for Aquatic Biodiversity	White	M	Current	Independent
Dr Ana Novoa	Spain	Stellenbosch University	White	F	Resigned	Independent
Dr Ana Nunes	Portugal	Stellenbosch University	White	F	Resigned	Independent

Name	Citizenship	Institution	Race	Gender	Status	Funding
Dr Melissa Plasman	Netherlands	Stellenbosch University	White	F	Resigned	Independent
Dr Wolf-Christian Saul	Germany	Stellenbosch University	White	M	Current	Partial
Dr Ross Shackleton	South Africa	Stellenbosch University	White	M	Resigned	Independent
Dr Florencia Yannelli	Argentina	Stellenbosch University	White	F	Current	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

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

Aquatic biology. Collaborator: Dr Tsungai Zengeya, SANBI, Kirstenbosch, Cape Town (Chimimba)

Biodiversity maintenance in African savanna systems. Collaborator: Prof. Petr Pyšek, Academy of Sciences of the Czech Republic and Charles University, Czech Republic (Foxcroft)

Biodiversity Patterns and Dynamics. Collaborator: Prof. William E. Kunin, Faculty of Biological Sciences, University of Leeds, UK (Hui)

Carp Invasions. Collaborator: Dr Tomás Maiztegui, Instituto de Limnología 'Dr Raúl A. Ringuelet' (ILPLA) (CONICET - UNLP), Laboratorio de Ecología de Peces, Argentina (Weyl)

Centrarchid fisheries and impacts. Collaborator: Prof. James Austin, Wildlife Ecology and Conservation, University of Florida (Weyl)

Centrarchid fisheries and impacts. Collaborator: Prof. Nicholas Mandrak, University of Toronto Scarborough, Canada (Weyl)

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

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

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

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

Impacts of invasive alien plants on soil properties. Collaborator: Dr Ana Novoa, Academy of Sciences of the Czech Republic (Foxcroft)

Limpopo Living Landscapes project on biodiversity, ecosystem services and climate change in Limpopo rangelands and orchards. Collaborators: Prof. Johannes Isselstein and Prof. Reimund Rötter, University of Göttingen, Germany (Taylor)

Novel detection methods for early invaders and rare species. Collaborator: Ms Becky Cudmore, Fisheries and Oceans Canada, Canada (Weyl)

Novel detection methods for early invaders and rare species. Collaborator: Prof. Nicholas Mandrak, University of Toronto Scarborough, Canada (Weyl)

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

Pathways research. Collaborator: Prof. Vincent Savolainen, Department of Life Sciences, Imperial College London, UK (Robertson)

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

Thermal properties of coloured integument: mechanisms and evolution. Collaborator: Prof. M. Shawkey, Biology Department, University of Ghent, Belgium (Clusella-Trullas).

Academic visits by Core Team Members to other institutions

Biological and Environmental Science, University of Hull, UK. Visit to K. Wollenberg, and presented a talk on 'South African frogs, the invaders and the invaded' to staff and students. (Measey)

Biological Sciences at the University of Southampton, UK. Visits to Jane Catford and Marc Rius; and delivered a talk, 'A global assessment of alien amphibian impacts in a formal framework' to staff and students. (Measey)

Biology Department at McMaster University, Canada. Visited collaborator Ben Evans' lab, and delivered a talk entitled 'Counting chirps: acoustic monitoring of cryptic frogs', in March 2017. (Measey)

Board of CapeNature. Presentation: Managing invasive alien plants in Cape Nature's protected areas (van Wilgen, with C·I·B research associate Dr David Le Maitre).

Department of Biological Sciences at the University of Toronto Scarborough, Canada. Visited Marc Cadotte, and presented a talk, 'A global assessment of alien amphibian impacts in a formal framework' to departmental staff and students in March 2017. (Measey)

IGB Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany. Collaboration on developing a global network on freshwater biodiversity conservation (Weyl)

Museum National d'Histoire Naturelle, Paris, France. Collaboration on morphometrics and sensory ecology of rodents and co-authoring of a chapter for the 2018 Lynx Edicions publication on Mammals of the World with Prof. Christiane Denys (Taylor)

Queens University Belfast, School of Biological Sciences, Northern Ireland, UK. Collaboration on functional responses (Weyl)

SANParks offices, Kruger National Park, Skukuza, South Africa. Collaboration on an alien species Risk Analysis Framework for South Africa with Llewellyn Foxcroft (Kumschick)

School of Biological Sciences, University of Bristol, UK. Visit to Marc Holderied, delivered a talk on 'Counting chirps: acoustic monitoring of cryptic frogs' to staff and students. (Measey)

UF/IFAS Nature Coast Biological Station, University of Florida, USA. Collaboration on Centrarchid fish invasions (Weyl)

University College London, UK. Meeting regarding the implementation of EICAT with Tim Blackburn, Kevin Smith, Piero Genovesi and Tom Evans (Kumschick)

University of Fribourg, Fribourg, Switzerland. Collaboration on assessment of mammals with EICAT and SEICAT with Sven Bacher and Lara Volery (Kumschick)

Western Cape Minister of Environmental Affairs. Presentation: Managing invasive alien plants in the mountain catchment areas of the Western Cape (van Wilgen, with C·I·B research associate Dr David Le Maitre).

Awards to Core Team Members

Core Team Member Colleen Downs was nominated for three 2016/2017 NSTF-South32 awards: the Lifetime Award, Research or Engineering Capacity Development Award and the Green Matter Award. Prof. Downs was awarded the Research or Engineering Capacity Development Award on 29 June 2017. Prof. Downs was awarded the Zoological Society of Southern Africa Gold Medal at their meeting held in Pretoria, 3-7 July 2017.

Prof. Downs was awarded a SA-Canada Trilateral Chair. This is an initiative jointly funded by Canada's International Development Research Centre (IDRC) and the NRF.

Research collaborations

Alien porcelain crabs. Collaborators: Prof. Christoph Schubert, University of Regensberg, Germany and Dr Rafael Lemaitre, Smithsonian Institution, Washington DC, USA (Griffiths)

Alien species Risk Analysis Framework for South Africa. Collaborators: John Wilson, SANBI and Centre for Invasion Biology, Stellenbosch University; Llewellyn Foxcroft, SANParks and C·I·B, Stellenbosch University (Kumschick)

Aquatic biology of freshwater systems. Collaborator: Professor Stephan Woodborne, iTemba Laboratories, Johannesburg (Chimimba)

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 and Prof. Nicholas Mandrak, Department of Biological Sciences, University of Toronto Scarborough, Canada. (Foxcroft)

Assessing uncertainty in impact scoring. Collaborators: Sven Bacher, Department of Biology, Unit Ecology & Evolution, University of Fribourg, Switzerland ; Lara Volery, Department of Biology, University of Fribourg, Switzerland; Bianca Hagen, Stellenbosch University; David Kesner, Stellenbosch University (Kumschick)

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)

Biodiversity and human evolution. Collaborator: Prof. Curtis Marean. Institute of Human Origins. School of Human Evolution and Social Change, Arizona State University, USA (Esler).

Biodiversity and human evolution. Collaborator: Prof. Richard Cowling. Department of Botany, Nelson Mandela University (Esler)

Biodiversity effects of animal burrows, 2016-2017. Collaborators: Maria Blanco-Perez, Imperial Collage, London; Maartin Strauss, University of South Africa; Mark Keith, University of Pretoria. (Somers)

Biodiversity maintenance in African savanna systems. Collaborator: Prof. Petr Pyšek, Academy of Sciences of the Czech Republic and Charles University, Czech Republic. (Foxcroft)

Biodiversity Patterns and Dynamics. Collaborator: Dr Vernon Visser, Centre for Statistical Ecology, the Environment and Conservation, University of Cape Town (Hui)

Biodiversity Patterns and Dynamics. Collaborator: Gordon, A. Fox, Department of Integrative Biology, University of South Florida, USA (Hui)

Biodiversity Patterns and Dynamics. Collaborators: Gadi V.P. Reddy, Western Triangle Agricultural Research Centre, Montana State University, USA (Hui)

Biodiversity Patterns and Dynamics. Collaborator: Melodie A. McGeoch, School of Biological Sciences, Monash University, Australia (Hui)

Biodiversity Patterns and Dynamics. Collaborator: Jianjun Guo, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou, China (Hui)

Biodiversity Patterns and Dynamics. Collaborator: Ana S. Vaz, Faculty of Science, University of Porto, Portugal (Hui)

Biodiversity Patterns and Dynamics. Collaborator: Mariona Roige, National Centre for Advanced Bio-Protection Technologies, Lincoln University, New Zealand (Hui)

Biodiversity Patterns and Dynamics. Collaborator: Zihua Zhao, Department of Entomology, College of Plant Protection, China Agricultural University, Beijing, China (Hui)

Biogeography and phylogeny of Australian trees. Collaborator: Dr J.T. Miller, National Science Foundation, USA (Richardson)

Bugweed, Tamarix Remote Sensing. Collaborator: Dr Solomon Newete, Agricultural Research Council (Byrne)

Carnivore Reintroduction Biology and effects on biodiversity, 2004-2017. Collaborators: Drs Kelly Marniwich & David Marneweck, Endangered Wildlife Trust; Matt Hayward, Bangor University, UK (Somers).

Centrarchid fisheries and impacts. Collaborators Prof. Micheal Allen and Prof. James Austin University of Florida, USA; Nicholas Mandrak, University of Toronto Scarborough, Canada; and Prof. Jean Vitule Universidade Federal do Paraná, Brazil (Weyl)

Chromolaena odorata and biodiversity in Hluhluwe-iMfolozi Park, 2011 – 2017. Collaborators: Dr Kate Parr, University of Liverpool; Prof. William Bond, SAEON (Somers).

Comparative aspects of fish Invasions in South America and South Africa. Collaborators: Prof. Jean Vitule, Universidade Federal do Parana, Brazil; Dr Tomás Maiztegui, Instituto de Limnología 'Dr Raúl A. Ringuelet' (ILPLA) (CONICET - UNLP), Laboratorio de Ecología de Peces, Argentina. (Weyl)

Comparing invasive success of the plant species Parthenium hysterophorus in- and outside the Kruger National Park. Collaborators: Prof. Ana Treydte, University of Hohenheim, Department of

Agroecology, Germany, and The Nelson Mandela African Institution of Science and Technology, Tanzania. (Foxcroft)

Conservation monitoring of otters in Europe and South Africa, 2011-2017. Collaborators: Zoltán Sallai, Hungarian National Parks; Dr István Lehoczky, HAKI; Dr József Lanszki, University of Kaposvár; Prof. Antoinette Kotze; Trevor McIntyre, University of Pretoria (Somers).

Determinants of species distributions in Mozambique, 2015-2017. Collaborator: Marcus Rowcliff, Imperial College London, UK (Somers).

Ecologically-based pest rodent management. Prof. Steve Belmain, Natural Resources Institute, University of Greenwich; other collaborators from University of Swaziland, University of Namibia, Association Vahatra in Madagascar, and Sekoine University of Agriculture in Tanzania (Taylor).

Ecology and biocontrol of Bugweed; Parthenium; and Lantana. Collaborator: Prof. Ed Witkowski, Wits, APES. (Byrne)

Ecology and management of invasive conifers. Collaborator: Dr M. Nunez, INIBIOMA, CONICET-Universidad Nacional del Comahue, Argentina (Richardson, van Wilgen)

Ecology and management of woody invasive alien species in East Africa. Collaborators: Dr Urs Schaffner (CABI Switzerland) and Dr Arne Witt (CABI Nairobi. Kenya) and many other collaborators (van Wilgen)

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

Functional responses in aquatic ecosystems. Collaborators: Prof. Jaimie Dick and Mr Ross Cuthbert, Queens University, UK; Dr Ryan Wassermann SAIAB; Dr Mhairi Alexander, University of the West of Scotland, UK; Dr Tatenda Dalu, Rhodes University; and Prof. William Froneman, Rhodes University (Weyl)

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

Global change effects on small mammals and bat ecosystem services (biological control of invasive crop pests). Collaborators: Prof. Teja Tscharntke & Dr Ingo Grass, University of Göttingen, Germany (Taylor).

Global phylogeny of the Hersiliidae (Araneae). Various collaborators (Foord)

Horizon scan of emerging challenges and opportunities in invasion science. Collaborator: Prof. A. Ricciardi, McGill University, Canada (Richardson)

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

Impacts of invasive alien plants on soil properties. Collaborator: Dr Ana Novoa, Academy of Sciences of the Czech Republic, Czech Republic. (Foxcroft)

Insect low temperature biology. Prof. Vlad Kostal and Dr Petr Simek, Institute of Entomology, Czech Academy of Sciences, Czech Republic; and Prof. Jesper Sorensen, Department 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)

Insect niche shifts. Collaborator: Dr Belinda Gallardo, IPE-CSIC Pyrenean Institute of Ecology, Zaragoza, Spain. (Hill, Terblanche)

Insect pest and pathogen accumulation of non-native trees. Collaborators: Professors B. Slippers & M.J. Wingfield, FABI, University of Pretoria (Richardson)

Metabolic fuel use. Collaborators: Prof. Marshall McCue, St Mary's University, San Antonio, Texas, USA (Terblanche, Clusella-Trullas)

Microbiomes of Australian acacias. Collaborators: Prof. Phil Hulme, Lincoln University, Christchurch, New Zealand (Le Roux)

National Alien Grass Working Group (incl. bamboos). Various collaborators at SANBI, CSIR, Rhodes, UCT. (Richardson, Wilson)

National Alien Cactus Working Group. Various collaborators at SANBI, PPRI, DEA, DAFF, Rhodes University, CapeNature. (Wilson)

Novel detection methods for early invaders and rare species. Collaborators: Prof. Nicholas Mandrak, University of Toronto Scarborough, Canada; Prof. Hugh MacIsaac, University of Windsor, Canada; Prof. Anthony Ricciardi, McGill University, Canada; and Dr Steven Crookes, University of Windsor, Canada. (Weyl)

Opuntia and Tamarix genetics. Collaborator: Dr Kelsey Glennon, Wits, APES. (Byrne)

Oxford University Press Book project: Biology of Mediterranean-Type Ecosystems. Collaborator: Drs Anna Jacobsen and Brandon Pratt, California State University, USA (Esler).

Parasites of Harmonia axyridis. Collaborator: Danny Healwaters, Harvard University, USA (Clusella-Trullas)

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

Phenotypic plasticity. Collaborators: Prof. Ary Hoffmann, University of Melbourne, Australia; Prof. Carla Sgro, Monash University, Australia (Terblanche)

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. (Barton, Terblanche)

Proteaceae: research and management priorities in a changing world. Collaborator: Dr Frank Schurr. Plant Ecology and Nature Conservation, University of Potsdam, Germany (Esler).

Remote Sensing. Collaborator: Dr Elhadi Adam, Wits, GAES. (Byrne) *Tamarix*. Collborator: Prof. Glynis Goodman Cron, Wits, APES. (Byrne)

Restoration of Natural Capital. Collaborator: Dr David Le Maitre, CSIR, Stellenbosch (Esler)

Restoration of Natural Capital. Collaborator: Prof. James Blignaut. ASSET, Jabenzi, Beatus & Department of Economics, University of Pretoria (Esler)

Role of native avian frugivores in dispersal and germination facilitation of invasive American bramble (Rubus cuneifolius) in South Africa. Collaborators: Zacharides, C., Plant Protection Research Institute; Rushworth, I. Ezemvelo KZN Wildlife; Tedder, M. University of KwaZulu-Natal (Downs).

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

Scientific and normative foundations for the valuation of alien species impacts. Collaborator: Prof. Franz Essl, University of Vienna, Austria (Richardson)

Scientometrics of WfW literature. Collaborator: Dr Nadia Sitas. CSIR, Stellenbosch (Esler)

Small carnivores in space and time, 2012-2017. 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 (Chimimba)

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

Social-ecological changes associated with plant invasions. Collaborators: Prof. C. Kull, University of Lausanne, Switzerland and Prof. C. Kueffer, ETH, Zurich, Switzerland (Hui, Richardson)

Soil nutritional status in areas invaded by alien trees. Collaborators: Prof. D.A. Cowan and Dr A. Valverde, Centre for Microbial Ecology and Genomics, Department of Genetics, University of Pretoria (Le Roux, Richardson)

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

Tamarix biocontrol. Collaborator: Dr Tom Dudley, Marine Science Institute, University of California, USA (Byrne)

Tamarix biocontrol. Collaborator: Dr Dan Bean, Colorado Department of Agriculture, USA (Byrne)

Tamarix biocontrol. Collaborator: Dr Massimo Cristifaro, Academia Nazionale Italiana di Entomologia, Italy (Byrne)

Taxonomy of bamboos. Collaborator: Dr Maria S. Vorontsova, Royal Botanic Gardens Kew, UK (Richardson, Wilson).

Information brokerage

Popular articles and talks

Articles

Anonymous. 2017. Scientists assess invasive alien plant control in Kruger. *The Water Wheel*, pp. 7.

Anonymous. 2017. South Africa's first biological invasions status report underway. *The Water Wheel*, pp. 6.

Duvenage, E. 2017. Felling pines: doing it sooner rather than later is better for fynbos. *AgriCultureKultuur*, pp. 52.

Kriel, G. 2017. Tips for restoring fynbos in pine plantations. *Farmer's Weekly*, pp. 22.

Phillips, L. 2017. Redclaw crayfish spread devastates ecosystems. *Farmer's Weekly*, pp. 19.

Rebelo, A. & Measey, J. 2017. Assessing the impacts of invasive amphibians *FrogLog* 118(1), pp. 27-28.

Talks

Downs, C.T. 2017. *Cape Parrot Distribution: Importance of Citizen Scientists*. Crocworld Conservation Centre. 10 June 2017.

Downs, C.T. 2017. *Nile Crocodiles in KwaZulu-Natal*. Crocworld Conservation Centre. 10 Sept 2017

Downs, C.T. 2017. *Persistence of wildlife in urban areas: A KwaZulu-Natal perspective*. National Science Week, UKZN, PMB campus. 11 Aug 2017.

Downs, C.T. 2017. *Biodiversity*. National Science Week, UKZN, Westville campus. 8 Aug 2017

Downs, C.T. 2017. *The importance of curiosity*. Guest speaker at Mtinzini Primary School Annual Prize-giving. 30 Nov 2017.

Downs, C.T. 2017. *Urban ecosystems: An overview of urban biodiversity research*. BirdLife Port Natal AGM. 18 Feb 2017.

Foxcroft, L.C. 2017. *Biological Invasions - status, threats and options*. Mpumalanga University Nature Conservation Department, Skukuza. 6 and 10 August 2017.

Foxcroft, L.C. 2017. *The Kruger experience: problems and solutions to biological invasions.* Organization for Tropical Studies, Skukuza. 15 January and 26 September 2017.

Measey, J. 2017. *Cape platanna conservation*. False Bay Nature Reserve Protected Area Advisory Committee. 5 December 2017.

Media interactions

Newspaper articles

Bega, S. 2017. Alien invasion is a double-edged sword. *Saturday Star*, 6 May 2017.

Bega, S. 2017. Biological invaders a danger for SA, says draft report. *Sunday Weekend Argus*, 7 May 2017.

Bega, S. 2017. SA famine threat from toxic alien. *Saturday Star*, 11 February 2017.

Duvenage, E. 2017. Student looks into fynbos rehabilitation. *Bolander*, 22 November 2017.

Farber, T. 2017. Fynbos seeds will not wait forever. *The Times*, 21 November 2017.

Van Jaarsveld, T.A. 2017. Uncovering secrets of platannas. *SANPARKS Times*, 01 March 2017.

Watson, A. 2017. Progress for DNA detectives. *The Citizen*, 21 August 2017.

Articles published by Stellenbosch University

Anonymous. 2017. SU boasts record number of NSTF finalists, Stellenbosch University News [online] 24 May 2017. Available at: https://www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=4908

Anonymous. 2017. US spog met rekordgetal NWTF-finaliste, Universiteit van Stellenbosch Nuus [aanlyn] 24 Mei 2017. Available at: https://www.sun.ac.za/afrikaans/Lists/news/DispForm.aspx?ID=4828

Anonymous, 2017. Boekskenking gee Iimbovane-mierprojek 'n hupstoot, Universiteit van Stellenbosch Nuus [aanlyn] 05 Junie 2017. Available at: https://www.sun.ac.za/afrikaans/Lists/news/DispForm.aspx?ID=4855

Anonymous, 2017. Book donation boosts Iimbovane ant project, Stellenbosch University News [online] 05 June 2017. Available at: https://www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=4935

Duvenage, E. 2017. Felling pines: doing it sooner rather than later is better for fynbos, Stellenbosch University News [online] 15 November 2017. Available at: https://www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=5277

Duvenage, E. 2017. Die afkap van denneplantasies: doen dit eerder vroeër as later vir fynbos se onthalwe, Universiteit van Stellenbosch Nuus [aanlyn] 05 Junie 2017. Available at : https://www.sun.ac.za/afrikaans/Lists/news/DispForm.aspx?ID=5197

Measey, J. 2017. Handel in wildlewe versprei siektes en indringerspesies, Universiteit van Stellenbosch Nuus [aanlyn] 09 Maart 2017. Available at: https://www.sun.ac.za/afrikaans/Lists/news/DispForm.aspx?ID=4652

Measey, J. 2017. Trade in wildlife spreading disease and invasive species, Stellenbosch University News [online] 09 March 2017. Available at: https://www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=4732

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Duvenage, E. 2017. Felling pines for fynbos restoration, Agriorbit [online] 20 November 2017. Available at: https://agriorbit.com/fell-pines-fynbos-restoration/

Duvenage, E. 2017. Felling pines: doing it sooner rather than later is better for fynbos, Science Daily [online] 22 November 2017. Available at: https://www.sciencedaily.com/releases/2017/11/171122103541.htm

Duvenage, E. 2017. Felling pines: doing it sooner rather than later is better for fynbos, Bolander [online] 22 November 2017. Available at: https://www.bolanderlifestyle.co.za/news/student-looks-into-fynbos-rehabilitation-12100669

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Watson, A. 2017. Progress for DNA detectives, The Citizen [online] 21 August 2017. Available at: https://citizen.co.za/news/south-africa/1619642/progress-for-dna-detectives/

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Radio and television

Downs, C.T. Interview on SAFM about research awards, October 2017.

Galloway, A. 2017. Interview on Radio Sonder Grense (RSG), about research on the restoration of fynbos after pine felling, November 2017.

Galloway, A. 2017. Interview on Smile FM about research on the restoration of fynbos after pine felling, November 2017.

Measey, J. Interview on Kaapse Kansel 729AM about Arum Lilly Frogs, April 2017.

Measey, J. Interview with Tim Neary on Sappi Nature Journal, Radio Today about research conducted on platanna hybridization, May 2017.

Measey, J. Invasion Science podcast: Freshwater invasions, December 2017.

Van Wilgen, B.W. Interview with John Maytham, on Cape Talk Radio, about the effectiveness of alien plant management, May 2017.

Service provision

International panels and committees

African Wildlife Institute, Advisory Board (Hui, Richardson)

BirdLife SA (Honorary President; 2016-2020) (Downs)

COST Action TD1209 'Alien Challenge': MC Observer (Kumschick)

EICAT Authority: Convener (Kumschick)

Future Earth bioDISCOVERY Core Project, Scientific Committee (Weyl)
GEO BON Species Populations Working Group (Wilson)
Global Biodiversity Information Facility: Task Group Member on Data Fitness for Use in Research on Invasive Alien Species (Wilson)
Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment: Review Editor (Esler)
International Plant Sentinel Network: International Advisory Group (Wilson)
Invasive Organism Observation Information Charter: A Task Group of Biodiversity Data Quality Interest Group. Biodiversity Information Standards (TDWG) (Wilson)
IUCN Mediterranean-Type Ecosystem Thematic Group (Esler)
IUCN Species Survival Commission (SSC) - Conifers (Richardson)
IUCN Species Survival Commission (SSC) - Freshwater Fish Specialist Group (Weyl, Regional Chair)
IUCN Species Survival Commission (SSC) - Invasive Species Specialist Group (Foxcroft, Kumschick, Richardson, Wilson)
IUCN Species Survival Commission (SSC) - Ladybird Specialist Group (Clusella-Trullas)
IUCN Species Survival Commission (SSC) - Non-Volant Small Mammals Specialist Group (Taylor)
IUCN Species Survival Commission (SSC) - Otter Specialist Group (Somers)
IUCN Species Survival Commission (SSC) - Re-introduction Specialist Group (Somers)
IUCN Species Survival Commission (SSC) - Small Carnivore Specialist Group (Somers)
IUCN Species Survival Commission (SSC) - Southern African Plants Specialist Group (Richardson)
IUCN Species Survival Commission (SSC) - Spider Specialist Group (Foord)
IUCN Species Survival Commission (SSC) - Wild Dog Specialist Group (Somers)
IUCN Species Survival Commission (SSC) - Wild Pig Specialist Group (Somers)
MEDECOS Association, ISOMED, Executive Committee (Esler, South African representative)
Mediterranean Research managers International Cooperative (Esler)
National Council for Higher Education (Namibia): Chair – University of Namibia Undergraduate Curriculum Review Panel (Biological Sciences) (Chimimba)
Organisation of Tropical Studies: Board (Byrne)
Southern African Plant Invaders Atlas: Advisory Board (Robertson)

National panels and committees

Alien Species Risk Analysis Review Panel (ASRARP): Members (Kumschick, Richardson, Weyl, Wilson)
Berg River Clearing and Rehabilitation Advisory Committee: Technical Advisor (Esler)
C.A.P.E. Invasive Alien Animal Working Group South Africa: Member (Wilson)
DST-NRF Centre of Excellence for Invasion Biology Board: Alternate Industry representative SANBI Member (Wilson)
Endangered Wildlife Trust - Healthy Rivers Programme: Panel of Experts: Member (Weyl)
Flower Valley Conservation Trust Sustainable Harvesting Programme Research Working Group: Member (Esler)
Fynbos Forum Committee: Member (Esler)
Green Trust: Member, Board of Trustees (Chimimba)

HERS Advisory Board: Chair (Esler)
National Biological Control Release Application Review Committee: Reviewer (Byrne) (x2)
NSTF: Adjudication Panel Member: Vice Chairperson (Chimimba)
Quinquennial Review (QQR) of the Wits Research Institute for Malaria: Reviewer (Byrne)
Reference and Advisory Committee for the National Status Report on Biological Invasions in South Africa: Member (Richardson)
Royal Society of South Africa: Vice President (Richardson)
Project Steering Committee, Water Research Commission project 'A climate change risk assessment of water hyacinth biological control': Advisor (Robertson)
South African National Biodiversity Institute (SANBI): Board Member (van Wilgen)
South African National Biodiversity Institute: Member, Advisory Board, Research Development & Innovation Committee of the Board (Chimimba)
South African National Biodiversity Institute Genetic Monitoring Group: Member (Le Roux)
Water Research Commission 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

African Journal of Herpetology (Measey)
BioInvasions Records (Editor in Chief - Terrestrial Invasions) 2013-2017) (Wilson)
Conservation Biology (Regional Editor - Africa) (Esler)
Koedoe (Foxcroft)
World Registry of Invasive Marine Species (Thematic editor) (Robinson-Smythe)

Associate Editor

African Journal of Wildlife Research (Somers)
African Zoology (Weyl)
AoB PLANTS (Richardson)
Aquatic Invasions (Weyl)
Austral Entomology (Terblanche)
BioInvasions Records (Measey, Weyl)
Biological Invasions (Hui, Le Roux, Novoa, Richardson, Weyl)
BMC Climate Change Responses (Terblanche)
Diversity and Distributions (Robertson, Wilson)
Forest Ecosystems (Richardson)
Frontiers in Physiology (Terblanche)
Functional Ecology (Clusella-Trullas)
Ibis (Downs)
Journal of Fish Biology (Weyl)
Journal of Thermal Biology (Clusella-Trullas)

Mammalian Biology (Somers)
Management of Biological Invasions (Novoa)
Neobiota (Foxcroft, Richardson, Wilson)
PeerJ (Measey, Somers)
Salamandra (Measey)
South African Journal of Science (Chimimba)
Urban Ecosystems (Downs)

Editorial Boards

African Entomology (Terblanche)
African Natural History (Griffiths)
Animals (Griffiths)
Applied Mathematics and Computational Sciences (Hui)
Ecological Complexity (Hui)
Frontiers in Biogeography (Richardson)
Frontiers in Ecology and Evolution (Hui)
Frontiers in Insect Physiology (Clusella-Trullas)
Journal of Thermal Biology (Terblanche)
Koedoe (Griffiths, Novoa, Somers)
Nature Conservation Research(Somers)
Open Zoology Journal (Hui)
Ostrich (Downs)
Scientific Reports (Terblanche)
Scientific World Journal (Hui)
Zookeys (Foord)

Reviewing

National (South African journals)
African Biodiversity and Conservation
African Entomology
African Journal of Aquatic Science
African Journal of Marine Science
African Zoology
Bothalia – African Biodiversity and Conservation
Koedoe
South African Journal of Botany
South African Journal of Science
Transactions of the Royal Society of South Africa
Water SA

International

Acta Oecologica
African Journal of Aquatic Science
American Naturalist
Amphibia-Reptilia
Annals of the Brazilian Academy of Sciences
Animal Biology
Asian Herpetological Research
Austral Ecology Basic and Applied Ecology
Bioacoustics
Biodiversity and Conservation
Behavioural Ecology
Biological Conservation
Biological Invasions
Biological Reviews
Bulletin of Entomological Research
Conservation Biology
Conservation Letters
Current Zoology
Diversity and Distributions
Ecography
Ecology
Ecology and Evolution
Ecology Letters
Ecological Indicators
Ecological Research
Ecosystem Services
Entomological Science
Flora
Forest Ecosystems
Frontiers in Marine Science
Functional Ecology
Global Change Biology
Integrative and Comparative Biology
Integrative Zoology
Invasive Plant Science and Management
Journal of Applied Ecology
Journal of Arachnology
Journal of Arid Environments
Journal of Biogeography
Journal of East African Natural History
Journal of Ecology
Journal of Experimental Biology

Journal of Experimental Marine Biology and Ecology
Journal of Fish Biology
Journal of Herpetology
Journal of Insect Physiology
Journal of the Marine Biological Association
Journal of Thermal Biology
Journal of Zoology, London
Journal of Zoology
Landscape Ecology
Mammalia
Marine Biodiversity
Marine Biology
Marine Ecology Progress Series
Molecular Ecology
Molecular Phylogeny and Evolution
Naturwissenschaften (The Nature of Science)
Neobiota
New Phytologist
Oecologia
PLoS ONE
Proceedings of the Royal Society of London B Biological Sciences
Regional Studies in Marine Science
Restoration Ecology
Western Indian Ocean Journal of Marine Science
Journal of Biogeography
Restoration Ecology
Risk Analysis
Science of the Total Environment
Scientific Reports
Transactions of the American Fisheries Society
Trends in Ecology and Evolution
Urban Ecosystems

Grant reviews for external bodies

Claude Leon Foundation (van Wilgen)
Claude Leon Post-Doctoral awards (Somers)
Czech Science Foundation (Kumschick)
French National Research Agency (Downs)
Israel-USA Binational Trust (Downs)
JRS Biodiversity Foundation (Weyl)
National Geographic (Downs, Richardson)

National Science Foundation (Downs, Terblanche)
Natural Environment Research Council of the UK (NERC) (Downs)
Singapore NRF (Griffiths)
Springer, book proposal (Wilson)
Water Research Commission (Weyl)

Appointment reviews and committees

Botswana Institute of Science and Technology, Promotions review (Terblanche)
CSIR, South Africa: review of Strategic Environmental Assessment for Aquaculture Development (Weyl)
International Union for the Conservation of Nature (IUCN): Lake Malawi National Park, World Heritage Site assessment (Weyl)
Scientific committee of the Southern African Marine Science Symposium (Robinson-Smythe)
University of Fort Hare, South Africa: Associate Professorial Appointment (Weyl)
University of Venda (Department of Ecology and Resource Management): Appointment Committee for the positions of Lecturer/Senior Lecturer/Associate Professor/Professor (Chimimba)
University of Pretoria (Byrne)
University of Toronto at Mississauga, Canada: Promotion to Professor (Richardson)
University of Wollongong, Australia: Promotion to Professor (Richardson)

Consulting and other services rendered

Consultancy products

Kumschick, S., Wilson, J.R. and Foxcroft, L.C. (2017). Framework and guidelines for conducting risk analyses under the NEM: BA Alien and Invasive Species Regulations of 2014. Report compiled for Department of Environmental Affairs, 54 pp. (Foxcroft, Kumschick, Wilson)
Van Wilgen, B.W. and Wilson, J.R. (editors) (2017). The status of biological invasions in South Africa in 2017. Report compiled jointly by the CIB and SANBI, for submission to the Minister of Environmental Affairs.
Vise, C.A. 2017. Assessment of Invasive Alien Plants in Vhembe Biosphere Reserve - Preliminary Report on Kruger and Mapungubwe National Parks. Unpublished Report.

NRF Service Provision

NRF reviews

NRF rating applications/reviews (13)
NRF project proposal reviews (3)
NRF Masters and Doctoral Scholarships, DAAD, DST, Scarce skills (8)
South African Research Chairs Initiative (SARChi)- Reviews and Evaluation Directorate
Southern African Systems Analysis Centre (SASAC); NRF SARChi Renewal Evaluation
Thuthuka Programme Funding Application Review (2)

Panel and committee service

Panel for Competitive Funding: Plant and Agricultural Sciences

South African Research Chairs Initiative (SARCHi) chair panel

South African Research Chairs Initiative (SARCHi) selection panel

South African Research Chairs Initiative (SARCHi) review panel

South African Research Chairs Initiative (SARChi) Five Year 2nd Round Review Panel Meeting, 28 September 2017

A.2. Audited financial statements

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

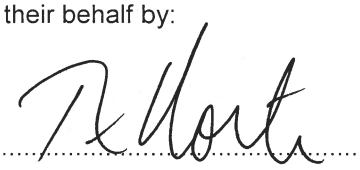
ANNUAL FINANCIAL STATEMENTS - 31 DECEMBER 2017

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

ANNUAL FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 DECEMBER 2017

CONTENTS **PAGE**

The annual financial statements have been approved by the Steering Committee and is signed on their behalf by:



29 March 2018
DATE

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Independent auditor's report

To the Council of Stellenbosch University

Our opinion

In our opinion, the financial statements of the DST/NRF Centre of Excellence for Invasion Biology (the Centre) for the year ended 31 December 2017 are prepared, in all material respects, in accordance with the basis of accounting described in note 1 to the financial statements.

What we have audited

The DST/NRF Centre of Excellence for Invasion Biology's financial statements set out on pages 5 to 13 comprise:

- the statement of financial position as at 31 December 2017;
- the statement of comprehensive income for the year then ended;
- the statement of changes in equity for the year then ended;
- the statement of cash flows for the year then ended; and
- the notes to the financial statements, which include a summary of significant accounting policies.

Basis for opinion

We conducted our audit in accordance with International Standards on Auditing (ISAs). Our responsibilities under those standards are further described in the *Auditor's responsibilities for the audit of the financial statements* section of our report.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Independence

We are independent of the Centre in accordance with the *Independent Regulatory Board for Auditors Code of Professional Conduct for Registered Auditors (IRBA Code)* and other independence requirements applicable to performing audits of financial statements in South Africa. We have fulfilled our other ethical responsibilities in accordance with the IRBA Code and in accordance with other ethical requirements applicable to performing audits in South Africa. The IRBA Code is consistent with the International Ethics Standards Board for Accountants *Code of Ethics for Professional Accountants* (Parts A and B).

Emphasis of Matter – Basis of Accounting restriction on distribution and use

We draw attention to note 1 to the financial statements, which describes the basis of accounting and the fact that the Centre has not operated as a separate entity. These financial statements are, therefore, not necessarily indicative of results that would have occurred if the Centre had been a separate stand-alone entity during the year presented or of future results of the Centre. The financial statements are prepared in accordance with the Centre's own accounting policies to satisfy the financial information needs of the Council of Stellenbosch University. As a result, the financial statements may not be suitable for another purpose.

Our report is intended solely for the DST/NRF Centre of Excellence for Invasion Biology and should not be distributed to or used by parties other than the DST/NRF Centre of Excellence for Invasion Biology. Our opinion is not modified in respect of this matter.

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Chief Executive Officer: T D Shango
Management Committee: S N Madikane, J S Masondo, P J Mothibe, C Richardson, F Tonelli, C Volschenk
The Company's principal place of business is at 4 Lisbon Lane, Waterfall City, Jukskei View, where a list of directors' names is available for inspection.
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Other Information

The Council of Stellenbosch University is responsible for the other information. The other information comprises the detail income statement set out on page 14, but does not include the financial statements and our auditor's report thereon.

Our opinion on the financial statements does not cover the other information and we do not and will not express an audit opinion or any form of assurance conclusion thereon.

In connection with our audit of the financial statements, our responsibility is to read the other information identified above and, in doing so, consider whether the other information is materially inconsistent with the financial statements or our knowledge obtained in the audit, or otherwise appears to be materially misstated.

If, based on the work we have performed, we conclude that there is a material misstatement of this other information, we are required to report that fact. We have nothing to report in this regard.

Responsibilities of the Council of Stellenbosch University for the financial statements

The Council of Stellenbosch University is responsible for the preparation of the financial statements in accordance with the basis of accounting described in note 1 to the financial statements and for determining that the basis of preparation is acceptable in the circumstances and for such internal control as the Council determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, the Council is responsible for assessing the Centre's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless the Council either intends to liquidate the Centre or to cease operations, or have no realistic alternative but to do so.

Auditor's responsibilities for the audit of the financial statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with ISAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with ISAs, we exercise professional judgement and maintain professional scepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Centre's internal control.

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- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the Council.
- Conclude on the appropriateness of the Council's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Centre's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the Centre to cease to continue as a going concern.

We communicate with the Council regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

PricewaterhouseCoopers Inc.

PricewaterhouseCoopers Inc.
Director: NH Döman
Registered Auditor
Stellenbosch
Date: 29 March 2018

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF FINANCIAL POSITION AT 31 DECEMBER 2017

	Notes	2017	2016
		R	R
ASSETS			
NON-CURRENT ASSETS		740 652.45	514 942.84
Equipment and vehicles	2	740 652.45	514 942.84
CURRENT ASSETS		12 691 007.99	12 101 856.26
Trade and other receivables	3	27 773.15	4 333.10
Stellenbosch University	4	12 663 234.84	12 097 523.16
TOTAL ASSETS		**13 431 660.44**	**12 616 799.10**
EQUITY AND LIABILITIES			
CAPITAL AND RESERVES		13 276 567.84	12 479 123.12
Accumulated funds		13 276 567.84	12 479 123.12
CURRENT LIABILITIES		155 092.60	137 675.98
Trade and other payables	5	155 092.60	137 675.98
TOTAL FUNDS AND LIABILITIES		**13 431 660.44**	**12 616 799.10**

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF COMPREHENSIVE INCOME FOR THE YEAR ENDED 31 DECEMBER 2017

	Notes	2017	2016
		R	R
Revenue		10 334 033.00	9 841 937.00
Other income		3 914 336.30	5 720 847.93
Operating expenses	7	(14 378 298.74)	(13 246 602.20)
Operating profit		(129 929.44)	2 316 182.73
Finance income		927 469.77	821 789.05
Finance cost		(95.61)	(569.86)
Surplus for the year		797 444.72	3 137 401.92
Total comprehensive income for the year		**797 444.72**	**3 137 401.92**

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF CHANGES IN EQUITY FOR THE YEAR ENDED 31 DECEMBER 2017

	2017	2016
	R	R
ACCUMULATED FUNDS		
At the beginning of the year	12 479 123.12	9 341 721.20
Total comprehensive income for the year	797 444.72	3 137 401.92
At the end of the year	**13 276 567.84**	**12 479 123.12**

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF CASH FLOWS FOR THE YEAR ENDED 31 DECEMBER 2017

		2017	2016
		R	R
CASH FLOWS FROM OPERATING ACTIVITIES			
Net surplus for the year		797 444.72	3 137 401.92
Adjustment for:			
Interest received		(927 469.77)	(821 789.05)
Interest paid		95.61	569.86
Exchange rate loss		267.34	2 535.40
Depreciation		178 374.42	310 869.75
Profit on sale of equipment and vehicles		(80 455.91)	(97 500.00)
Operating (loss) / profit before working capital adjustments		(31 743.59)	2 532 087.88
Working capital adjustments		(6 290.77)	130 793.64
(Increase) / decrease in trade and other receivables		(23 440.05)	187 597.05
Increase / (decrease) in trade and other payables		17 149.28	(56 803.41)
Cash (utilised by) / generated from operations		(38 034.36)	2 662 881.52
Interest received		927 469.77	821 789.05
Interest paid		(95.61)	(569.86)
NET CASH FLOWS FROM OPERATING ACTIVITIES		**889 339.80**	**3 484 100.71**
CASH FLOWS FROM INVESTMENT ACTIVITIES			
Equipment and vehicles purchased		(564 128.68)	(227 181.34)
Proceeds on the sale of fixed assets		240 500.56	97 500.00
Increase in amount owed by Stellenbosch University		(565 711.68)	(3 354 419.37)
NET CASH FLOWS FROM INVESTMENT ACTIVITIES		**(889 339.80)**	**(3 484 100.71)**
NET INCREASE IN CASH AND CASH EQUIVALENTS	*	-	-
CASH AND CASH EQUIVALENTS AT THE BEGINNING OF THE YEAR	*	-	-
CASH AND CASH EQUIVALENTS AT THE END OF THE YEAR	*	**-**	**-**

*** Note 4**

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

NOTES TO THE ANNUAL FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 DECEMBER 2017

1. ACCOUNTING POLICY

BASIS FOR PREPARATION

The DST-NRF Centre of Excellence for Invasion Biology ("C I B") is an inter-institutional Centre of Excellence established within the Department of Science and Technology's Centre of Excellence Programme, and is co-funded by the Department of Science and Technology through the National Research Foundation and Stellenbosch University.

Although the CIB is hosted by Stellenbosch University, the CIB conducts research and student training through a distributed network of researchers at seven South African universities and institutions. These include the Universities of Kwazulu-Natal, Cape Town, Pretoria, Venda and the Witwatersrand, and the City of Cape Town, South African National Parks (SANParks), South African Institute for Aquatic Biodiversity (SAIAB) and the South African National Biodiversity Institute (SANBI).

The DST-NRF Centre of Excellence for Invasion Biology Financial Statements, prepared in connection with the Arrangement, present the historical financial position, results of operations and cash flows of CIB. The CIB Financial Statements have been derived from the accounting records of Stellenbosch University and should be read in conjunction with Stellenbosch University's annual audited Consolidated Financial Statements and the notes thereto for the year ended 31 December 2017. The accounting records of the CIB are maintained within cost centres specifically dedicated to the activities conducted by it. All expenses attributable to the CIB are separately identifiable and are thus accounted for in these cost centres. The CIB Financial Statements thus do not necessarily reflect what the results of operations, financial position, or cash flows would have been had CIB been a separate entity.

EQUIPMENT AND VEHICLES

Equipment and vehicles are stated at historical cost and depreciation is calculated on the straight-line method to write off the cost of the assets to their residual values over their estimated useful lives as follows:

Laboratory equipment at 20% per year on the straight-line method;
Office equipment at 10% per year on the straight-line method;
Computers at 33.3% per year on the straight-line method;
Vehicles at 25% per year on the straight-line method, with a 40% residual value.

The assets' residual values and useful lives are reviewed, and adjusted if appropriate, at each balance sheet date.

IMPAIRMENT OF ASSETS

Equipment and vehicles are reviewed for impairment losses whenever events or changes in circumstances indicate that the carrying amount may not be recoverable. An impairment loss is recognised for the amount by which the carrying amount of the asset exceeds its recoverable amount, that is, the higher of an asset's selling price and value in use. For the purposes of assessing impairment, assets are grouped at the lowest level for which there are separately identifiable cash flows.

TRADE AND OTHER RECEIVABLES

Trade and other receivables originated by the centre are initially recognized at the fair value and subsequently measured at amortised cost using the effective interest rate method, less provision for impairment. Fair value is the estimated future cash flows discounted at the effective interest rate. A provision for impairment is established where there is objective evidence that the centre will not be able to collect all amounts due according to the original terms of the transaction. The amount of the provision is the difference between the carrying amount and the recoverable amount, being the present value of expected cash flows, discounted at the market rate of interest for similar borrowers.

TRADE AND OTHER PAYABLES

Trade and other payables is initially recognized at the fair value of the consideration to be paid in future for goods or services that have been received or supplied and invoiced or formally agreed with the supplier and subsequently recognized at amortised cost.

FINANCIAL INSTRUMENTS

Financial instruments on the statement of financial position include trade and other receivables, trade and other payables and a loan to Stellenbosch University. These instruments are generally shown at their estimated fair value.

Financial instruments are initially recognised when the centre becomes a party to the contractual terms of the instruments and are measured at cost, including transaction cost, which is the fair value of the consideration given (financial assets) or received (financial liabilities). Subsequent to initial recognition, these instruments are measured as set out in the applicable accounting policies.

Financial assets (or a portion thereof) are de-recognised when the centre realises the rights to the benefits specified in the contract, the rights expire or the centre surrenders or otherwise loses control of the contractual rights that comprise the financial asset.

On de-recognition the difference between the carrying amount of the financial asset and the proceeds receivable are included in the income statement.

Financial liabilities (or a portion thereof) are de-recognised when the obligation specified in the contract is discharged, cancelled or expired. On de-recognition, the difference between the carrying amount of the financial liability, including related unamortised costs and amounts paid for it are included in the income statement.

The carrying amounts of financial assets and liabilities with maturity of less than one year are assumed to approximate their fair value.

1. ACCOUNTING POLICY (continued)

INCOME RECOGNITION

Income consists mainly of a National Research Foundation grant, the contribution from the Vice-chancellor: Research to the centre and income received for work performed on sundry projects.

Income from the National Research Foundation and the Vice-chancellor: Research is recognised when it is received. Other income is recognised as it accrues.

Interest income is recognised as it accrues (taking into account the effective return on assets) unless collectability is in doubt.

FOREIGN CURRENCY TRANSLATION

(a) Functional and presentation currency
Items included in the annual financial statements are measured using the currency of the primary economic environment in which the centre operates ('the functional currency'). The annual financial statements are presented in South African Rand ("R"), which is the centre's functional and presentation currency.

(b) Transactions and balances
Foreign currency transactions are translated into the functional currency using the exchange rates prevailing at the dates of the transactions. Foreign exchange gains and losses resulting from the settlement of such transactions and from the translation at year-end exchange rates of monetary assets and liabilities denominated in foreign currencies are recognised in the income statement.

ALLOCATED OVERHEADS

Included in operating expenses is a levy charged by Stellenbosch University for administrative, information technology, and infrastructure overheads incurred by them and alllocated to all cost centres within the University based on a percentage of revenue.

PAYROLL LIABILITIES

The payroll of employees of the centre are administrated by Stellenbosch University. Although all the payroll costs are allocated to the centre, payroll liabilities of the relevant employees are carried on the balance sheet of the University. This includes post retirement liabilities, long-service awards and accrued leave pay.

CRITICAL ACCOUNTING ESTIMATES AND JUDGEMENTS

Estimates and judgements are continually evaluated and are based on historical experience and other factors, including expectations of future events that are believed to be reasonable under the circumstances.

Useful lives of assets

The useful lives of assets is estimated based on past experience and the characteristics of the specific items.

There were no critical judgements in applying the centre's accounting policies.

2. EQUIPMENT AND VEHICLES

	EQUIPMENT R	VEHICLES R	TOTAL R
31 December 2017			
Carrying amount at the beginning of the year	166 237.45	348 705.39	514 942.84
Cost	3 409 714.40	547 463.13	3 957 177.53
Accumulated depreciation	(3 243 476.95)	(198 757.74)	(3 442 234.69)
Additions during the year	130 110.56	428 514.05	558 624.61
Transfers	5 504.07	-	5 504.07
Cost	18 142.18	-	18 142.18
Accumulated depreciation	(12 638.11)	-	(12 638.11)
Disposals	-	(160 044.65)	(160 044.65)
Cost	(41 039.53)	(337 791.55)	(378 831.08)
Accumulated depreciation	41 039.53	177 746.90	218 786.43
Depreciation for the year	(143 753.85)	(34 620.57)	(178 374.42)
Carrying amount at the end of the year	158 098.23	582 554.22	740 652.45
Cost	3 516 927.61	638 185.63	4 155 113.24
Accumulated depreciation	(3 358 829.38)	(55 631.41)	(3 414 460.79)
31 December 2016			
Carrying amount at the beginning of the year	343 467.45	255 163.80	598 631.25
Cost	3 488 861.94	494 105.01	3 982 966.95
Accumulated depreciation	(3 145 394.49)	(238 941.21)	(3 384 335.70)
Additions during the year	17 509.76	209 671.58	227 181.34
Disposals	-	-	-
Cost	(96 657.30)	(156 313.46)	(252 970.76)
Accumulated depreciation	96 657.30	156 313.46	252 970.76
Depreciation for the year	(194 739.76)	(116 129.99)	(310 869.75)
Carrying amount at the end of the year	166 237.45	348 705.39	514 942.84
Cost	3 409 714.40	547 463.13	3 957 177.53
Accumulated depreciation	(3 243 476.95)	(198 757.74)	(3 442 234.69)

	2017 R	2016 R
3. TRADE AND OTHER RECEIVABLES		
Trade receivables	25 473.50	-
Other	2 299.65	4 333.10
	27 773.15	4 333.10
The ageing of these receivables are as follows:		
Up to 2 months	2 299.65	4 333.10
2 months to 6 months	25 473.50	-
	27 773.15	4 333.10

4. STELLENBOSCH UNIVERSITY

The loan to Stellenbosch University is not secured and is subject to interest rates linked to prime. The rate at 31 December 2017 was 6.9% (2016: 6.95%). The loan has no fixed terms of repayment. The bank account of Stellenbosch University is also used for the centre's purposes and amounts are transferred between the two entities via loan accounts. This loan account is thus used for this purpose.

The centre does not have its own bank account but transacts all business via the Stellenbosch University bank account. Thus, although the Centre does not have cash flows of its own, the Statement of Cash Flows represents the nature of its cash income and expenses.

5. TRADE AND OTHER PAYABLES		
Leave pay provision	89 807.40	69 053.08
Other creditors	49.84	7 080.00
Provision for audit fees	65 235.36	61 542.90
	155 092.60	137 675.98

6. INCOME TAX

The centre is not separately registred for tax, but a division of Stellenbosch University which is exempt from income tax in terms of article 10(1)(cA)(i) of the Income Tax Act.

7. OPERATING EXPENSES		
Audit fees - audit	65 235.36	53 409.90
Depreciation	178 374.42	310 869.75
Foreign exchange loss	465.40	3 053.28
Salaries	6 712 598.98	6 161 280.82
Student and post doc bursaries	2 958 674.00	-
Team member research cost	3 119 743.82	5 389 788.43
Other	1 343 206.76	1 328 200.02
	14 378 298.74	13 246 602.20

8. FINANCIAL INSTRUMENTS

Foreign currency management and exposure

The centre is exposed to exchange rate fluctuations. Payments are evaluated on an individual basis with assistance from the bank to decide whether options should be used as forward cover. No forward exchange contracts exist at year end.

Liquidity risk

Liquidity is managed by monitoring forecast cash flows. The maturity profile of liabilities are set out below:

	Carrying value	Contractual cash flows	< 1 year	1 - 5 years	> 5 years
	R	R	R	R	R
Financial liabilities					
31 December 2017					
Trade and other payables	155 092.60	155 092.60	155 092.60	-	-
Net financial liabilities	155 092.60	155 092.60	155 092.60	-	-

	Carrying value	Contractual cash flows	< 1 year	1 - 5 years	> 5 years
	R	R	R	R	R
31 December 2016					
Trade and other payables	137 675.98	137 675.98	137 675.98	-	-
Net financial liabilities	137 675.98	137 675.98	137 675.98	-	-

Credit risk management

Financial assets that can potentially subject the centre to credit risk consist of trade and other receivables. Even though the centre has debtors, it is not deemed to be a risk due to the amounts involved. The financial condition of these clients in relation to their credit standing is evaluated on an ongoing basis. The carrying values of the financial assets represent the maximum exposure to credit risk.

The credit risk related to the loan to Stellenbosch University is also considered low due to it being a financially sound related party.

Cash flow and fair value interest rate risk

As at 31 December 2017 and 2016, if the interest rate had been 100 basis points higher / lower and all other variables held constant, the centre's profit / (loss) would have increased / decreased as a result of interest received on loans by R126 687.23 (2016: R120 975.23). The other financial instruments are not exposed to interest rate risk.

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

DETAIL INCOME STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2017

	2017 R	2016 R
INCOME	**15 175 839.07**	**16 384 573.98**
National Research Foundation grant	10 334 033.00	9 841 937.00
Other income	2 800 278.94	4 638 646.05
SU contribution	1 033 403.39	984 184.00
Interest received	927 469.77	821 789.05
Foreign exchange profit	198.06	517.88
Profit on sale of equipment	80 455.91	97 500.00
EXPENDITURE	**14 378 394.35**	**13 247 172.06**
Operational expenses	7 665 795.37	7 085 891.24
Advertisements	3 900.00	17 280.00
Audit fees - current year	65 235.36	61 542.90
- previous year over provision	-	(8 133.00)
Clothing	2 677.10	-
Consumables	37 385.00	30 305.03
Consultation	7 000.00	-
Copying and stationery	72 729.24	103 307.61
Depreciation	178 374.42	310 869.75
Entertainment	10 541.07	17 221.43
Entertainment - workshops	59 115.74	-
Foreign exchange loss	465.40	3 053.28
Interest paid	95.61	569.86
Insurance	9 926.32	4 912.63
Levies	104 289.83	165 313.97
Membership and affiliation fees	2 870.00	-
Non-capitalised books	1 610.06	72 347.90
Small capital works: not capitalised	33 114.92	35 282.28
Postage, telephone and fax	81 258.94	58 339.08
Rent paid for facilities	550.00	225.00
Repairs	156 795.71	94 913.34
Software and internet	16 097.81	14 638.16
Student and post doc bursaries	2 958 674.00	-
Sundry expenses	7 722.69	6 000.91
Team member research costs	3 119 743.82	5 389 788.43
Transport and accommodation	472 958.88	456 327.99
Workshops	262 663.45	251 784.69
Personnel expenses	6 712 598.98	6 161 280.82
Salaries	6 712 598.98	6 161 280.82
SURPLUS FOR THE YEAR	**797 444.72**	**3 137 401.92**