C·I·B

DST-NRF Centre of Excellence for Invasion Biology

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Annual Report

2014

REDUCING THE RATE AND IMPACTS OF BIOLOGICAL INVASIONS

C•I•B

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Executive summary

Reporting period from 1 January 2014 to 31 December 2014

Identification

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
Date completed	:	Report: 26 February 2015
	:	Financials: 26 February 2015

Progress against our five Key Performance Areas (KPAs)

Research

The C•I•B's research tackled a wide range of disciplines, taxa, spatial and temporal scales, and scientific approaches in 2014, resulting in the most productive year in our history in terms of publications. We published 145 peer-reviewed papers in 86 journals, including contributions in the high-impact journals *PLoS Biology*, *Proceedings of the National Academy of Sciences of the USA*, *Systematic Biology*, and *Annual Review of Ecology, Evolution and Systematics*. Another seven contributions appeared in edited books. The 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 for 2012 to 2014. 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.

A review of the C•I•B's achievements between 2004 and 2014 was published during 2014, in preparation for our highly successful Partners' Conference in September (see van Wilgen et al. 2014; S. Afr. J. Sci.; 110(7/8), Art. #a0074). The overview shows that the C•I•B has emerged as a leading force in the globally competitive field of invasion biology, and has several unique features that differentiate it from research institutes working on biological invasions in other parts of the world. These include: (i) its broad research focus that embraces environmental, social and economic facets, leading to a diverse research programme and producing many integrated products, such as international collaborations, workshops and special issues of journals; (ii) an extensive network of researchers with diverse interests, spread over a wide geographical range; and the production of policy- and management-relevant research products arising from the engaged nature of research conducted by the C·I·B and (iii) its fellowship programme which is starting to attract leading

and emerging researchers from a variety of related disciplines to work with Centre members and interact with its students and post-docs.

Education and Training

The C•I•B supported 65 post-graduate students in 2014. Overall the C·I·B's student body (excluding post-doctoral associates) was 85% South African, 48% black and 58% female. Fifteen students (nine honours, four masters and two PhDs) graduated or completed their degrees in 2014 and are awaiting the first graduation ceremony in 2015. Of the 65 students supported in 2014, 23 were fully funded and 18 were partially funded, receiving a bursary top-up and/or running costs from the Centre, along with co-funding from another organisation or fund, demonstrating the power of being able to co-fund students using a flexible funding model. Twenty-four students were independently funded but still benefitted from the Centre's support in the form of supervision by a team or staff member and inclusion in Centre activities. The Centre also supported or hosted fourteen post-doctoral fellows in 2014.

The whereabouts of our graduates is tracked wherever possible; we try to keep track of students who continue to another degree or a post-doc or were employed in the field. In 2014, fifteen students graduated, and of these, five are in full time positions, three have entered internships in the field, and two are registered for subsequent post-graduate degrees.

Information Brokerage

The C•I•B held its first Partners' Conference in September 2014, to celebrate the success of current partnerships and to explore new areas of collaboration. The conference brought together Centre members and partners from research organisations, conservation authorities, NGOs and government departments, and was attended by some of South Africa's top conservationists, officials and invasive species managers. Among the topics discussed in the day-long meeting were: the current and potential future priorities of the C·I·B; long-standing research partnerships and applied partnerships, and explored possibilities to develop further partnerships in new areas. In November 2014, the C·I·B supported an international workshop on 'Drivers, mechanisms and impacts of insect invasions', organised by C•I•B post-doctoral researcher Matt Hill together with core team members John Terblanche and Susana Clusella-Trullas. The meeting brought together a diverse group of scientists across many different aspects of entomological and biological invasions research to discuss what makes insect invasions unique, and where future research efforts should be focussed. The C•I•B's Annual Research Meeting was held on 27 and 28 November 2014 at Stellenbosch University. The meeting was well-attended, with 35 guests as well as the majority of our team members, staff, students and post-docs attending.

The C•I•B continued to disseminate information about its activities via its very active web-based services, including the web site, Facebook page and Twitter account (@InvasionScience). The Information Retrieval and Submission System now contains a total of 1563 items, including 1158 publications and 405 projects datasets, theses and student outputs. The Iimbovane project continued to flourish in 2014, continuing its activities in partnership schools and subscription schools, holding two learner workshops and participating in career and environmental expos. The project stayed in touch with previous participants who are now registered for life science degrees at Stellenbosch University.

Networking

The C•I•B implemented a Fellowship Programme during 2014, and hosted its first three fellows, Profs Brendon Larson (University of Waterloo, Canada) and Anna Traveset (Mediterranean Institute of Advanced Studies, a joint institute of the Spanish Research Council and the University of the Balearic Islands, based in Mallorca, Spain), and Dr Joana Vicente (University of Évora, Portugal). In 2014 the C•I•B, through Senior Researcher Dr John Measey, initiated a collaboration with Environmental Humanities South, based at UCT's Departments of Social Anthropology and Historical Studies. The C·I·B will be involved in lecturing to MPhil and PhD students on the Environmental Humanities course.

In addition to these specific initiatives, the Centre continued to work at developing partnerships with national and international organisations and individuals who can both benefit from and advance invasion biology research.

Service Provision

C•I•B core team members, post-docs and students provided service in a variety of ways, by serving on national and international panels and committees and peer-reviewing and editing journals and periodicals. C•I•B members were editor or associate editor of 25 different journals and served on 22 unique editorial boards, as well as performing reviews for numerous journals and appointment committees, and the National Research Foundation's researcher rating process. In addition, the team produced several significant pieces of advice to government, chiefly the coordination of the *National Strategy for Dealing with Biological Invasions in South Africa* (for the Department of Environmental Affairs). This product paves the way for full implementation of Chapter 5 of the National Environmental Management: Biodiversity Act and promotion of South Africa's National Development Plan.

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

The C·I·B gives careful attention to the representation of females in all facets of its work. Although females only represent 35% of the core team (9 out of 26), females are much better represented among the C·I·B staff (94%; 16 out of 17), post-docs (50%; 7 out of 14) and students (57%; 45 out of 79). The Iimbovane project is staffed entirely by women, providing a powerful role model and informal career path guidance for potential young scientists.

Iimbovane is increasingly being drawn into nurturing learners who wish to do vacation work in the Iimbovane labs, and it is almost invariably young women who volunteer in this way (see also Section 3.2.4).

Red Flags

The average time for completion of Masters degrees for 2014 was 2.1 years – a marked improvement over previous years. Unfortunately the same cannot be reported for the time taken to complete PhD degrees – this rose to an average of 5.7 years in 2014, as several part-time students finally completed their degrees, raising the overall average time to completion. We anticipate that this trend will be widespread in South Africa in future, as we aim to raise the number of PhD graduates by involving students who are employed in full-time jobs.

General Comments

2014, the final year of the current development stage of the C•I•B, was successful in all respects. Our papers continued to appear in all the top-rated ecology journals and received many citations, and much attention in the media. The C·I·B continued to make substantial contributions to policy relating to biological invasions and associated issues in South Africa and internationally. Various measures clearly show that the Centre is widely acknowledged as a global centre of excellence in this field. New partnerships continue to be sought to ensure coverage of all geographic and thematic areas in South Africa. Our partnerships with the Natural Resources Management Programmes, the South African National Biodiversity Institute, the South African Institute for Aquatic Biodiversity and the City of Cape Town were especially productive during 2014. Options for expanding and improving these collaborations were debated at the Centre's first Partners' Conference in September 2014 and in several follow-up meetings. The C·I·B Fellowship initiative is now firmly in place and is attracting top international researchers to work with core team members.

Overall, we are in an excellent position to enter the challenging five-year phase that now faces us, in which we aim to make the Centre indispensable to its partners and ensure its sustainability over the longer term.

1 Scientific Research

1.1 Objectives

The C•I•B's research focusses on the rates and biodiversity impacts of biological invasions, how these might 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.

The C•I•B's Strategic Plan for the period 2012-2014 details the rationale for research priorities for long-term and short-term research projects. **The overarching goal is to undertake world-class research that draws on South Africa's unique biodiversity heritage and environmental problems, with a strong focus on providing practical solutions to the major problem of biological invasions**. Permanent transects in three of South Africa's mountain ranges are the foundation for the C•I•B's long-term research. An initiative to implement a long-term monitoring programme for alien invasive plants and animals in the Cape Town metropole is a recent addition to the C•I•B's long-term research portfolio.

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 a 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 given on the C•I•B's web site, http://academic.sun.ac.za/cib/.

The projects summarized below give a précis of the wide range of disciplines, taxa, spatial and temporal scales, and scientific approaches in the C•I•B's research during 2014 (Fig. 1). The reports that appear below describe a sample of research projects for which products were published in 2014, representing– the most productive year in the C•I•B's history in terms of publications. We published a record number of peer-reviewed papers (145, in 86 journals), including contributions in such high-impact journals as *PLoS Biology*, *Proceedings of the National Academy of Sciences of the USA*, *Systematic Biology*, and *Annual Review of Ecology, Evolution and Systematics*. Another seven contributions appeared in edited books.

Fig. 1 Word cloud made from the titles of all C•I•B publications for 2014.

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.

An overview of the C•I•B'S first decade

A review of the C•I•B's achievements between 2004 and 2014 was published during 2014 (van Wilgen et al. 2014; S. Afr. J. Sci.; 110(7/8), Art. #a0074). This overview shows that the C•I•B has emerged as a leading institute in the field of invasion biology globally, with several unique features that differentiate it from research institutes working on biological invasions in other parts of the world. These include the broad research focus that embraces environmental, social and economic facets, which has led to a diverse research programme and produced many integrated products; an extensive network of researchers with diverse interests, spread over a wide geographical range; and the production of policy- and management-relevant research products arising from the engaged nature of research conducted by the C·I·B.

1.2.1 Long-term collaborative research:

Long-term change in insect assemblages

The C•I•B team as a whole 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 below, followed by more detail on aims and achievements for each transect. The overall 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 the 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

Duration	Type of sampling	Sites	Replicates / site	Traps / replicate	Aspect	Sampling periods	Elevation range (m amsl)	Target groups
Cederberg: 2002-2014	climate; biological	17	4	10	W	Mar, Sep	0-1926	Ants, carabid beetles, 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, spiders*

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

Ants play important roles in the ecosystems of the Western Cape, most notably as seed dispersers and as facilitators of nutrient recycling. Therefore knowledge of their diversity and distribution is useful for understanding these systems. Furthermore, ants have been very successfully used as indicator species of environmental change in many ecosystems worldwide. To study the impacts of environmental change (e.g. global climate change, biological invasions) on biodiversity, spatially and temporarily replicated data are required.

Various publications have emerged from the long-term transects, but the most exciting current initiative is an integrated analysis of the four transects, led by Monash University, University of Oxford and the C•I•B. This will facilitate the production of high impact papers that make full use of the temporal and spatial range of sampling which has been conducted by the C•I•B and its partners since the Centre's inception. Several high impact publications and interactions are underway and will be completed between 2015 and 2017. The broad aim of the transects is to understand patterns of biodiversity across gradients of

space (e.g. elevation, climate and aspect) and time, thereby gaining insights into drivers of biodiversity.

The September sampling on Sani Pass coincides with a field trip for a third-year course (Conservation Ecology) taught in the Department of Zoology & Entomology at the University of Pretoria. Students participate in the sampling and assist with specimen identification after the field trip.

Sani Pass

Understanding how biodiversity responds to environmental change is a major challenge for conservation. Anthropogenic climate change is expected to cause dramatic changes to biodiversity and some of these changes have already been documented. Long-term surveys using standardised methods are necessary in order to understand the nature and extent of changes at the population, species and assemblage level. Studying assemblages of species across an elevation gradient makes it possible to gain valuable insights on the factors that structure these assemblages and paves the way for predicting how they may change.

During 2014, the importance of temperature and available area were evaluated as potential drivers of elevational diversity patterns. C•I•B-affiliated student, Mr Tom Bishop (registered at Oxford University, UK) and co-workers found mid-elevation peaks of species density and evenness measures (Bishop *et al*. 2014; *J. Biogeogr*. 41, 2256-2268). Abundance patterns were more complex, with a weak linear decline across elevation in the wet season and a bell-shaped curve in the dry season. The peak in species density changes in magnitude and position depending on the season, with fewer species and a more pronounced hump shape observed in the dry season than in the wet season. Temperature variables were found to be important for explaining both species density and abundance patterns. Species density was influenced by available area and showed seasonal changes at low elevations. Therefore, temperature appears to be a major driver of spatial and temporal ant diversity patterns, whereas area only has a weak influence. This long-term study is particularly valuable since it was only possible to gain key insights into the drivers of diversity patterns by sampling the ant community across the elevation gradient in two seasons over several years.

Soutpansberg

The aim of this transect is to develop a 10-year time-series and, hopefully, to document the effects of an *El Nino* event. Sampling and identification are well underway. Several partner organisations are involved with this transect, which is co-ordinated by University of Venda's Department of Zoology (Prof. Stefan Foord). The South African Environmental Observation Network (SAEON) will provide plant data for each of the 44 replicates as well as small mammal assemblages across the mountain. SPACES (Science Partnerships for the Assessment of Complex Earth system Processes) funding from Germany will provide for the characterization of thermal tolerances of ants across the mountain to develop a mechanistic

model. Earthwatch participates at each of the sites, quantifying micro-scale variation in diversity and its drivers.

Other outcomes

These transects use broadly the same sampling protocol as the Iimbovane Outreach Project's seven reference sites in protected areas in the Western Cape's fynbos and succulent karoo biomes. Iimbovane's biodiversity sampling contrasts urban, peri-urban and rural school grounds with paired protected sites matched with each school. Involvement of learners in gathering and analysing the data allows learners and educators to be involved in a 'real world' science project, and to participate in collection, processing and publication of primary biodiversity data, led by role models in science and outreach (C•I•B full time staff and volunteers).

Longer-term plans

The transects, though related, each have their own aims and purposes and their long-term futures may be distinct. For example, biological sampling on the Cederberg transect was suspended after 12 years, but will be re-instated if an *El Nino* event or similar large-scale perturbation takes place. The Sani Pass transect, on the other hand, will continue to at least 2016 (sampling commenced in 2006) and the Soutpansberg transect to 2019 (sampling commenced in 2009). Thereafter the frequency or intensity of sampling may be reduced as research products appear.

Monitoring the rate of spread of alien plant invasions and evaluating outcomes of management actions in the Cape Town metropole

Metropolitan areas such as the City of Cape Town are particularly vulnerable to the introduction of invasive alien species. As one of the hottest 'hot-spots' of biodiversity, the Cape Peninsula has the highest density and number of threatened plants of any metropolitan area in the world. Alien plant invasions have been identified as being one of the biggest threats to native biodiversity and ecosystem services. Invasive plants are also regarded as a serious fire hazard in Cape Town.

The City of Cape Town's Biodiversity Management Branch is responsible for controlling invasions and restoring functional native ecosystems in Nature Reserves, Critical Biodiversity Areas and Ecological Support Areas. A major challenge for the Branch is that funding for alien clearing operations and restoration is difficult to obtain. Management actions therefore have to be carefully justified, and monitored to identify the most effective solutions and demonstrate levels of success.

The main objective of the Invasive Species Unit is to monitor the spread of selected invasive plant species in relation to control efforts. The overall question we are trying to answer is: Is the problem of invasions getting worse, is it stabilising, or is it getting better? The C•I•B

hosts a researcher, Dr Mirijam Gaertner, who is responsible for leading the monitoring operations of the City, while post-graduate students and technical staff of the Centre assist with monitoring.

To date the team has developed the monitoring protocol and evaluated it against previous monitoring efforts, an important task if the new long-term monitoring programme is to make optimal use of existing data and knowledge. Fig. 2 below shows the relationship between the1989, 2009 and 2013 data, identifying a downward trend of invasion density in the CoCT monitoring sites.

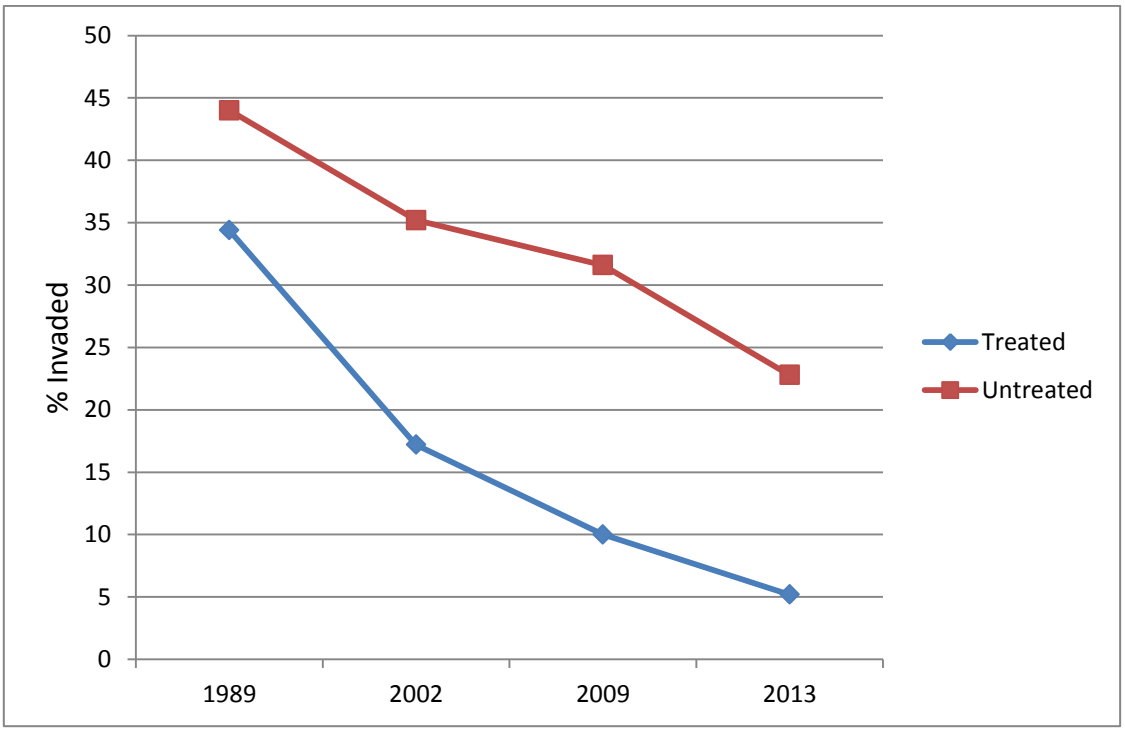

Fig. 2. Estimates based on a random sample of 20x20 plots (n=184) of the percentage of the Cape Peninsula invaded outside of the urban edge from 1989 to 2013 within treated and untreated Working for Water areas.

The future focus of the monitoring project will be the BIONET lowland areas within the COCT (Fig. 3). Monitoring plots are being used to make estimates of invasive tree cover for the following sub-groups: (1) Protected-treated areas; (2) Unprotected-treated areas; (3) Protected-untreated areas; (4) Unprotected-untreated areas, using the same sampling approach as that described above.

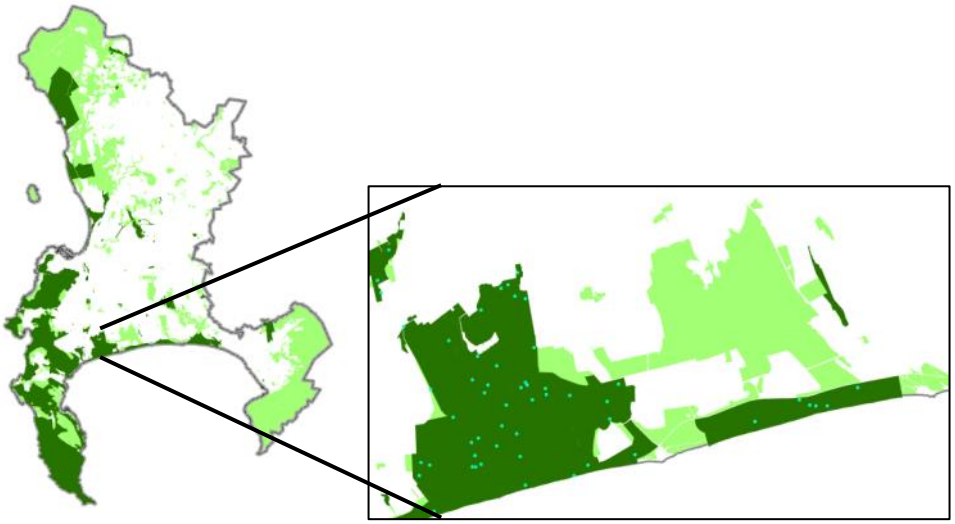

Fig 3. All green (dark and light) are the BIONET areas within the City of Cape Town boundary. The dark green areas are protected areas and parks. The inset map shows some of the randomly selected plots that will be used to make an estimate of invasive tree cover for lowland areas.

1.2.2 Short-term collaborative research

A. 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.

How should we define soil heath?

There has been a recent push by scientists and agriculturalist to try to improve (or at least maintain) 'soil health'. But what exactly is soil health? And how does one measure it? In a paper that emerged from the 2nd Meeting of the Soil Ecosystem Research Grouping in Potchefstroom in 2013 C•I•B core team members Sarah Davies and John Wilson and collaborators developed a conceptual scheme for defining soil health in terms of three key components: Abiotic; Biotic; and Socio-economic (Louw *et al*. 2014; *S. Afr. J. Sci*.; 110(5/6), Art. #a0064). They suggest that 'happy healthy' soils are those have sustainable ecological function as well as providing direct and indirect value to people's livelihoods. It is important to note, however, that the benefits derived from soils can vary across the landscape. The authors argue that the aim should be to ensure that all three aspects are needed somewhere. This work is part of the C•I•B's emerging thrust to understand the role of introduced species in soil ecology.

New species of nitrogen-fixing bacteria described

Determining the impacts of invasive species requires an understanding of biological diversity and interactions at numerous levels. During an investigation on the impacts of Australian acacias on the interactions between nitrogen-fixing bacteria (commonly known as rhizobia) and native legumes, C•I•B post-doc Nathasha Mavengere and co-workers found and described a new rhizobial species. This nitrogen-fixing species belongs to the genus *Burkholderia*, members of which are commonly associated with fynbos legumes. The new bacterium was named *Burkholderia asphalathi* after its association with the native legume, *Aspalathus abientina* (Mavengere *et al*. 2014.; *Int. J. Syst. Evol. Mircrobiol*. 64, 1906-1912) (Fig. 4).

Fig. 4. *Aspalathus abientina*; Photo: J.J. Le Roux

Reproductive Cape honey bee workers are social parasites selected to avoid foraging

C•I•B core team member Theresa Wossler continued collaborations researchers at the University of Sydney, Australia, and the Agricultural Research Council on many aspects of honey bee ecology. The Reproductive Ground Plan (RGP) hypothesis suggests that gene networks that once regulated the oviposition and foraging phases of an ancestral solitary insect's life cycle have been co-opted to establish the queen-worker dimorphism in extant eusocial insects. Queens permanently express genes that were once expressed during the oviposition phase, whereas workers express genes that were once associated with foraging. According to the RGP-forager hypothesis workers expressing a more reproductive

phenotype forage early in life and specialise in pollen collection. An alternative hypothesis suggests that workers with high reproductive potential should avoid foraging.

A 2014 study found a negative association between work foraging and reproduction among Cape honey bee *Apis mellifera capensis* workers (Roth *et al*. 2014; *Behavior. Ecol*. 25, 668-674). This suggests that workers with a predisposition towards reproduction are less, not more, likely to forage, supporting the alternative hypothesis that whenever selection favours worker reproduction, reproductive workers are selected to avoid foraging.

The role of termite mounds in savannas

Termites have important impacts in savannas, mostly through their transportation of soil nutrients both vertically and horizontally as well as by altering soil structure and hydrology. Termite mounds contribute to the spatial heterogeneity of ecological processes in many savannas. However, the factors that influence mound distributions across the landscape are not well understood. A study lead by C•I•B PhD student Andrew Davies mapped the distribution of termite mounds across a rainfall gradient within a river catchment of the Kruger National Park to determine the distribution of the mounds spatially and the factors that determine these patterns (Davies *et al*. 2014; *Ecography* 37, 852-862). They assessed how different factors were associated with the distribution and height of termite mounds at three spatial scales: the entire catchment, among three broad vegetation types, and on individual hillslope crests. Abiotic factors such as the underlying geology and mean annual precipitation shaped mound densities at broad scales, while local hill slope morphology strongly influenced mound distribution at finer scales, emphasising the importance of spatial scale when assessing mound densities. Mounds showed a clustered pattern throughout the landscape, occurring at relatively high densities on crests, which are nutrient-poor parts of the landscape. The contribution to biodiversity and ecosystem functioning that mounds provide is not uniform throughout landscapes, but varies considerably with spatial scale and context.

Termite mounds form nutrient hotspots in savannas that support high plant diversity. However, little is known about grass communities on and around mounds or how important the mounds are in savannas along nutrients and rainfall gradients. A study was undertaken in the Kruger National Park to explore these issues (Davies *et al*. 2014; *J. Veg. Sci*. 25, 1405-1416). Grass diversity and tissue nitrogen concentrations were measured on and off termite mounds and along transects away from mounds to calculate the spatial influence of termite mounds on savanna grass communities. Although there were fewer species of grasses on mounds than in the savanna matrix, the species composition varied significantly. Higher nutrient concentrations were found in grasses located on mounds than away from mounds. This pattern became more distinct with increasing rainfall. The spatial extent of these nutrient-rich grasses also differed across the rainfall gradient, with a larger sphere of influence around mounds in wetter areas. Mounds distinctly altered grass communities over

about 2% of the entire landscape. The study shows that termite mounds are important components of savanna heterogeneity, and that the functional importance of mounds increases with increasing rainfall.

A new common currency for quantifying and linking biodiversity patterns and relationships
Mounting challenges from man-made environmental change means that measuring and tracking changes in biodiversity is becoming increasingly more important. Scientists have for decades debated how best to measure biodiversity and to track changes in its properties.

Zeta diversity, as defined in a paper by C•I•B core team member Cang Hui and Research Associate Melodie McGeoch (Hui & McGeoch 2014; *Am. Nat*. 184: 684-694), is the average number of species shared by any number of sites or habitats. It can be used to calculate a broad range of existing diversity metrics, and to quantify continuous change in biodiversity over landscapes. It can also be used for examining if environmental change affects rare and common species differently, and to test hypotheses about the relative importance of deterministic (niche-based) versus stochastic (neutral) processes in generating patterns in biodiversity.

In the past, changes in the presence or absence of species in a community between sites (or over time) was calculated by working out which species any and all pairs of sites have in common. This is called diversity turnover, or beta diversity. Estimating changes in biodiversity by comparing two sites at a time in this way has become the norm. However, when three or more sites are involved, beta diversity can't partition the total community into components uniquely shared by each pair of sites or shared by all sites. We are missing important information on the nature and condition of biodiversity with these pairwise beta diversity and individual site richness numbers.

There is a second important challenge in the study and description of biodiversity. This is the fact that different mathematical languages are used to calculate and depict various diversity patterns and relationships. As a result it has not been possible to integrate various models of biodiversity. Doing so is one of ecology's main goals. Zeta diversity provides a mathematical link between the patterns that we see, for example, in species richness, species endemism and relative range sizes. Zeta diversity provides a common currency for application across a broad range of problems in ecology and conservation planning, for understanding the processes that drive patterns in biodiversity and the impacts of global change.

Determinants of carnivore space use

Work on this theme, though not 'invasion biology' per se, is important for elucidating the factors that determine the composition of the top-predator guild in southern African ecosystems. Such insights are crucial for providing sound management advice for, among other things, re-introduction of predators to areas where they have been extirpated.

Large carnivores play a key role in regulating terrestrial ecosystems, and competition between them is considered a key ecological factor affecting carnivore species within the same guild. World-wide few protected areas still exist that are large enough for wide-ranging large carnivores. In addition, subordinate species such as cheetahs and African wild dogs tend to move into areas with low densities of their dominant competitors which frequently fall inside agricultural areas. This necessitates a conservation action plan on a countrywide scale covering both conservation and human-dominated areas, and also conservation plans for smaller fenced areas where they all occur. Understanding the dynamics of large carnivore distribution and factors threatening their survival on a national and local level is thus crucial for developing effective management strategies, especially in critical areas required for the maintenance of healthy viable populations. The three main factors that influence the distribution and population viability of large carnivores are prey availability, interspecific competition, and conflict with humans. Each large carnivore species has its preferred prey species and prey in preferred weight ranges, and the availability of prey most likely plays the primary role in determining the suitability of an area for persistence. However, in areas where natural prey is scarce, predators often resort to killing livestock which is the most widespread cause of conflict with people.

As protected areas are rarely large enough to maintain viable large carnivore populations, non-protected areas are important in the conservation of large carnivores. However, carnivore populations in non-protected areas are frequently in conflict with rural communities, commercial farmers and game keepers, and retaliatory killing in response to human–large carnivore conflict is common. Such conflict-related killing can have both direct and indirect demographic consequences for carnivore populations. For example, legal and illegal retaliatory killing of large carnivores can result in the removal of mature, reproductively active individuals. Retaliatory killing can thus hamper carnivore population sustainability as well as impede the recovery of threatened populations.

In 2014, C•I•B core team member Michael Somers and collaborators looked at various aspects of the three things that determines carnivore use of habitats (prey, competition and humans), from local use in a reserve (Darnell *et al*. 2014), to how humans affect them (Andresen *et al*. 2014; *J. Zool*. 292, 212–220; Everett *et al*. 2014; *PLoS ONE 9*: e99389) to a broad country-wide scale (for Botswana) looking at prey availability.

At a larger scale, in Botswana, wild prey and livestock occur widespread across the country. Thus local prey availability and numbers of livestock can serve as indicators of suitable habitats for the different large carnivore species and levels of potential human-carnivore conflict. On a smaller, scale looking at competition within the guild we (Darnell *et al*. 2014; *PLoS ONE* 9, e98846) used data collected concurrently on large carnivores in Hluhluwe-iMfolozi Park (HiP) in northern KwaZulu-Natal province. We tested the hypothesis that African wild dog space use was affected by other large carnivores. Lions are a more significant threat to wild dogs as they regularly injure and kill them, while hyenas pose a significant, but less serious, threat by stealing wild dog kills. Considering the differing levels of threat, and that lion distribution in HiP is generally clustered and that hyenas are more evenly distributed on the landscape, the prediction was that wild dogs' space use would differ relative to their two main competitors, preferentially avoiding lions more strongly than hyenas. Different responses were found for wild dogs and their two main competitors. Wild dogs avoided lions, particularly during denning, through a combination of spatial and temporal avoidance. However, wild dogs did not exhibit spatial or temporal avoidance of spotted hyenas, likely because wild dog pack sizes were large enough to adequately defend their kills. Understanding that larger carnivores affect the movements and space use of other carnivores is important for managing current small and fragmented carnivore populations, especially as reintroductions and translocations are essential tools used for the survival of endangered species, as with African wild dogs.

Work in Mozambique (Andresen *et al*. 2014; *J. Zool*. 292, 212–220; Everett *et al*. 2014; *PLoS ONE* 9, e99389) has shown that although prey and other carnivores are important, humans can influence individual species of large carnivores in conservation areas. It is concerning that the natural processes that previously determined movement of top order species has been disrupted, even in a large national park.

B. Acacias as model systems for understanding invasions and impacts

Australian acacias provide a good model system for exploring the full range of challenges associated with introduced species that have: commercial and other positive benefits in certain contexts, but increasing negative impacts in others; substantial influence (positive and negative, depending on geographical and socio-political context) on ecosystem services; much value as a natural experiment of widespread introductions and plantings around the world which allows useful lessons to be learnt from other regions. This group of plants has featured prominently in research at the C•I•B since its launch and has resulted in many research products and collaborations.

Multi-scale predictive maps as a tool for managing invasive trees

Eradication of invasive alien plants requires that all populations of the plants have been found and every plant removed. This entails intensive searching, which often comes at a great expense. Maps that show where species are likely to occur are useful for guiding

searches, and may reduce the costs and increase the success of eradication operations. Such maps are based on models that explore the links between plant distributions and climatic factors in order to predict where the plants might occur.

C•I•B MSc student Haylee Kaplan and co-authors examined the factors that determine where the invasive tree hop wattle (*Acacia stricta*) occurs in the landscape (Kaplan *et al*. 2014; *Biol. Invasions* 16, 691–703). All hop wattle populations within a 1900 km² study area in the Knysna and Wilderness sections of the Garden Route were mapped. Trees were found to occur almost exclusively in forestry plantations, especially those that had recently been planted or harvested. Soil-stored seeds do not disperse far from the parent plant but are spread by road maintenance vehicles; this means that plants tend to occur in dense clumps close to roads.

These findings were combined with climatic data to construct risk maps to predict where hop wattle is likely to be found. Results indicate that searches should be done in plantations within climatically suitable zones (the southern Cape and the eastern part of the country). Vehicle searches should take place along gravel roads that cross forestry plantations, especially at recently harvested or planted plantation blocks, while searches on foot should be done within 50m of roads close to where plants have previously been found. Targeting searches in this way can reduce the search effort needed by around 80%.

This multi-scale mapping approach (Fig. 5) provides the means for designing effective strategies for managing hop wattle populations. Similar multi-scale risk mapping approaches could be developed for other invasive species.

Applying species distribution modelling in risk assessment

Predicting which introduced species are likely to become invasive is a key challenge for invasion biology. Species distribution models have been widely used to predict invasions. These models can predict the potential distribution for a species by using occurrence records and climatic predictor variables. Areas that are identified as being climatically suitable can indicate where the species is likely to be able to survive. Although these models are often used for pre- and post-border risk assessments, the data that can be used to evaluate predictions is often not available until after an invasion has occurred. However, data available for species that were tested for their suitability as forestry trees in forestry trials may be useful. The data from these trials provide historical information on intentional introductions and on their outcome, making it possible to explore factors influencing the success of introductions across different areas and for evaluating distribution models. A study led by C•I•B funded MSc Student Rethabile Motloung and several C•I•B-affiliated co-workers explored the potential for using historical data for Australian *Acacia* species used in forestry trials in southern Africa (Fig. 6) to assess the performance of climate-based species distribution models (Motloung *et al*. 2014; *NeoBiota* 20, 31-48). The researchers found

that forestry trials provided useful data for species distribution model evaluation as there is information on species that were repeatedly introduced to different localities within southern Africa with a clear indication of trial outcome (success or failure).

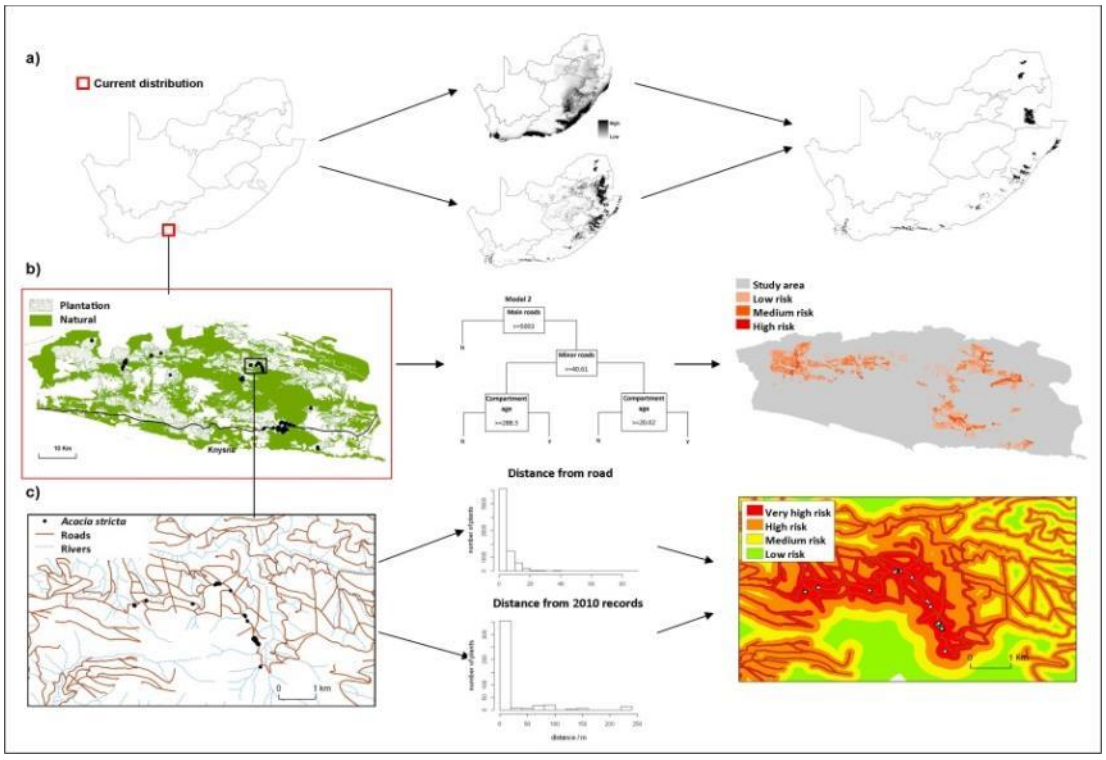

Fig. 5. Risk maps for *Acacia stricta* to improve surveillance at different spatial scales. At a national scale (a), a climate model and a map of forestry plantations were overlaid to determine where an awareness campaign should be directed; at a landscape scale (b), correlates of the known distribution (distance to particular road type and compartment age) were used to determine similar areas to be prioritised for future survey; and at a local scale (c), the position of plants found, in relation to distance to roads and locations of plants from the previous year, was used to inform criteria for detailed searches [From Kaplan *et al.* 2014; *Biol. Invasions* **16**, 691–703]

Modelling the effect of biocontrol agents on Acacia cyclops

Controlling invasive alien plants is expensive. Traditional control methods, such as mechanical and chemical control and use of fire, are particularly expensive and require re-investment over time. In contrast, the use of biocontrol agents is comparably cheap and often only needs a once-off investment.

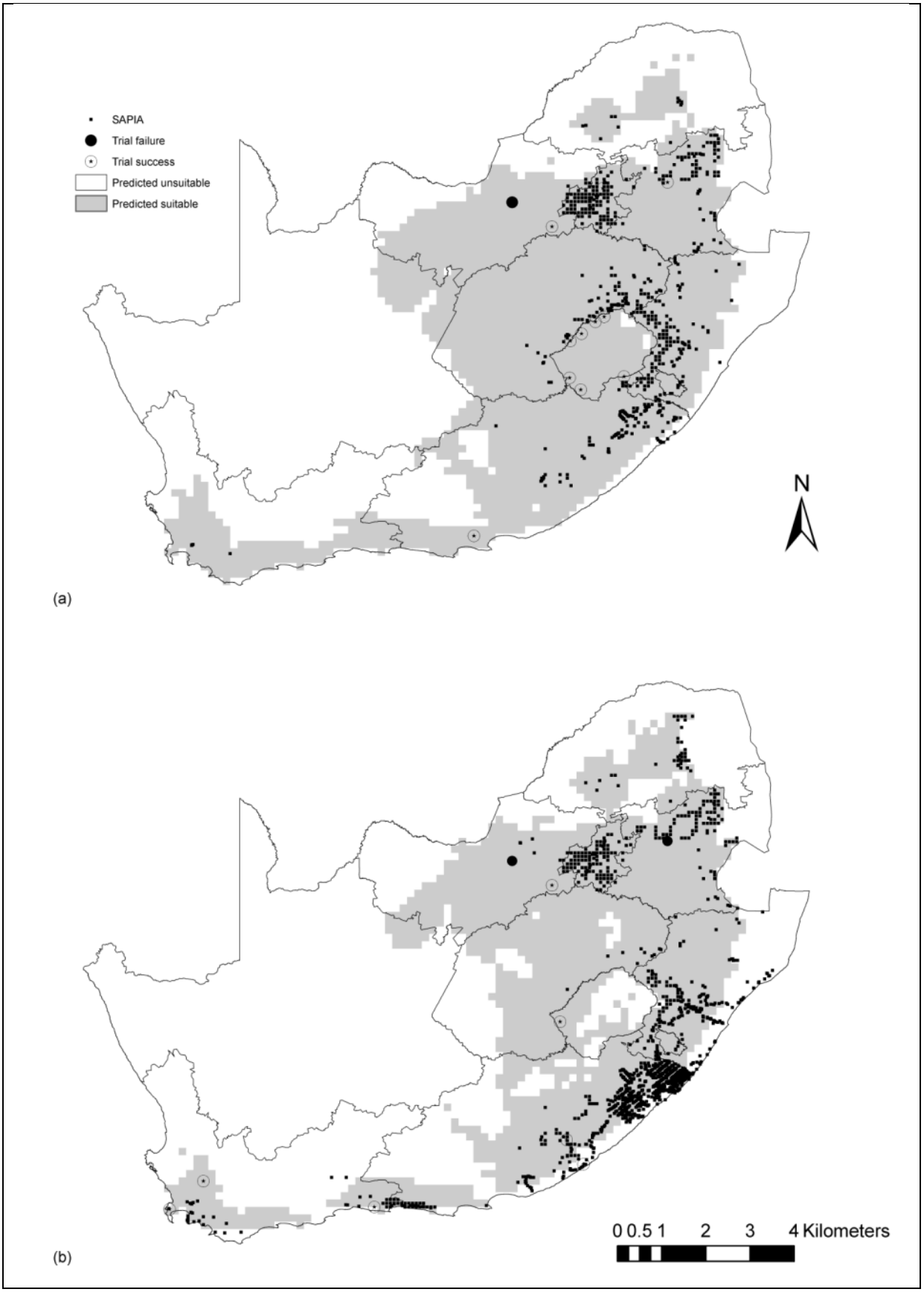

Fig. 6 Current distribution [from both forestry trials (noted as trial failure or success) and SAPIA] and potential distribution for *Acacia dealbata* (a) and *A. mearnsii* (b) in Lesotho, South Africa, and Swaziland [From Motloung *et al.* 2014; *NeoBiota* **20**, 31-48].

Biocontrol agents are usually insects, pathogens or fungi which either damage the invasive alien plant itself or reduce the production of seeds. One group of these biocontrol agents are seed-attacking agents. These destroy the flowers or the seeds of an alien invasive plant and consequently reduce its seed production. Predicting how biocontrol agents impact seed production and how seed production reacts is important for guiding further interventions. For example, such knowledge can inform researchers whether a certain agent should be released, and whether the release of a second agent is justified.

A study examined a system consisting of two seed-attacking biocontrol agents (a midge, *Dasineura dielsi* and a weevil, *Melanterius servulus*) and one invasive alien plant (*Acacia cyclops*) (Krug & Richardson 2014; *Ecol. Model*. 278, 100–113). A computer simulation model was used to predict the impact of these biocontrol agents on flowering and seed set. The paper showed that the in the system, even without biocontrol agents, fluctuations are very likely to occur and that the fluctuations increased after the release of the biocontrol agents. Nevertheless, the number of seeds produced was, on average, substantially smaller.
These results and the modelling approach followed here have much potential for developing more effective biological control strategies by optimizing the use of multiple agents.

Birds helped Acacia trees travel 18 000 km from Hawaii to La Réunion
Island biogeography theory predicts that most island species originate from nearby mainland regions and therefore arrive through rare, long-distance dispersal events. How close islands are to mainland regions must therefore be an important factor in determining the make-up of island biotas. For example, the Hawaiian Islands are approximately 4 000 km from the nearest mainland and it is estimated that historically one new species arrived every 35 years or so. However, long-distance dispersal alone is not enough for the establishment of island biota; environmental conditions need to be similar on the island and the mainland of origin. For example, most of the Hawaiian Islands' dry alpine flora originated from similar regions in the dry south-western United States and Mexico, whereas a large percentage of the archipelago's beach flora are direct descendants of beach plants from other nearby tropical Pacific islands and tropical continental shores.

When new species arrive on islands they often undergo impressive radiations due to various evolutionary factors such as strong genetic drift and the availability of diverse and unoccupied niches. Moreover, islands are also often considered the 'last stop' for species on extreme long-distance voyages. In other words, islands rarely act as donors of flora to other far-off regions but only exchange biota with nearby neighbouring islands. This observation is probably one of the biggest contributing factors that made Darwin realize the important link between geographic isolation and evolution during his voyage on the HMS Beagle.

Work by C•I•B researchers Jaco Le Roux, Mathieu Rouget, David Richardson and co-workers described what is possibly the longest (and most unlikely) natural dispersal event ever recorded (Le Roux *et al.* 2014; *New Phytol*. 204, 230-242). The Hawaiian Islands in the Pacific Ocean and La Réunion Island in the Southern Indian Ocean are just about as far apart as you can get – they lie at opposite ends of the planet, some 18, 000 km apart. Despite the huge geographical separation, the morphological similarity between koa trees (*Acacia koa*) and *tamarin des hauts* (*A. heterophylla*) is remarkable. Both tree 'species' were until now considered endemic to their respective island homes. Wood from both trees is highly valued and the trees are of significant cultural value. Outrigger canoes and the very first surf boards were made from *A. koa* wood in Hawaii.

Botanists have been wondering about the peculiar distribution of koa and *tamarin des hauts* for more than a century. These two 'species' are curious outlier members of the Australian phyllode acacias – a group of some 1012 species that were previously grouped in *Acacia* subgenus *Phyllodineae*. Three hypotheses have been advanced over the years to explain the disjunct distribution of these two iconic trees: 1) They originated via two separate and independent long-distance dispersal events from mainland Australia (the centre of origin of the genus *Acacia*); 2) Koa trees are the descendants of an acacia that colonized the Hawaiian Islands from Australia which then dispersed onwards to Réunion to give rise to *tamarin des hauts*; 3) Early humans moved both species to their island destinations through Asia.

Using a molecular phylogeny in conjunction with the known ages of the Hawaiian Islands, the authors showed that the mysterious distribution of these island endemics is due to a natural long-distance dispersal event from Australia, followed by an even-longer (18, 000 km) leap between the Hawaiian Islands and Réunion (Fig. 7). This is the longest single natural dispersal event ever recorded and the researchers estimated that it must have occurred in the last 1.4 million years, long before the existence of modern humans. These two acacias on different islands are so closely related that they will need to be reclassified as the same species. Niche modelling by Le Roux *et al*. confirmed that these acacia populations occupy similar ecological niches on their respective home islands.

So how did a tree manage to travel 18 000 km between two tiny and isolated specs of land? Plants can achieve extreme long-distance dispersal in one of two ways — through the air or in the sea. The latter takes place when seed or plant fragments are carried by sea currents (e.g. coconuts) or by rafting (e.g. attached to a log). Dispersal through the air can be accomplished through strong wind and storm conditions, or more commonly, by hitching a ride on birds. The researchers argued against a sea voyage for the ancestors of *tamarin des hauts* as acacia seeds are poorly adapted for survival in seawater and both koa and *tamarin des hauts* are mid to high elevation trees, i.e. they do not occur anywhere near the shore. Le Roux says 'Our best guess is that seabirds — in particular petrels, such as the endemic Barau's Petrel from Réunion Island — transported the seeds. In Réunion, these birds dig

burrows at elevations that coincide with the distribution of the acacias. It is also well-known that ingested seeds can be retained in the stomachs of petrels for weeks and even months'. It is therefore possible that lost petrels from Hawaii strayed into the wrong ocean, finding there a new mountainous island at the right latitude, and delivered the seeds that would later become the *tamarin des hauts* so typical of Réunion Island. This research came about as by-product of work on the ecology and biogeography of Australian acacias undertaken to understand why many species in the group are important invasive species.

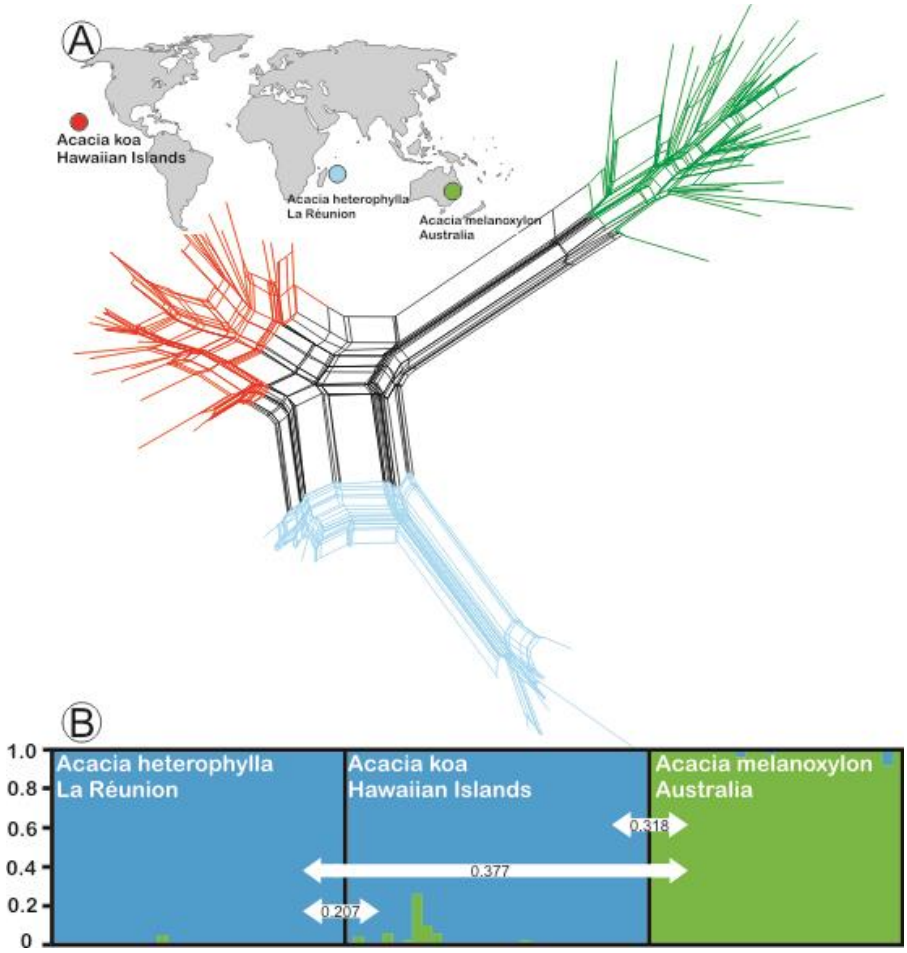

Fig. 7. Population genetic structure based on AFLP analysis of *Acacia koa*, *A. heterophylla* and *A. melanoxylon*. [From Le Roux *et al.* 2014; *New Phytol.* 204, 230-242]

C. Detection, demonstration, responses and remediation

New alien species hiding in our harbours

Marine alien species have not been as well studied in South Africa as their terrestrial counterparts. However, recent research has shed some light on the occurrence of marine alien species in Western Cape harbours. Marine organisms have been moved around the globe for centuries. These organisms travel through a number of ways, for example, as external fouling on the hulls of ships and yachts, in ballast water, through the movement of aquaculture organisms and via the aquarium and pet trades. In a recent study C•I•B

student Koebraa Peters, along with core team members Tammy Robinson and Charles Griffiths set out to survey Western Cape harbours for marine alien species. While they had expected the highest number of aliens to be in the larger harbours, surprisingly they found the most aliens occurred in Hout Bay harbour, one of the smaller local harbours (Fig. 8). Interestingly, harbours on either side of Cape Point (Table Bay, Hout Bay, Simon's Town and Kalk Bay) had higher numbers of aliens than other harbours (Peters *et al*. 2014; *Afr. J. Marine Sci*. 36, 49–57).

Another important finding was that the presence of yachts was the most important factor predicting which harbours have higher numbers of alien species. In addition, some new discoveries were made. The alien disc lamp shell (*Discinisca tenuis*) was recorded for the first time outside of aquaculture facilities, where it was previously thought to be contained. Also, the alien amphipod *Ericthonius difformis* was recorded in South African waters for the first time. As resources to manage marine alien species are limited there is a need to prioritise harbours that should be monitored for non-indigenous species. This study is important as the results can be used by managers in the prioritisation process.

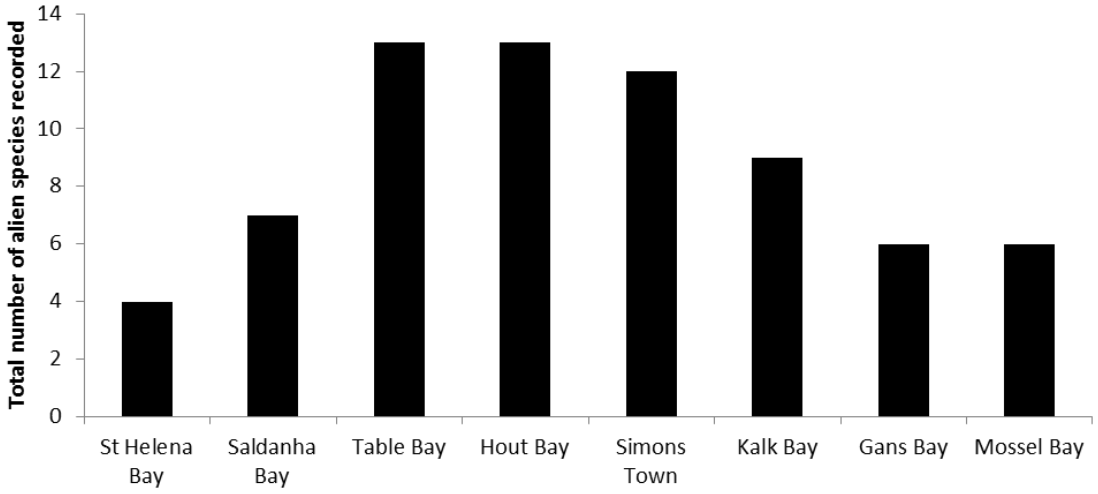

Fig. 8. The total number of marine alien species found in Western Cape harbours [From: Peters *et al*. 2014; *Afr. J. Marine Sci*. **36**, 49–57]

Mussel invasions and their impacts

As a result of human movement and oceanic global trade, the introduction of invasive species is occurring at an increasing rate and this can have a number of significant negative impacts both to the environment and the economy. However our ability to predict those species that are likely to have the most serious impact is weak and there is a need to understand the processes and consequences associated with such events. Damaging invasive species are often characteristically more able to rapidly and efficiently utilise resources than native species. Following from this, the comparison of resource utilisation

rates and patterns among known invaders and trophically analogous natives could allow for more reliable predictions of invader impact.

As a result of successive mussel invasions, the West Coast of South Africa has undergone dramatic changes to the intertidal communities. As a result the system provides a case study to test whether resource use by such invasive species in comparison to natives would have been an effective predictor of invasiveness along this coastline and whether it may be applied in the forecasting of future spread and establishment of invasive species along the South Coast. By examining the algal consumption of two invasive and one native mussel species, it was found that the lab-derived resource use matched current abundances of the mussels on the West Coast where they co-occur. It was also found that the increased consumption by the dominant invasive species on the shore *Mytilus galloprovincialis* under conditions that simulated the cooler West Coast would have predicted the success of this species establishment on the shore. These results combined with the performance of *M. galloprovincialis* and another more recently detected invasive species, *Semimytilus algosus*, under warmer South Coast conditions implies that *M. galloprovincialis* will remain the dominant mussel species on the shore.

Developing invasive species watch lists for resource-poor nations

Invasive species risk assessments have been developed to identify species that pose an invasion risk. Unfortunately, risk assessments tend to be expensive and time consuming, and due to a lack of resources (data, skills and funding) many resource poor nations cannot implement these tools. For developing nations, a useful alternative approach may be to develop watch lists of invasive species. Watch lists identify species that have an invasion history, and are absent from the region of interest, but could pose an invasion risk if brought into the region. The methodologies used to develop these watch lists are often much simpler than risk assessments (e.g. use less criteria), and are therefore suitable for universal use.

Research by C•I•B student Katelyn Faulkner and core team members Mark Robertson, Mathieu Rouget and John Wilson set out to develop a protocol for developing watch lists for invasive species (Faulkner *et al*. 2014; *Biol. Conserv*. 179, 25–32). The team developed a five-step methodology which takes into account three predictors of invasion success: a history of invasion elsewhere, suitable environmental conditions and propagule pressure. Only readily available data, open-source software and simple techniques are used to identify species that meet these three criteria. To test the methodology, the team used South Africa as a case study. The methodology (Fig. 9) was tested nationally for a wide variety of taxonomic groups and at a provincial level (Western Cape and Limpopo provinces) for plants. It was found that the methodology could be easily applied at different political levels and 400 species that may pose an invasion risk to South Africa in the future were identified.

This approach has many advantages. It is transparent and based on sound scientific principles. As the data used are available, and the techniques are simple, the methodology can be used by anyone with internet access and GIS experience. The methodology can, at a low cost, rapidly identify potential invasive species, making it particularly valuable for nations that are lacking resources.

Fig. 9. A simple, rapid methodology for developing invasive species watch lists. [From Faulkner *et al.* 2014; *Biol. Conserv.* 179, 25–32]

Assessing the distribution of rose-ringed parakeets in Ethekwini

C•I•B core team member Colleen Downs and post-doctoral fellow Lorinda Hart have been studying the current distribution of Rose-ringed Parakeets (*Psittacula krameri*) 1769) in the Durban Metropolitan area of eThekwini (Hart & Downs 2014; *Afr. Zool*. 49, 283-289).

This species is the most invasive parrot species in the world and have invaded 35 countries on five continents. In South Africa, the first sightings were noted in the 1970s with strongholds predominantly in Gauteng and KwaZulu-Natal. Populations are also now known from Cape Town in the Western Cape and Steytlerville in the Eastern Cape. The rose-ringed parakeet is a generalist species that occurs in a range of habitats and feeds on a

variety of food items. They nest cavities and where food and nest sites are not limiting these birds have the capacity to reproduce successfully and rapidly, fledging an average of two chicks per breeding pair annually.

Newspaper articles, newsletters and networking with local bird clubs were used to identify roost sites and areas where parakeets were observed. Surveys were then conducted to determine parakeet presence in and around these areas (Fig. 8). The South African Bird Atlas Project 2 indicates that the parakeets currently occupy 475 km^2 of the 2292 km^2 of the Durban Metropolitan area. Surveys from the C•I•B-funded study revealed an occupancy of c. 730 km^2, suggesting that rose-ringed parakeets are expanding their distribution. This could have negative consequences on native bird species, particularly cavity nesters. These parakeets are currently associated with urban areas, but could potential expand their niches as populations grow.

Quantifying the impacts of alien species, developing an IUCN list

One of the major transformations of the planet from human activities is the redistribution of species to areas outside their native range. These alien species have in many cases caused substantial harmful impacts to the recipient environment. These environmental impacts include driving native species to extinction, disrupting soil nutrient and water cycling, and altering natural disturbance regimes like fire and flooding. Preventing and mitigating such impacts is a major drain on limited conservation resources. There is thus a considerable need to understand which species are currently, or are likely to be, the most damaging. But how do you compare the enormous range of impacts attributable to diverse alien taxa, acting on different levels of ecological complexity, and at different spatial and temporal scales?

An international team of experts, including six researchers affiliated with the C•I•B, have proposed a practical solution to this problem. The paper, led by C•I•B Research Associate Tim Blackburn defines scenarios describing the levels of impact on native species by different mechanisms (Blackburn *et al.*2014; *PLoS Biology*, 12, e1001850, 35 pages. DOI: 10.1371/journal.pbio.1001850).

Scenarios are designed so that successively higher categories reflect an increase in the order of magnitude of the particular impact mechanism (e.g. impacts on native individuals, populations, communities), so that the magnitudes of impacts caused by different mechanisms are directly comparable. A species assigned to a higher impact category is considered to have had a greater harmful impact on some aspect of an environment in which it is alien, than a species in a lower impact category.

The scheme allows for the ranking of alien species from different animal and plant groups according to the magnitude of their environmental impacts into lists of harmful species (Fig. 10). It is designed to be similar in structure and logic to the widely adopted International

Union for Conservation of Nature (IUCN) Red List for categorizing extinction risk. Like the IUCN Red List, it can be used to identify priority species for action, as required by international policies on biological invasions. The scheme provides not only a basis for decision-making, but potentially also a formal indicator of progress towards the achievement of the aims of Aichi target 9 on the identification and management of priority invasive alien species and the pathways by which they arrive.

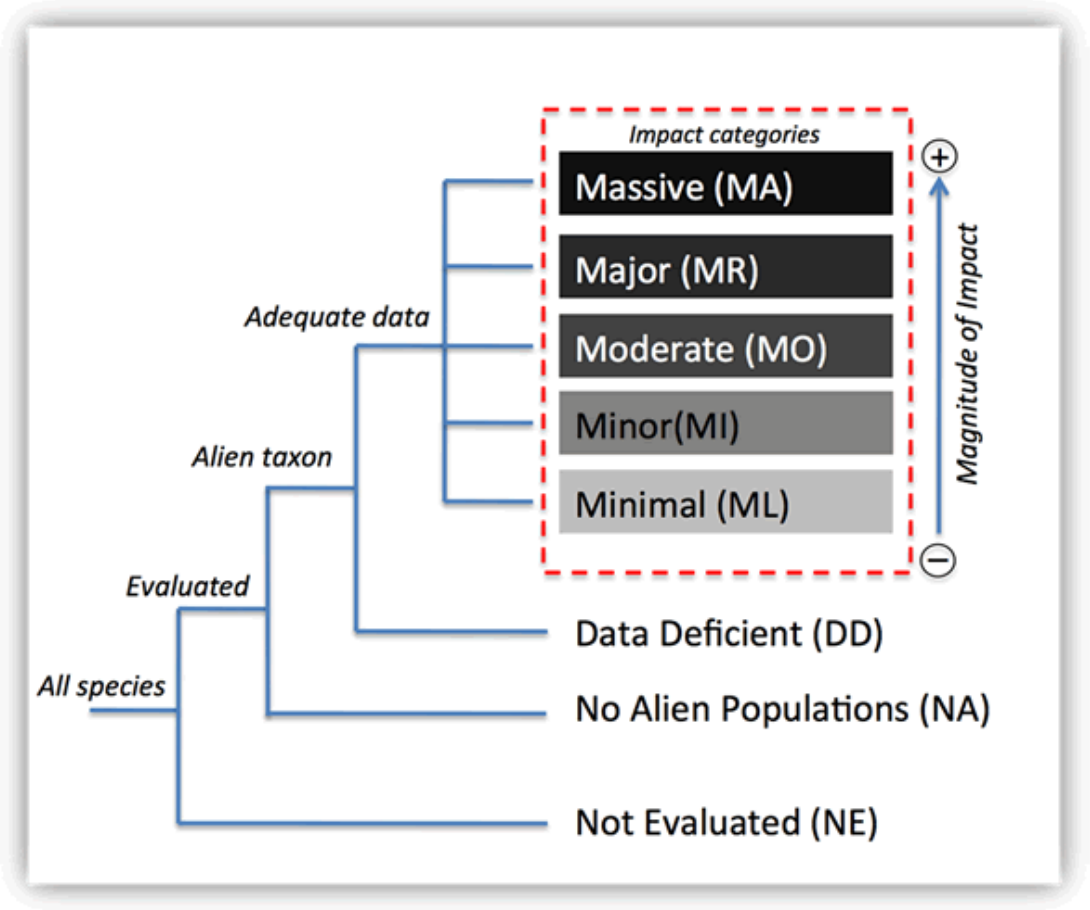

Fig. 10. The different categories in the scheme to classify the impacts of alien species, and the relationships between them [From Blackburn *et al.* 2014; 12, e1001850, 35 pages. DOI: 10.1371/journal.pbio.1001850].

Using remote sensing to detect bugweed in plantations

Bugweed (*Solanum mauritianum*) is a problematic invasive species that invades forestry plantations in the eastern parts of South Africa. It forms dense invasive stands that not only have an impact on commercial forestry activities but also cause significant ecological and environment damage in natural areas. To effectively manage this species, robust approaches are required to accurately detect, map and monitor weed distribution. A study was undertaken to determine the utility of support vector machines (a type of image classification technique) with hyperspectral remote sensing imagery to detect and map the

presence of bugweed in mature pine plantations (Atkinson *et al*. 2014; *J. Sel. Topics Appl. Earth Observ. Remote Sens*. 7, 17-28). The imagery consisted of 272 wave bands and was captured from an aircraft that was flown over pine plantations in KwaZulu-Natal. The support vector machine approach required only 17 optimal wavebands from the original image to produce a classification accuracy of 93%. Results from this study indicate great potential for using support vector machines for the accurate detection and mapping of bugweed in commercial plantations.

'High-impact' invaders merit priority treatment

The magnitude of biological invasions is increasing world-wide. Areas affected by alien plant invasions are continuously expanding and the extent and complexity of their impacts are increasing. Because of limited funding for invasive species control managers are under huge pressure to use objective and defendable protocols for deciding which invasive species need priority treatment. All too often, impacts are assumed rather than proven or quantified, which means that valuable resources may be spent on invasive species that have little or no impact. An international team of experts presented a novel approach of distinguishing species that have the potential for causing major impacts from those with limited impacts (Gaertner *et al*. 2014; *Divers. Distrib*. 20, 733-744). The authors argue that species that have the potential to cause regime shifts (i.e. fundamentally restructure and transform ecosystems) should be considered the most high-impact species.

C•I•B core team member Mirijam Gaertner, lead author of the paper, says that this work represents an exciting and novel approach for flagging invasion events that cause impacts that everybody agrees deserve urgent management attention. 'Regime shifts have been described for other situations, like the eutrophication of lakes or bush encroachment in savannas, but this is the first time that the concept has been applied as a way of identifying high-impact invasive species.'Co-author and international expert on regime shifts, Reinette Biggs from the Stockholm Resilience Centre in Sweden, says these shifts are large, often abrupt changes in ecosystem structure and function: 'Regime shifts are associated with the reorganisation of the internal feedback mechanisms that structure an ecosystem, such as plant-soil feedbacks. Once an ecosystem reaches a certain threshold, the regime shift can happen abruptly and unexpectedly and is often difficult or impossible to reverse.'

The research team identified five feedback mechanisms (e.g. Fig. 11) by which high-impact invasive plants achieve high abundance and persistence. These feedback mechanisms include abundant seed banks (leading to a dominance of invader seedlings which eventually outcompete native species); changes in the frequency and intensity of fire (e.g. the features of some woody plants promote high-intensity fires in grasslands and shrublands); increased nitrogen levels (which promotes further proliferation of the invader and other weedy species); high litter volumes (inhibiting the growth of native species by outcompeting them

for light and nutrients); and changes to the soil by altering the composition and function of the soil community (promoting the growth of the invader).

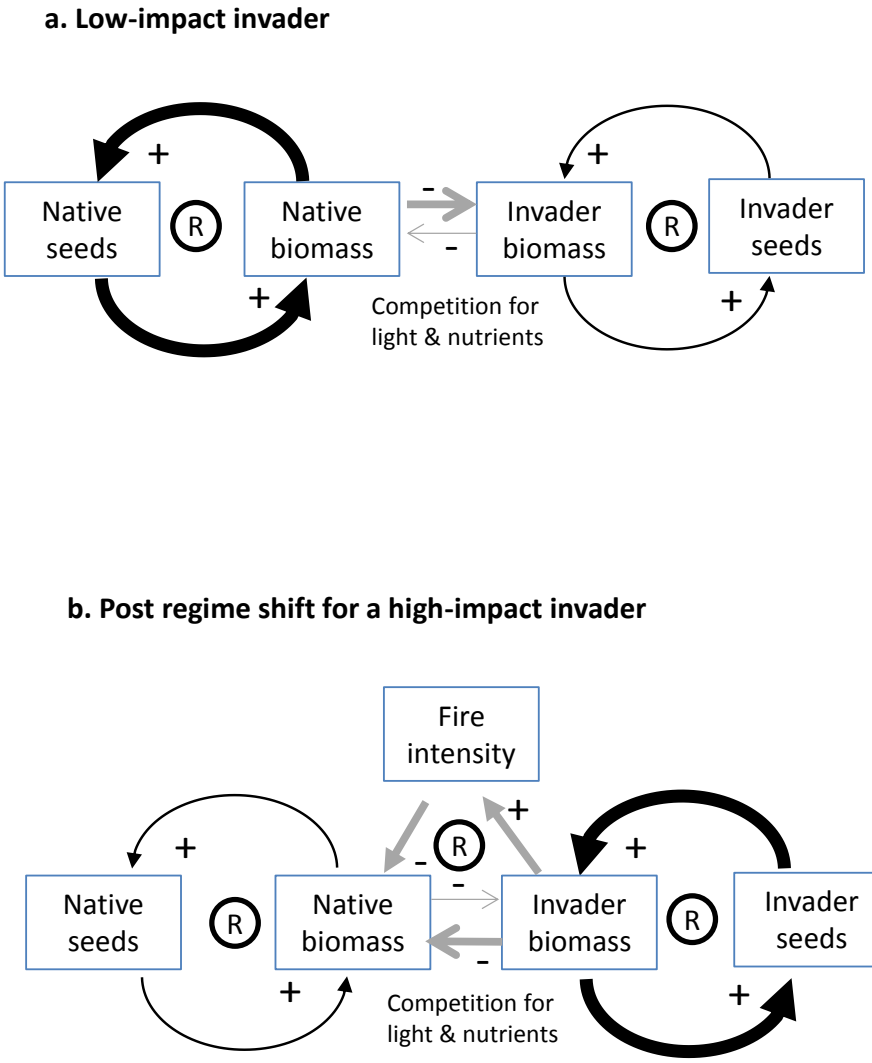

Fig. 11. Simplified conceptual diagrams illustrating shifts in dominant system feedbacks that may accompany a regime shift driven by a high impact invader. [From: Gaertner *et al.* 2014. *Divers. Distrib.* **20**, 733-744.]

Using systems analysis and meta-analysis approaches to synthesize changes to ecosystems caused by 173 invasive plant species worldwide, the authors found that impacts on nutrient cycling in the soil have the highest likelihood of affecting reinforcing feedbacks which could eventually result in regime shifts. The culprits here are primarily shrub and tree invaders [such as Silver Wattle (*Acacia dealbata*) in Chile and Norway maple (*Acer platanoides*) in the USA] in forests, and herbaceous invaders (such as canary grass, *Phalaris arundiancea*) in wetlands. Feedbacks resulting in regime shifts were found to be most related to processes associated with seed banks, fire and nutrient cycling.

This study has identified a useful method for prioritising invasive species for management action: It provides a robust approach for flagging those events that occur due to the interaction between the invasive species and the ecosystems they invade, and allows managers to focus on those invasions that really matter. Specifically targeting newly created feedback relationships can provide managers with a cost-effective action plan, which allows them to target newly identified positive feedback relationships and work to reverse them, for example by developing strategies to reduce nitrogen input into wetlands. Future research will focus on identifying the ecological thresholds at which dominant feedbacks switch in relation to levels of invasion. More work is needed to quantify both the impacts on native ecosystems and any changes in the feedback processes that drive or reinforce invasions.

Getting the measure of tree invasions

'If you can't measure it, you can't manage it' is, as with all such well-worn phrases, only partly true. But to adapt another such maxim, while we might be able to make progress without measurement, we do need proof to satisfy everyone else.

There are a range of methods, but surprisingly few consistent measures. In fact, international comparisons of invasions have been hampered by inconsistent data collection. There is an urgent need to move beyond basic lists of invasive taxa, to reporting information at a level that be used to identify problems and prioritise actions, and ideally at a level that will allow a mechanistic understanding of the dynamics which might allow reliable predictions to be made. But as a fundamentally international phenomenon, one of the most important goals in invasion science is to take the lessons learned in one place and apply them elsewhere. In fact, invasiveness elsewhere is commonly cited as one of the most reliable predictors of invasiveness.

At a workshop on 'Tree Invasions – Patterns & Processes, Challenges & Opportunities' held in September 2012 in Bariloche, Argentina, C•I•B core team member John Wilson lead a discussion on this topic. He and 13 colleagues from 8 countries reviewed different sampling methods used and reviewed a variety of metrics dealing with key dimensions of an invasion, from simple and cheap to complicated and expensive. It was important to define some core aspects of invasions that are necessary to: provide base-line statistics for biodiversity assessments; estimate impacts; estimate costs of different management strategies; estimate the threats posed; and ultimately place species into management and legislative categories as part of a strategic planning process (Fig. 12).

Based on this ground work, a paper in a journal special issue on tree invasions argues that a set of metrics should provide information on status, abundance, spatial extent, and impact of an invasion and how these characteristics change through time (Wilson *et al.* 2014; *Biol. Invasions* 16, 535-551). Six key metrics have been identified:

- Current status in the region
- Potential status
- The number of foci requiring management
- The area of occupancy (AOO) (i.e. compressed canopy area or net infestation)
- The extent of occurrence (EOO) (i.e. range size or gross infestation)
- Observations of current and potential impact.

These metrics were used to develop and test a standard reporting template for tree invasions.

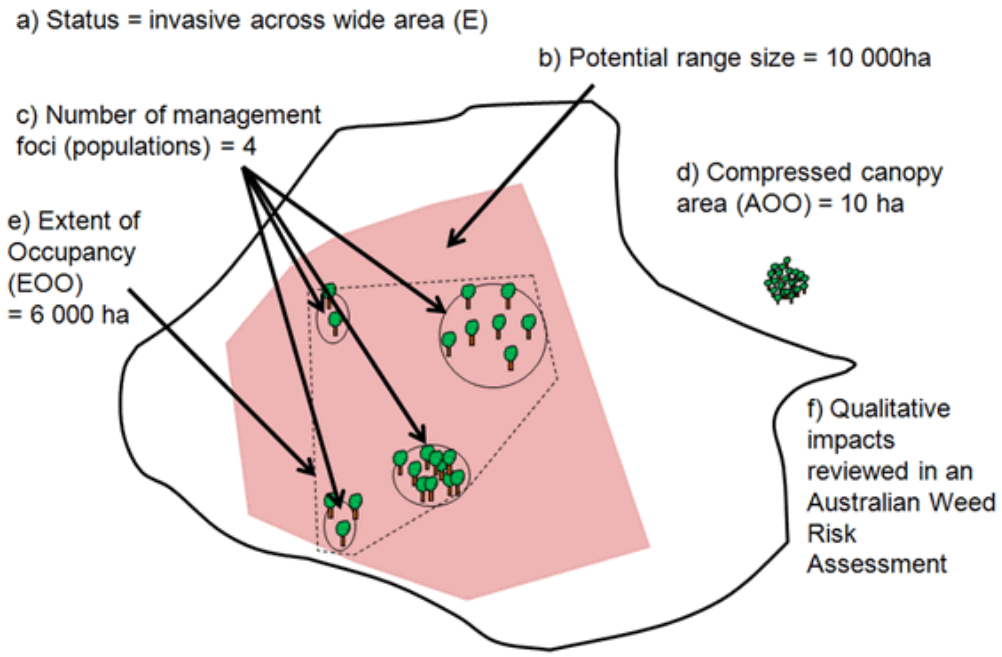

Fig. 12. Schematic representation of six proposed metrics for tree invasions [From: Wilson *et al.* 2014; *Biol. Invasions* **16**, 535-551]

Volcanic lava flow fuels tree invasion on La Réunion

The volcanic island of La Réunion in the Indian Ocean is the least disrupted of the biodiversity-rich islands of the Mascarene archipelago, with around 30% of the native vegetation still intact. She-oak or ironwood (*Casuarina equisetifolia*), a fast-growing tree native to Australia, Melanesia, Micronesia, the Philippines, Polynesia, and Southeast Asia, was introduced to La Réunion in 1738, mainly for use as firewood. Today, it is one of the

most prominent invasive tree species on the volcanic lava flows of the active Piton de la Fournaise volcano in the south-east of the La Réunion.

Former C•I•B Masters student Luke Potgieter and co-authors explored how interactions between natural disturbance, in this case volcanic lava flows, and invasions govern plant succession on these lava flows (Potgieter *et al*. 2014; *Biotropica* 46, 268-275).Vegetation surveys from 1972 and 1990 were compared with results of a survey in 2012 to detail the spread of these trees over time. The team determined the influence of variables, including altitude, fire and lava flow age, on the abundance of *C. equisetifolia*.

The team found that lava flows facilitated the spread of *C. equisetifolia*, with the extent increasing twentyfold over the past 40 years, from 110 ha in 1972 to 2 373 ha in 2012. This species displace native species by changing the natural plant processes. The degree to which this species continues to spread across the island will determine the fate of the native lowland rain forests. This study demonstrated how a single invasive species can have a dramatic effect on the successional development of a landscape (Fig. 13).

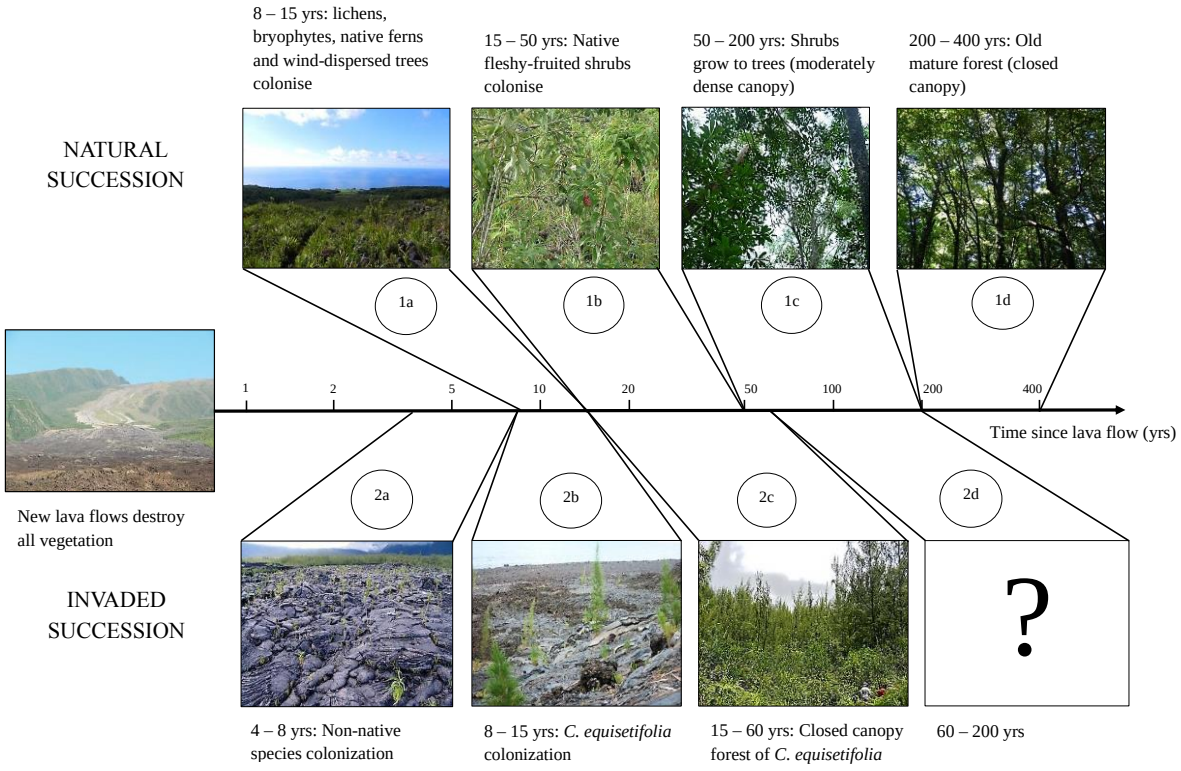

Fig. 13. Conceptual model of (1) natural succession and (2) current successional processes where non-native invasive species now dominate on volcanic substrates of the Piton de la Fournaise Volcano, La Réunion Island [From: Potgieter *et al.* 2014; *Biotropica* 46, 268-275]

Estimating eradication feasibility: the case of Melaleuca parvistaminea

As part of the C•I•B's on-going collaboration with SANBI's Invasive Species Programme and CapeNature, MSc student Llewellyn Jacobs has been working on a detailed field assessment of a species not previously recorded as invasive anywhere in the world. Llewellyn mapped, measured, and organised the control of *Melaleuca parvistaminea* (rough-barked honey myrtle; Myrtaceae), a woody plant invader taking hold in seasonally wet areas in the Tulbagh Valley in the Western Cape. The study found that, although detectability before flowering is low, the plant is easily controlled, and, given the long lag between flowering and seed release and a relatively long juvenile period, the species could be eradicated from South Africa (by 2021 at a cost of ZAR 3 475 000 (US$ 355 400)).

This project highlighted the value of field observations. Initially plants were thought to be *Melaleuca ericifolia*, but Llewellyn noticed that the flowers 'did not seem right', and, importantly for management, that plants did not resprout, but relied on seed for regeneration. Given that *M. ericifolia* is regarded as primarily a resprouter in its native range, the success of management operations to date made Llewellyn wonder whether the identification was correct. On further searching it became clear that there were quite a number of misidentification on such species in South African herbaria, suggesting some further taxonomic work is needed in South Africa.

The first paper published on *M. parvistaminea* as an invasive species anywhere in the world (Jacobs *et al*. 2014; *S. Afr. J. Bot*. 94, 24-32) indicated that eradication of the species is feasible and desirable and that the species should be listed as a category-1a invader (requiring compulsory control) under the proposed invasive species regulations of South Africa's National Environmental Management: Biodiversity Act.

Unlocking the potential of Google Earth ™ as a tool in invasion science

The use and popularity of Google Earth has grown tremendously since its launch, and it has a range of uses from mapping and viewing mountain bike routes to monitoring chimpanzee forest habitat. However, Google Earth had no formal recognition or guidelines for its use in the field of invasion science, despite the fact that many scientists and managers use it on a regular basis. The lack of formal sources of information on how to use Google Earth effectively in research projects provided the motivation for a research paper that provides helpful hints and tips for the use of virtual globes, such as Google Earth, in invasion science.

C•I•B post-doc Vernon Visser, along with C•I•B Director David Richardson and two Chilean collaborators, showed how Google Earth can be used to map tree invasions, monitor their progress and to identify field sites (Visser *et al*. 2014; *Biol. Invasions* 16, 513-534). The C•I•B team worked with collaborators in Chile, using very detailed spatial information on *Pinus contorta* invasions in Patagonia as a test case (Fig. 14). Google Earth can also be used for awareness raising and sharing of information online. To this end, the authors developed

a Google Earth dataset that highlights some impressive tree invasions in ecosystems around the world.

Further work is underway to set up a global network of sentinel sites to monitor alien tree invasions, for example, from commercial alien tree plantations, botanical gardens and suburbia that are situated in largely treeless areas. The authors also provide a smaller Google Earth dataset for the Western Cape of South Africa, of the type of network they would like to see ultimately developed for the entire globe.

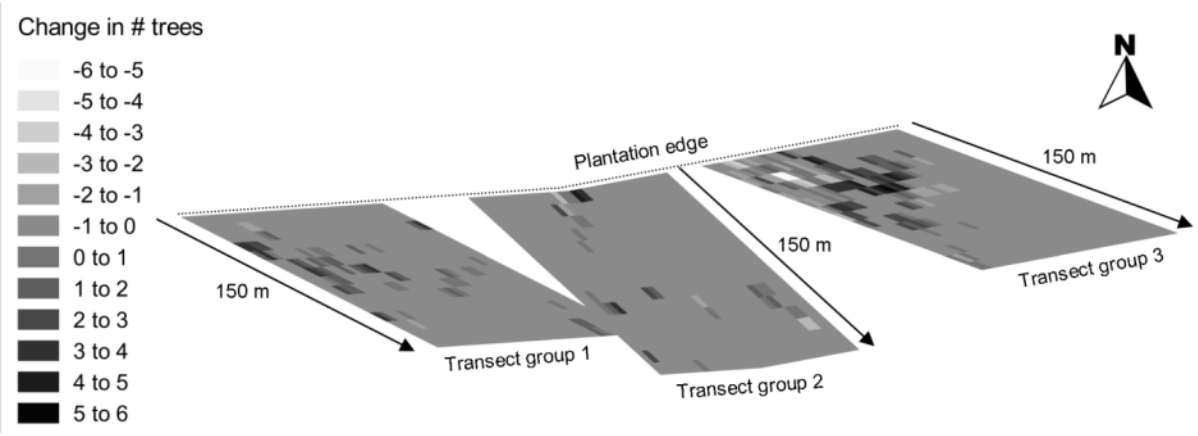

Fig. 14. The change in numbers of *Pinus contorta* trees around Coyhaique city, Chile, per 10 x 3 m subtransect between 2004 and 2010 determined by visual inspection of imagery from Google Earth [From Visser *et al.* 2014; *Biol. Invasions* 16, 513-534].

D. Global environmental change and ecosystem services

Warming responses of marine crustaceans

Determining the extent to which organisms are able to withstand and respond to climate change is vital for assessing species vulnerability and informing strategies for future conservation of species diversity. Recent work has demonstrated that responses to warming may be less variable and more predictable in marine than in terrestrial organisms, suggesting that the buffer against environmental change may be greater in marine organisms than for terrestrial species. However, the idea that warming responses are more coherent for marine taxa has rarely been explored.

Clear variation in the upper limits of temperature tolerance has been demonstrated in terrestrial organisms and from patterns of this trait at global scales, three general rules have emerged. First, according to Janzen's rule, the range of temperature tolerated by organisms should increase with latitude. Second, Vernberg's rule states that the extent of acclimation should increase with latitude; that is, species in higher latitudes should be able to compensate to short-term temperature exposures more readily than species at lower

latitudes. Finally, Gause's rule proposes that acclimation ability should be reduced in organisms that have the highest initial or basal tolerance. In addition to these rules, experimental rates of temperature change have a profound effect on temperature tolerance limits and acclimation capacity. Predictions made using results from typically fast-rate experiments may therefore be confounded and further complicated by the influence of rate of temperature change on the acclimation responses of marine species.

C•I•B student Katelyn Faulkner and co-workers assessed the effect of rate of temperature change and temperature acclimation on the upper temperature tolerance of several crustacean populations along a latitudinal gradient to test these three rules. The authors showed that for all intertidal populations sampled in the sub- Antarctic Marion Island and in South Africa, slow rates of temperature change reduced temperature tolerance and compromised acclimation responses (Faulkner *et* al. 2014; *Funct. Ecol*. 28, 895-903).

Species from South Africa had a smaller margin between the highest temperature that they could withstand and the maximum microsite temperature compared to their sub-Antarctic counterparts, supporting Janzen's rule. In addition, Sub-Antarctic species had more plasticity as in the ability to change in the short-term compared to South African species, supporting Vernberg's rule. This finding demonstrates that sub-Antarctic species pre-exposed to cold or warm spells could cope more optimally to subsequent climatic changes compared to South African species. Finally, Gause's rule was also supported as species with highest tolerance had the lesser ability to acclimate to short-term temperature exposures.

Overall, temperate populations of marine crustaceans had a lower ability to withstand or respond to increasing temperatures than populations from the sub-Antarctic, even if these populations used behavioural thermoregulation to avoid extreme temperatures. Thus the responses of marine organisms to warming may not be as coherent and predictable as previous work had suggested. Rather variation in long-term responses may be a consequence of geographical variation in organismal traits, thermal environments, acclimation capacity and evolutionary potential. Finally, this work demonstrates the importance of understanding the microclimates experienced by crustaceans in field sites and the extent to which lethal conditions may be avoided through behavioural thermoregulation.

Examining the link between climate change and biological invasions

Temperature is one of the most important abiotic factors affecting the area within which species are found. Climate change is expected to change temperature regimes and cause poleward and upslope shifts in the distribution of native species. Alien species provide an opportunity to witness the establishment of range boundaries in a way that cannot be observed for native species.

Former C•I•B post-doctoral fellow, Dr Marc Rius, core team members Susana Clusella-Trullas and Charles Griffiths, and co-authors combined regional and global distribution patterns of marine organisms ere compared with genetic, climatic and physiological data to understand how climate change affects alien species. They showed that alien species with a variety of thermal tolerances and distributions have expanded their ranges and increased in abundance as seawater temperature patterns have changed. There was little variation in shipping movement through time, which means that human-mediated transport did not increase during the study period. However, genetic data showed that there are high levels of gene flow across species ranges (Rius *et al*. 2014; *Global Ecol. Biogeogr*. 23, 76-88).

This study provides evidence that alien marine animals, regardless of their thermal tolerance, range size and genetic variability, are expanding their ranges and increasing in abundance. This trend is not linked to human-mediated transport such as shipping but is rather linked with changes in seawater temperature, which suggests that climate change increases nonindigenous species spread and abundance.

Biocontrol agents in a changing world

As climate warming takes place, changes in environmental conditions can affect not only pest or invasive species but also their biocontrol agents. There is therefore a need to assess and incorporate physiological data of biocontrol species to be able to predict their efficiency to control invasive species in future scenarios. The weevil *Cyrtobagous salviniae* is a highly effective biological control agent for the invasive water fern *Salvinia molesta* (Fig. 15). The life histories of both organisms are affected by temperature, making the potential impacts of climate change on efficacy of control an important area in which comprehensive understanding is required.

C•I•B student Jessica Allen and co-workers examined the warming tolerance and low-temperature tolerance as measures of the weevil's sensitivity to climate warming, calculated across South Africa using critical thermal limits, lethal temperature limits and mean maximum and minimum environmental temperatures under present climatic conditions and two future scenario periods (2040s and 2080s). Results indicated that the weevil *C. salviniae* may face greater constraints on survival as the maximum microclimate temperature nears the upper thermal limits but may be counterbalanced by increased population persistence over cool months as the minimum microclimate temperature also increases in future scenarios (Allen *et al*. 2014; *BioControl* 59, 357-366).

Fig. 15. The weevil *Cyrtobagous salviniae* is a highly effective biological control agent for the invasive water fern *Salvinia molesta*.

Biological control by bats of alien and native insect agricultural pests in macadamia orchards

In recent years the top-down control of pest insects by insectivorous bats, and the associated benefits of these ecosystem services to farmers in terms of reduced crop damage, have been demonstrated in the cotton industry in the United States and in coffee/cacao agroforests in Central America and south-east Asia. Until very recently, there were no African studies on the economic impact of bats eating agricultural pest insects.

The major pests of macadamia orchards include a few 'stink bug' species of the Heteroptera pest complex (Pentatomidae and Coreidae) and moths of the Torticidae complex. Stink bugs have been estimated to cause losses of some R50 million annually to macadamia orchards and economic damage occurs at very low population thresholds of about 0.4 insects per tree. A review of recent studies by C•I•B core team member Peter Taylor showed that a variety of local bat species forage in macadamia orchards (Fig. 16). Most bat species tested occurring in macadamia orchards frequently feed on at least one species of pest stink bug including the invasive cosmopolitan pest species, *Nezara viridula* (Taylor 2014; *S. Afr. Macadamia Yearbook* 22, 6-11). Understanding the ecosystem services provided by bats requires a good local knowledge of drivers of local bat communities (Linden *et al*., 2014. *Acta Chiropterologica* 16; 27-40).

Fig. 16. Bat scientist Merlin Tuttle (left) trapping bats in a macadamia orchard with a local farmer (Photo: Peter Taylor).

Predicting performance and survival of agricultural crop pests in the Western Cape

Predicting the impacts of climate change on biological systems is a difficult, but necessary, challenge of ecological research. This challenge is particularly important for agricultural pests that can cause damage to a region's economy and food security. In the case of invasive pest insects, land managers require information on not only the presence of a species, but also its relative performance at a given location (i.e. potential damage to crops). To make such predictions under novel climates, an understanding of the processes through which climate constrains, or enhances, an organism's survival and performance is required.

In a recent study, core team member John Terblanche and Madeleine Barton, both of whom are based at the Department of Conservation Ecology & Entomology, wrote a biophysical species distribution model focusing on the African Bollworm (*Helicoverpa armigera*) (Barton & Terblanche 2014; *Austral Entomol*., 53, 249-258.). The model interprets spatially explicit data on climate and terrain into the microclimates encountered by the different life-history stages of the Bollworm (on the trunk of a tree, on a leaf within the canopy, or buried underground). Once conditions in the Bollworm's immediate environment are determined, the model calculates the animal's core-body temperature, and then draws on existing datasets to establish its capacity to survive. This process is performed at hourly time-steps, tracing the insect's phenology throughout the year, and then repeated for multiple sites across a fruit-growing region of the Western Cape.

The authors found that local topography had significant impacts on predicted core-body temperature and phenology: at higher altitudes, individuals should have a reduced number of generations although this effect was reduced on north-facing slopes in comparison to counterparts on south-facing slopes. As such, the timing of changeovers from one life-history stage to the next varied among locations. 'These findings provide valuable insights into the appropriate timing of control efforts, and which areas are most likely to be invaded by the pests' says Barton. Further work will explore effects of climate change on this pest's abundance and distribution in collaboration with C•I•B core team member Susana Clusella-Trullas.

Understanding the recent range expansion and invasiveness of Bactrocera invadens *in South Africa*
Fruit flies causing huge economic losses to production of a wide range of commercial fruits in many parts of the world. Some of the most notorious invasive species are found in the family Tephritidae, many of which cause widespread damage through puncturing fruit during egg laying and then larvae subsequently developing within the fruit. Climatic suitability is a major driver of invasion success and helps to determine ecological overlap between similarly related species. As many of the tephritids are highly invasive, we need to understand the role that climate plays in their pest status and in determining spread.

Africa is already home to a large number of the tephritid fly species, including the Mediterranean fruit fly (*Ceratitis capitata*) Natal fly (*Ceratitis rosa*) and (*C. cosyra*). A new tephritid fly was detected in Kenya in 2003. This fly was thought to have come from Sri Lanka and was described as a new species, *Bactrocera invadens*, commonly known as the African invader fly. *Bactrocera invadens* is part of the economically important *B. dorsalis* complex, comprising ~75 species. It is highly polyphagous, reported to have over 43 host plants and has spread rapidly through Africa, recently established in northern South Africa, in the Limpopo province after repeated incursions and eradication reported from 2010.

Throughout Asia and elsewhere in the Pacific, including the USA, the oriental fruit fly, *Bactrocera dorsalis* s.s. (the species named *B. dorsalis* within a group of species called the *B. dorsalis* complex), is a major established pest with 250 identified plant hosts. *Bactrocera invadens* is very hard to tell apart from *B. dorsalis* s.s. and the original description of *B. invadens* only separates the two species on subtle morphological characters (Fig. 17). The similarities between the two species have increasingly led to the identity of *B. invadens* being called into question. Recent studies have examined the invasion potential of both *B. dorsalis* s.s. and *B. invadens* separately, using different types of distribution models. Since these modelling attempts, *B. invadens* has undergone rapid range expansion to establish in areas thought to be marginally climatically suitable (the establishment in Limpopo, for instance, as a case in point). Research was conducted to determine whether environmental overlap between *B. invadens* and *B. dorsalis* s.s. is high; if so, this would support the hypothesis that they are the same species (Hill & Terblanche 2014; *PLoS ONE* 9, e90121).

Predictive distribution models were then constructed incorporating different species combinations. In doing so we wanted to quantify the potential distribution of these species to understand overlap and also the future invasion potential of *B. invadens* in southern Africa and globally. Consistent with other studies, we found that *B. invadens* has a high degree of overlap with *B. dorsalis* s.s. (and *B. philippinensis* and *B. papayae*) in terms of climatic suitability. The ecological niche models built for *B. dorsalis* s.s. were able describe the range of *B. invadens* well, and *B. invadens* is able to project to the core range of *B. dorsalis* s.s. The models of both *B. dorsalis* and *B. dorsalis* combined with *B. philipenesis* and *B. papayae* were significantly higher in predictive ability to capture the distribution points in South Africa than for *B. invadens* alone. These results then allowed us to look at the global invasion potential of these species together. We found that the measured ecological similarity and overlap between these species is high. Including the other two *B. dorsalis* complex species better describes the range expansion and invasion potential of *B. invadens* in South Africa. We therefore suggest that these species should be considered the same - at least functionally - and global quarantine and management strategies applied equally to these *Bactrocera* species.

Fig. 17. *Bactrocera invadens* (left) and *B. dorsalis* (right). Images used under Creative Commons Attribution Non-Commercial License from IAEA (International Atomic Energy Agency) image bank http://www.flickr.com/photos/iaea_imagebank/

Flight performance of invasive fruit flies: colder is better

Understanding the temperature-dependence of flight performance is critical to forecasting or managing invasive species, especially if dispersal is key to the invasion process. Here, the influence of rearing history on temperature-dependent flight performance was investigated in an invasive agricultural pest insect, *Ceratitis capitata* (Diptera: Tephritidae) by a team of

researchers from the C•I•B, the Electronic and Electrical Engineering Department, and Conservation Ecology and Entomology Departments at Stellenbosch University (Esterhuizen *et al*. 2014; *J. Exp. Biol*. 217, 3545-3556). Flies were exposed to one of four developmental acclimation temperatures (T_{acc}: 15, 20, 25, 30°C) during their pupal stage and tested at these temperatures (T_{test}) as adults using a full-factorial study design. Major factors influencing flight performance included sex, body mass, T_{test} and the interaction between T_{test} and T_{acc}. Successful flight performance increased with increasing T_{test} across all acclimation groups (from 10% at 15°C to 77% at 30°C).

Although T_{acc} did not affect flight performance independently, it did have a significant interaction effect with T_{test}. Multiple comparisons showed that flies acclimated to 15°C and 20°C performed better than those acclimated to 25°C and 30°C when tested at cold temperatures, but warm-acclimated flies did not outperform cold-acclimated flies at warmer temperatures. This provides partial support for the 'colder is better' hypothesis. To explain these results, several flight-related traits were examined to determine if T_{acc} influenced flight performance as a consequence of changes in body or wing morphology, whole-animal metabolic rate or cytochrome c oxidase enzyme activity. Although significant effects of T_{acc} could be detected in several of the traits examined, with an emphasis on sex-related differences, increased flight performance could not be explained solely on the basis of changes in any of these traits. Overall these results are important for understanding dispersal physiology despite the fact that the mechanisms of acclimation-related changes in flight performance remain unresolved.

Pollination ecosystem services in South African agricultural systems

Globally insect pollinators, both managed (domesticated e.g. honey bee *Apis mellifera*) and wild (other bee species that exist as non-managed wild populations including wild *Apis*), have become a focus of scientific, political and media attention due to their apparent decline and the perceived impact of such declines on crop production. Crop pollination by insects (predominantly provided by bees) is an essential ecosystem service that increases yield and quality of 35 % of crop production worldwide.

Pollinator declines worldwide are a consequence of multiple environmental pressures, e.g. habitat transformation or fragmentation resulting in loss of suitable forage and the nutritional quality of forage, pesticides, pests and diseases, and climate change. Similar environmental pressures are faced by pollinators in South Africa with a high demand for pollination services for many crops. This project aims to assess the importance of different pollinator species as a basis for pollination services to South African crop production.

C•I•B core team member Mathieu Rouget and collaborators reviewed the current economic value and importance of insect pollination services within the Western Cape Province (Melin *et al*. 2014; *S. Afr. J. Sci*. 110(11/12), Art. #2014-0078). They focussed on the

dependency on landscape and regional level floral resources needed to maintain sufficient numbers of managed honey bee colonies. The Western Cape deciduous fruit industry is an industry worth R9800 million per year that is heavily reliant on the provision of insect pollination services through managed honey bees (Fig. 18). The research highlighted a lack of data on diversity and abundance of crop pollinators, a lack of long-term data to assess declines and that honey bees are key pollinators. It also emphasised the critical role of floral resource availability, including the role of alien *Eucalyptus* stands, at the landscape and regional scale to sustain pollinator populations. Understanding the dynamics of how floral resources are used will help inform how landscapes could be better managed in order to provide long-term sustainable pollination services.

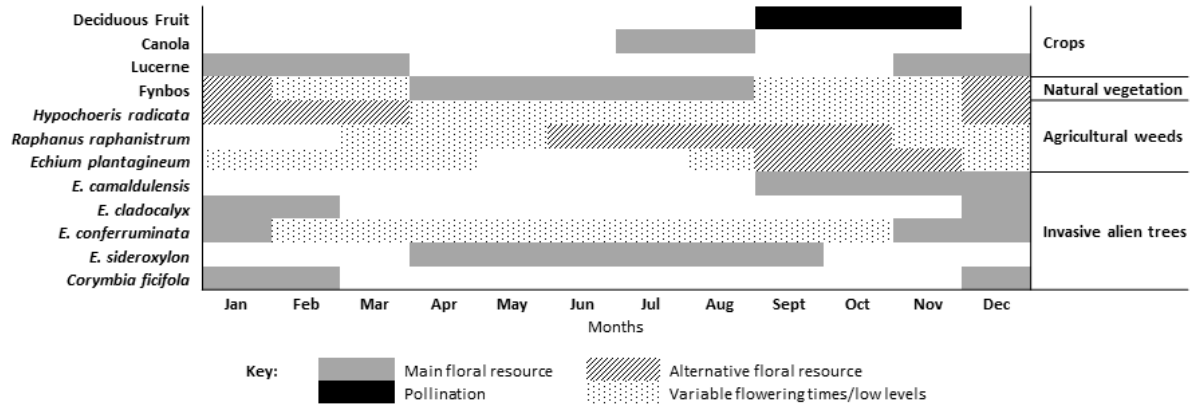

Fig. 18. Floral resource availability in the Western Cape [From Melin *et al.* 2014; *S. Afr. J. Sci.* 110(11/12), Art. #2014-0078]

Proactive land management can help reduce natural disasters

Climate change is predicted to have serious consequences for people, who will be exposed to natural disasters such as floods, droughts, fires and coastal storm surges that are linked to climate change. It is further predicted that climate change will be inevitable, even under the most optimistic of scenarios, as the world continues its commitment to the use of fossil fuels. Reducing the cover of invasive alien pine trees could reduce the intensity of wildfires. Given this inevitability, a team of scientists based at the Council for Scientific and Industrial Research (CSIR), and supported by C•I•B-affiliated researchers Dr David Le Maitre and Prof. Brian van Wilgen, explored the feasibility of ameliorating some of the predicted natural disasters through appropriate land management (Nel *et al*., 2014; *PLoS ONE* 9, e95942).

This study found that land cover changes due to human activities are likely to increase natural disasters. In particular, the study highlights how the clearing of invasive alien trees,

the re-vegetating of clear-felled forests and the restoring of coastal dunes could reduce the impacts of natural disasters to a large degree. For example, controlling the spread and reducing the cover of invasive alien pine trees in fynbos catchment areas, could reduce the intensity of wildfires by almost half. The same levels of control could also reduce the impacts of droughts on the level and duration of low flows in rivers. The study highlights the value of maintaining well-managed and uninvaded landscapes, and their role in reducing the impacts of extreme climate events.

E. Human dimensions

Managing conflicts arising from fisheries

The human dimensions of invasions in aquatic ecosystems have been poorly studied in South Africa. C•I•B-funded PhD student Bruce Ellender and collaborators studied issues relating to the management of conflicts arising from fisheries based on non-native fishes in southern Africa (Ellender *et al*., 2014.; *J. Fish. Biol*. 85, 1890-1906) (Table 2).

Table 2. Summary of conflicting negative environmental and positive socio-economic effects of key species involved in stock replacement projects throughout South Africa [From Ellender *et al.* 2014; *J. Fish. Biol.* 85, 1890-1906; see the paper for details on references cited in the table]

Species	Impact	*Cyprinus carpio*	Salmonids	Centrarchids	*Oreochromis niloticus*	*Limnothrissa miodon*
Negative environmental impacts	Predation		● d	● g		
	Competition		● e	● h	● i	
	Hybridisation				● j	
	Introduction of pathogens	● a				
	Environmental modification	○ b	○ f		○ k	● m
Positive socio-economic impacts	Recreational fishery	● c	● c	● c		
	Subsistence and small scale fishery	● c				● n
	Commercial/ Aquaculture	● c	● c		● l	● m

Notes: ● = Impact documented within southern Africa; ○ = Impact documented in international literature.

The paper focuses on important inland fisheries in the region that are based on non-native species and discusses the trade-off between ecological impacts of fish introductions and the need to address national policy objectives of economic development, food security and poverty eradication. As a result, conflicts have developed between economic and conservation objectives. A first assessment of conflicts is provided, with an emphasis on existing and evolving legislation, implementation strategies and the sometimes innovative approaches that have been used to prioritize conservation areas and manage non-native fishes in conflict situations.

Conflicts around invasive alien trees

Alien trees provide numerous benefits to the people of South Africa, as welcoming features of gardens, parks and streets, and providing shade, fruit, nuts and timber. However, a small subset of these trees can become invasive, spreading across the landscape where they use excessive amounts of water, degrade rangelands, increase the intensity of fires, and impact negatively on biodiversity.

Research at the C•I•B has been investigating ways of managing these 'conflict' species, where trees can simultaneously bring benefits and cause harm (van Wilgen & Richardson 2014; *Biol. Invasions* 16, 721-734). Over 350 alien tree species worldwide are known to be invasive, and the list is growing as more tree species are moved around the world and become established in novel environments. The impacts of conflict species grow over time as invasions spread, and as societal perceptions of the value of alien trees change in response to growing understanding grows and shifting values. This leads to a dynamic environment in which trade-offs are required to maximise benefits and minimise harm. Our research, published recently in *Biological Invasions*, suggests that the management of alien tree populations needs to be strategic and adaptive, combining all possible management interventions to promote the sustainable delivery of optimal outcomes. We used examples, mainly from South Africa (where issues relating to invasive alien trees introduced for forestry have received most attention), to argue for holistic and collaborative approaches to alien tree management. Such approaches need to consider the inclusion of bold steps, such as phasing out unsustainable plantation forestry that is based on highly invasive species, and in which the costs are externalised. In addition, it would be advisable to impose much stricter controls on the introduction of alien trees to new environments, so that problems that would arise from subsequent invasions can be avoided.

Exploring perceptions, attitudes and behaviour using a trans-disciplinary approach

C•I•B core team member Karen Esler and PhD students Mathew Zylstra and Nadia Sitas addressed issues relating to human perceptions of environmental issues. Zylstra's work explored what it is like to have meaningful nature experiences and why they are important in terms of their impact on perceptions, environmental behaviour and their relationship to an individual's connectedness with nature (Zylstra *et al.* 2014; *Springer Sci. Rev.* 2, 119-143). He also investigated the impact of Invasive Alien Plants on these human dimensions. The research has important links to conservation and sustainability education (www.eyes4earth.org).

Sitas' research bridges the gap between science and practice by contributing to a better understanding of the opportunities and challenges for mainstreaming ecosystem services in development planning at a local level. Despite an increase in research on ecosystem services, and how these services link to development, it would seem that there is still a gap between ecosystem service research and the implementation of management activities on the ground.

A case study in the Eden District of South Africa highlighted the role of knowledge brokers, power dynamics, research process and relationships. Sitas *et al*. (2014a; *Sustainability* 6, 3802-3824; 2014b *Landscape Ecol*. 29, 1315-1331) identify both opportunities facilitating the integration of ecosystem service information in decision making, and challenges impeding integration, in order to bridge the gap between science and practice. The research found that many challenges for mainstreaming ecosystem services exist, such as: insufficient resources; confusion about the concept of ecosystem services; tension between environmental and development concerns; weak alignment of policies and legislation and minimal proactive planning. Despite the challenges, the research also found some opportunities for mainstreaming ecosystem services, especially in relation to: communicating ecosystem service science; the contribution of information to disaster risk-reduction; sector and spatial planning; policy tools and regulatory instruments and the important role of champions.

Tourists' perceptions and willingness to pay for the control of alien plant invasions in protected areas
While protected areas aim to maintain biodiversity, intact landscapes and the ecosystem services these provide, most have been invaded to varying extents. In many cases alien plant species were intentionally introduced as ornamentals, later becoming highly invasive and widespread, including, for example, *Opuntia stricta* (sour prickly pear). Many visitors to protected areas/ national parks do not necessarily have a good understanding of all the conservation challenges being faced, including those posed by the invasion of alien species. Where visitors are aware of the threats posed by invasions, and are even strong supporters of the efforts made by conservation agencies in protecting biodiversity, little is known about whether they would be willing to contribute financially to the control of alien plants to assist these agencies in reaching their goals. A study by Italian student Natasha Nikodinoska, C•I•B core team members Llewellyn Foxcroft and Mathieu Rouget and others assessed the perceptions of tourists to national parks regarding alien plants in general, and their willingness to pay for a hypothetical control programme for *O. stricta*. Tourists' knowledge of IAPs was relatively high, with 75% of respondents having previously heard of the invasive species listed in the survey (wattle, pine trees, lantana, gum trees, water hyacinth, prickly pear), with various other species also being added by the respondents (e.g. Queen of the night cactus and *Chromolaena*).

All of the negative impacts listed (ecosystem functioning, expensive control methods, landscape aesthetics, agricultural weeds, human health, death to livestock) were rated as being highly important. The risks posed to ecosystem function, and the costs of control programmes, were listed as the most concerning impacts from invasive species. Fully 78% of the tourists were willing to pay additional fees to support the control of alien plants in protected areas, with about a third being willing to pay an additional R100. On average, tourists were willing to pay an amount of about R57. The willingness of tourists to pay for *O. stricta* management provides useful insights in the decision-making process of park management. The results are encouraging as tourists are generally aware of the problem and

are in support of providing additional economic input for preventing future alien plant invasions (Nikodinoska *et al*. 2014; *Koedoe* 56, Art. #1214, 8 pages).

Improving pastures for the livestock industry poses major weed threat

The new approach of 'sustainable intensification' in the livestock industry aims to increase food production from existing farmland while minimising pressure on the environment. While beneficial in many respects, this approach poses a major environmental risk, since many newly developed pasture plants pose a high risk of becoming invasive. Livestock production is already the largest user of land on earth, accounting for 30% of the world's land area. Growing demand means that production must rise more than 50% by 2050 as global human population and per capita consumption increase. In response to this demand, agribusiness is developing new pasture plants to increase productivity, grow faster, produce more seeds and tolerate environmental extremes.

'The problem is that in making these pasture varieties more robust, they are more prone to becoming a problem for the environment. New varieties can invade adjacent areas and spread across the landscape, or they can interbreed with existing invasive weeds, ' says Professor Don Driscoll from the Fenner School of Environment and Society at the Australian National University in Canberra who is lead author of the paper. 'New pasture plants intensify invasive species risk' he says. Using data from eight countries on six continents, the authors show that few governments regulate conventionally bred pasture plants to limit threats to natural areas. However, most of these pasture plants pose a substantial weed risk. In Australia, for example, gamba grass (*Andropogon gayanus*) was introduced from Africa in the 1980s as it potentially supports 40 times more cattle than native species. The rate of spread of gamba grass in Australia is now among the highest of any invasive plant in the world. Growing up to four metres tall, this aggressive invader has increased the cost of fire management from less than AUD$2 000 for each fire to as much as AUD$43 000 per fire.

South Africa is fortunate to currently have few problematic pasture species. However, a number of species cultivated here are problematic elsewhere in the world and are also sometimes agricultural weeds. In South Africa, 22 pasture species are prohibited in the regulations for NEMBA. NEMBA also provides for weed risk assessment as a cost-effective biosecurity measure. However, at a subspecies level, there are few barriers to importing new taxa of permitted pasture species. South Africa's legislation for invasive species is among the best in the world. To a large extent South Africa has foreseen this problem, but laws in this country are by no means perfect. This study serves as a wake-up call that further refinement of our legislation is needed. Importantly, the legislation regulates species, but does not regulate the development or importation of new varieties of species that already occur in South Africa. Whereas South Africa's legal framework is relatively strong, the rest of Africa faces a huge risk regarding the importation of species for different forms of agriculture. There is little or no legislation in other parts of Africa regarding the importation or

development of new plants for agriculture: Many aid agencies are under pressure to increase agricultural productivity in Africa, but there are no regulations for controlling which species they introduce. In East Africa, for example, aid agencies continue to promote the use of well-known invasive trees such as *Prosopis* species for agroforestry.

The authors of the paper recommend four approaches that governments could consider to limit the risk of new invasions (see Fig. 19): (i) Develop a national list of pasture species and varieties that are prohibited based on the risks they pose to the environment; (ii) Conduct formal weed risk assessment for all new pasture species, including new varieties of species already present in a country; (iii) Develop a program to rapidly detect and control new taxa that invade natural areas, and (iv) implementat a polluter-pays mechanism, so that if a newly-introduced pasture plant becomes an environmental weed, industry pays for its management.

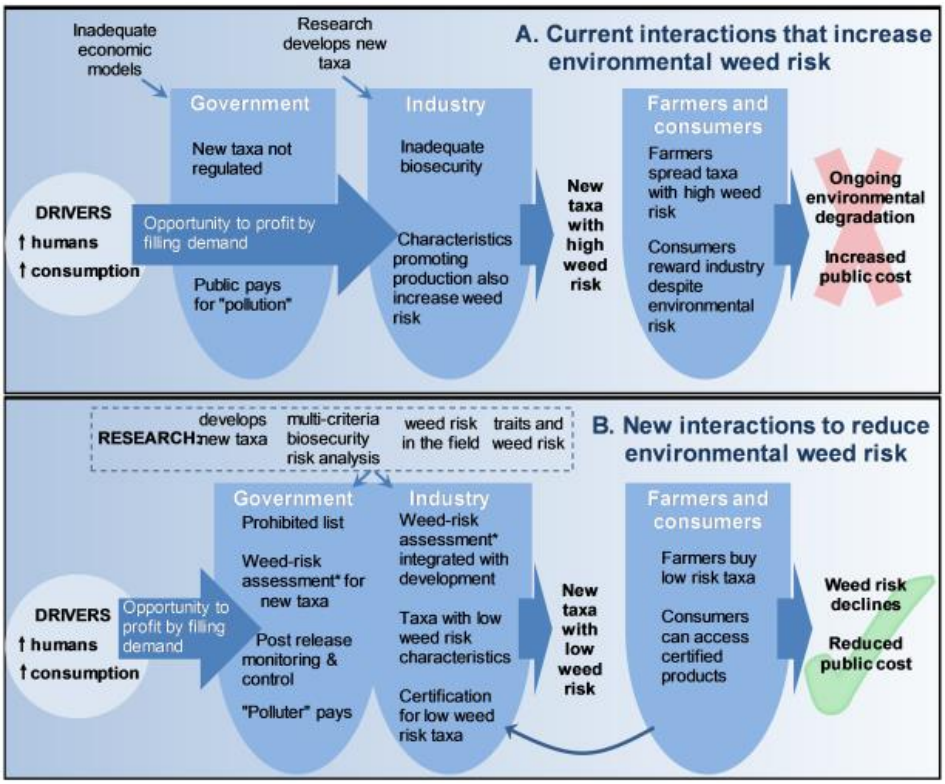

Fig. 19. Pathways influencing the risk that pasture taxa will invade natural areas and become environmental weeds [From Driscoll *et al.* 2014; *PNAS* **111**, 16622-16627].

2 Education and training

2.1 Objectives

The provision of skilled human resources for the South African National System of Innovation forms a central component of the business of the C·I·B. Indeed, the large majority of the research undertaken by the Centre takes place via student training at the post-graduate level. Recognising the enduring requirement for improving the demographic, gender and age profiles of the South African scientific community, and for retaining excellence in the science system, the C•I•B will continue to support 3rd and 4th year students who meet either (or both) of these requirements. The main idea is to draw students into the Centre's sphere of influence and to encourage them to think about the research done by the Centre as a rewarding career path.

2.2 Progress

The C•I•B supported 65 students in 2014. Overall the C•I•B's student body (excluding post-doctoral associates) was 85% South African, 48% black and 58% women. Details of supported students and post-doctoral associates are shown in Sections 7.2 and 7.3.

2.2.1 Graduations

Fifteen students (nine honours, four masters and 2 PhDs) graduated or completed their degrees in 2014 or are awaiting the first graduation ceremony in 2015. Details can be found in Sections 7.2 and 7.3.

2.2.2 Funding

Of the 65 students supported in 2014, 23 were fully funded and 18 were partially funded, receiving a bursary top-up and/or running costs from the Centre, along with co-funding from another organisation or fund. Twenty-four students were independently funded but benefitted from the Centre's support in the form of supervision by a team or staff member and inclusion in Centre activities. The Centre also supported or hosted fourteen post-doctoral fellows in 2014, one of whom resigned to pursue other opportunities in China (Dr Feng Zhang).

2.2.3 Employment

The whereabouts of our graduates is shown in the 'Resources in the market place' table in Section 7.5.

2.2.4 Awards

Once again, the Centre made generous awards to outstanding students for their presentations at the Annual Research Meeting. The winning PhD presentation was by Saachi Sadchatheeswaran (UCT, supervised by Dr Colleen Maloney (UCT) and Dr Tammy Robinson, SU), titled 'The habitat effect: the real estate market on the rocky shore'. Vernon

Steyn gave the best presentation by a Masters student when he spoke about 'Dispersers and non-dispersers of invasive fruit flies differ in their flight physiology and morphology' (Fig. 20). The two winning students received R 25 000 to enable them to travel to an international conference, course or laboratory. Runners-up in the awards were Savannah Nuwagaba (PhD candidate; 'The emergence of food web biodiversity') and David Phair (MSc candidate; 'Detecting the morphometric signal of spatial sorting during the range expansion of European starlings in South Africa and Australia').

Fig. 20. Student award winners for 2014. Above left, Saachi Sadchatheeswaran (extreme right) at the C•I•B's annual dinner. Above right, Vernon Steyn accepting his award from the Director, Prof. David Richardson

3 Information brokerage

3.1 Objectives

One of the central roles of the C•I•B is to foster the knowledge economy, and to use the outcomes of its knowledge production to promote a sustainable society. In consequence, information brokerage at a wide variety of levels forms an important part of the C•I•B's business. In essence, two ways exist for the knowledge, skills and insights of the C•I•B team to be made widely available. First, direct interactions with the C•I•B core team, staff, post-doctoral associates and students provide a means for those directly associated with the C•I•B, across a broad spectrum of society, to benefit from the C•I•B's knowledge generation. Typically this contact takes place via scientific and public lectures; researchers interfacing with students and the general public; interactions at workshops, public meetings and science expos; through the direct media such as radio talk shows; and, importantly, through its major outreach intervention, the Iimbovane Outreach Project. Second, C•I•B makes special efforts to host international workshops and meetings to ensure that students can interact with some of the world's leading biodiversity scientists without incurring substantial, and often unaffordable, costs.

3.2 Progress

3.2.1 Scientific communication with peers (including partners and students)

Workshops hosted

Insect invasions workshop

To coincide with the 2014 Annual Research Meeting, the C•I•B supported a workshop on the 'Drivers, mechanisms and impacts of insect invasions', held on 24 and 25 November in Stellenbosch. The workshop was organised by C•I•B post-doctoral researcher Matt Hill together with core team members John Terblanche and Susana Clusella-Trullas. The meeting brought together a diverse group of scientists across many different aspects of entomological and biological invasions research to discuss what makes insect invasions unique, and where future research efforts should be focussed. In total there were 37 delegates, with many international speakers invited to take part and share their views and expertise on insect invasions (Fig. 21). Three C•I•B post-docs and two post-graduate students attended, and benefited greatly from interaction with international researchers.

The workshop met with the explicit goal of generating an important review paper, which will share the title of the workshop. In addition there was much support and enthusiasm for a journal special issue on insect invasions and the workshop delegates have set about targeting specific topics that will form this collection of papers. Sandy Liebhold delivered the plenary address and set the scene of the workshop, providing an excellent overview and historic context. Helen Roy, Alain Roques, Richard Duncan and Carla Sgro all gave keynote talks, tackling the themes of impacts, mechanisms, drivers and adaptation respectively.

Fig. 21. Participants in the insect invasions workshop hosted by the C•I•B in Stellenbosch in November 2014.

Partners conference: celebrating successful partnerships

The first C•I•B Partners' Conference was held in Stellenbosch in September 2004, ten years after the launch of the C·I·B. The aims of the meeting were to celebrate the success of current partnerships and to explore new areas of collaboration. The conference brought together Centre members and partners from research organisations, conservation authorities, NGOs and government departments, and was attended by some of South Africa's top conservationists, officials and invasive species managers (Fig. 22).

The conference was structured around four main themes: current and potential future priorities of the C·I·B; long-standing research partnerships; applied partnerships; and the C•I•B as the research partner of choice where invasive species are concerned. It began with an overview of some highlights and challenges that the C•I•B faced in its first decade and a discussion of ideas for the future.

Fig. 22. Partners from Invasive Species South Africa, Cape Nature and the C•I•B Director at the Partners' Conference in September 2014. From left: David Richardson (C·I·B), Warren Schmidt (Department of Environmental Affairs, Biosecurity Unit), Ernst Baard (CapeNature) and Kay Montgomery (Department of Environmental Affairs, Biosecurity Unit). *Photo credit: Warren Schmidt*

Annual research meeting

The C•I•B's Annual Research Meeting was held on 27 and 28 November 2014 at Stellenbosch University. The meeting was well-attended, with 35 guests as well as the majority of our team members, staff, students and post-docs attending (Fig. 23). Two core team members were unable to attend due to commitments in their home departments (Profs Chris Chimimba, UP and Steve Johnson, UKZN).

Web-based services

Information Retrieval and Submission System

The C•I•B's Information Retrieval and Submission System (IRSS) contains a total of 1563 items, including 1158 publications and 405 projects datasets, theses and student outputs.

Fig. 23. C•I•B team members and guests at the 2014 Annual Research Meeting, Stellenbosch University

Web page

The C•I•B web page had 17 692 unique visitors (SA: 4 891 [28%], USA: 7 244 [40%], UK: 1775 [10%], Spain: 416 [2%], other nations: 20%). This amounted to 35 441 unique page views and an average visit duration of just over 3 minutes. How do people find our web page? Most visitors reached the page through search engines (53%), a direct link (6 943), or by being redirected from other sites. An example of the information available from our tracking system is shown in Fig. 24 below.

Social media

The C•I•B has maintained a Facebook presence since July 2013 (URL: https://www.facebook.com/centreforinvasionbiology). To date we have had 185 likes. Most visitors are between the ages of 25 and 34; 59% of the people who visit our page are female, and 39% are male (the other 2% did not disclose their gender). During 2014, 49 posts were submitted with an average reach per post (i.e. number of people who view each post) of 86. Therefore, total reach of our page is 86.

Late in 2014, the C•I•B became active on Twitter. Our Twitter handle, @InvasionScience, tweeted from the Annual Research Meeting and now has 28 followers.

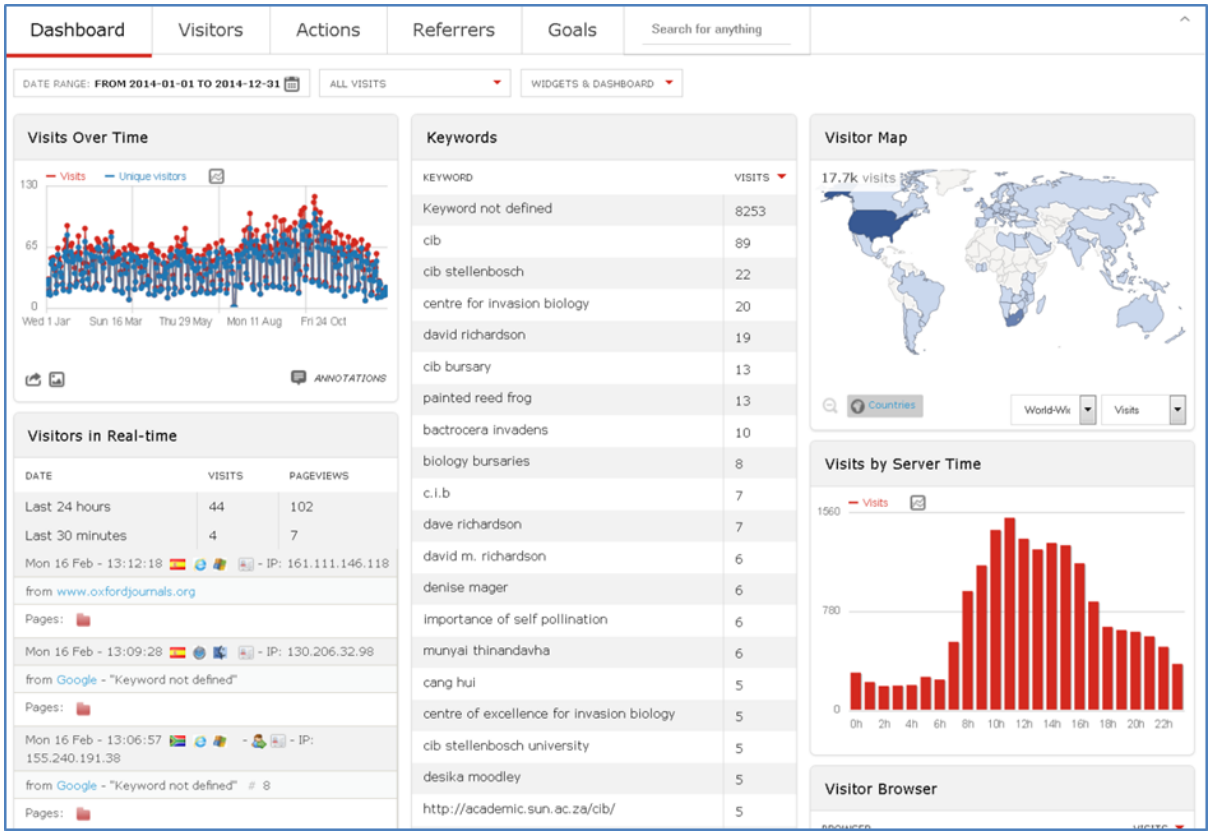

Fig. 24. Breakdown of 2014 visit and visitor information from our web page (URL: http://academic.sun.ac.za/cib/)

3.2.2 Scientific communication with students

Students communicate with the C•I•B through Centre events such as the Annual Research Meeting, and through our web site and social media sites (see 'Scientific communication with peers' above).

In 2014 the C•I•B, through Senior Researcher Dr John Measey, initiated a collaboration with Environmental Humanities South, based at UCT's Departments of Social Anthropology and Historical Studies. The C•I•B will be involved in lecturing to MPhil and PhD students on the Environmental Humanities course.

3.2.3 Communication with partners

See 'Scientific communication with peers' above

3.2.4 Communication with the public

Iimbovane Outreach Project

The Iimbovane Outreach Project flourished in 2014, continuing its outreach in partnership schools and subscription schools, holding learner workshops and participating in career and environmental expos. In March and August 2014, the project team visited all 18 partnership schools to give Grade 10 learners hands-on experience of the scientific research process. The

project team first introduced the learners to the theory of biodiversity and the importance of biodiversity in the biomes of the Western Cape. The learners were introduced to insect and environmental data collection and collected data in their school grounds. Later in the year, the learners learnt how to formulate a research question, collect data and interpret results using the data they had collected during the March fieldwork. During the school visits, the Iimbovane project staff, Ms Dorette du Plessis, Ms Melanie de Morney and Ms Sophia Turner, interacted with approximately 950 Grade 10 learners from secondary schools across the Western Cape and 18 educators. Twenty six of the 28 schools that participated in the project are located in previously disadvantaged areas.

The Iimbovane Outreach Project made full use of the winter school holiday to present two learner workshops. The first workshop, 'Big on Biodiversity', was attended by 30 learners from Vusisizwe Secondary School, Worcester (Fig. 25). The second workshop was for learners from various subscription schools, including Lavender Hill Secondary School (Retreat), Atlantis Secondary School (Atlantis), Breërivier Secondary School (Worcester), Malibu Secondary School (Blue Downs), Sarepta Secondary School (Kuilsrivier), Manzomthombo Secondary School (Blue Downs) and Luhlaza Secondary School (Khayelitsha).

Fig. 25. Above left: Learners attending the 'Big on Biodiversity' workshop examining the diversity of freshwater invertebrates sampled from the Eerste River in Stellenbosch. Above: Learners attending the '*Big on Biodiversity*' workshop using a 'problem tree analysis' to examine global warming. Left: The Iimbovane project team handing over a state-of-art microscope to the Life Science classroom of Fezekile Secondary School, in Oudtshoorn.

Iimbovane project staff taught learners about the scientific method that scientists use to collect biodiversity and environmental information. Later, the learners explored the diversity of ecosystems at the Helderberg Nature Reserve, where they practiced making their own plant reference books to help with identification of fynbos plants, and, despite low water temperatures, explored the aquatic environment and its insects. During the microscope session, each learner used her/his own microscope to identify insects using a dichotomous key. Learners rated this activity highly, as it gave them the experience of working with a microscope and taught them how to recognise the different body parts and features of insects.

One of the key aims of this workshop was to stimulate learner interest in the biological sciences, especially at a tertiary level. Learners were taken on a campus tour and shown the different faculties and the qualification that each faculty offer, as well as a visit to the underground library. Learners left for home having a greater understanding of the importance of biodiversity and how we rely on it in our daily lives. Feedback from learners who attended the workshops included:

'*It was a great experience to work with my group to find insects with different sampling methods and then looking at them through a microscope and to see that they have hair on their bodies*.' (a learner from Vusisizwe Secondary School)

'*I've learnt that ants are very important to us even if they're small and that we must value biodiversity*.' (a learner from Vusisizwe Secondary School)

'*The workshop was extremely helpful - working with actual microscopes was great. The fieldwork was awesome, as it made me realize how precious those animals are and also how human activities can affect animals' habitats*.' (a learner from Sarepta Secondary School).

Although Iimbovane focuses on learners at the school level, it also provides opportunities for undergraduate students to gain work experience. Two third year BSc (Biological Sciences) students worked in the Iimbovane laboratory during their university break. One of the students, Samantha Witbooi, was first introduced to the project in 2010 when she participated in Iimbovane as a Grade 10 learner at Atlantis Secondary School, and she has remained in touch with the project ever since.

Expos and career events

In 2014, the Iimbovane Outreach Project joined other Western Cape institutions to showcase career options in the biological sciences at the Western Cape Education Department's (WCED) Careers Expo at Overberg Primary School, in Caledon. Iimbovane played an important role in giving the learners guidance on subject choices and tertiary institution entry requirements. The interactive discussions by the project team attracted a large number

of learners, who were intrigued by the insects on display, not knowing there was such a vast variety in the Western Cape.

Job shadowing

Grade 10 learners are expected to complete a number of days in the workplace for their Life Orientation curriculum. During the 2014 school holidays Iimbovane opened its doors for learners to gain work experience in the ant identification laboratory.

The year ended on a high note for Iimbovane with the announcement that the project has been awarded a three-year grant from the First Rand Foundation, through the Rand Merchant Bank Fund.

3.2.5 Media highlights

During 2014 the C•I•B's research was reported widely in both local and international media. A few highlights deserve special mention, but the full list of media mentions can be viewed in Section 8 of this report.

In June 2014, the publication of the Alien and Invasive Species Regulations under Chapter 5 of the National Environmental Management: Biodiversity Act led to controversial interactions and letters to the media by members of the public. In response, C•I•B researchers Profs Brian van Wilgen and David Richardson published two articles explaining the facts of biological invasions and their impacts on ecosystems. The articles appeared in multiple newspapers including *The Witness* and the *Weekend Argus*. The C•I•B's research on the impacts of trout on South African rivers was further publicised in an interview with Dr Jeremy Shelton on *Cape Talk* radio.

A paper by C•I•B core team members Jaco Le Roux, Mathieu Rouget and David Richardson and collaborators received considerable attention in the media. The paper, published in the journal *New Phytologist*, investigated the evolutionary history of acacia trees and showed that the acacias on La Réunion are direct descendants of koa populations in Hawaii through an impressive colonisation event around 1.4 million years ago. The paper has led to several articles in both national and international media, accessible on websites *The Times of India*, *Nature*, *Cape Times* and *Daily News*. In addition to the exposure in the online media world, articles also featured in local newspapers and *Classic FM* conducted a radio interview with Dr Le Roux.

In August 2014, a paper by former C•I•B PhD student, Bernard Coetzee, in the journal *PLoS ONE* drew international media attention. The paper analysed more than 30 years of research to determine the effectiveness of parks and nature reserves in the protection of biodiversity. Dr Coetzee found that protected areas do in fact safeguard biodiversity effectively and

featured in articles of *News24*, *Science Daily*, *Science Milestone*, *Science Codex*, *Exeter University* and *Bizcommunity*.

The C•I•B herpetology group has received attention from media after C•I•B core team member, John Measey, introduced local journalists to his research and frog spotting. The frog spotting lead to several articles in local community newspapers, *Sentinel News* and *Constantia Bulletin*, and in newspapers such as *Mail & Guardian* and *Cape Argus*.

In 2014, Prof. David Richardson was honoured for his work when he was included in the Thomson Reuters list of most influential researchers in their respective fields of expertise. Prof. Richardson was recognised for his multidisciplinary contribution to science in South Africa through his exceptional work on the ecology of biological invasions and management strategies for introduced species. This outstanding achievement by Prof. Richardson was reported on in *Eikestad News* and on various websites.

The complete list of media interactions can be viewed in the media section (Section 8).

4 Networking

4.1 Objectives

The C•I•B achieves scientific progress in a variety of ways, from key breakthroughs by individuals to solutions generated through large, multidisciplinary collaborations. The C•I•B encourages a variety of approaches to scientific excellence, and facilitates networking both among its members and with like-minded individuals and organizations in South Africa and abroad. In consequence, networking continues to be a critical component of the C•I•B's work.

4.2 Progress

4.2.1 Agreements with partner institutions

Fellowship Programme

The C•I•B implemented a Fellowship Programme during 2014, and hosted its first three fellows, Profs Brendon Larson (University of Waterloo, Canada) and Anna Travaset (Mediterranean Institute of Advanced Studies, a joint institute of the Spanish Research Council and the University of the Balearic Islands, based in Mallorca, Spain), and Dr Joana Vicente (University of Évora, Portugal). Applications for C•I•B Fellowships are invited from persons from any part of the world who can contribute to any or all of the KPAs, to be considered for appointment as a C•I•B Fellow. Fellows are expected to visit the C•I•B for a period of between one and three months to engage with C•I•B staff, core team members, research associates and students on an issue or issues clearly aligned with the mission and vision of the C•I•B. The engagement may be aligned to any of the five KPAs but should preferably address more than one KPA. Fellowship awards are competitive.

Prof Brendon Larson has a background in ecology, but now conducts interdisciplinary social scientific research about invasive species, for example related to how to communicate about them and how different stakeholders evaluate them. He has also written philosophical papers about our conceptualization of invasive species, specifically in the context of the dramatic changes occurring to socio-ecological systems in the Anthropocene.

Prof Anna Traveset is an expert on island ecology, and is especially interested in the ways that different drivers of global change, including biological invasions, influence the interactions between plants and animals. Her current projects involve predicting how invasive species integrate into, and impact on, the mutualistic networks of different archipelagos – including the Galápagos, the Canary Islands, and the Balearic Islands.

Dr Joana Vicente has a background in fundamental and applied research on ecological modelling of biogeographic patterns, landscape ecology, environmental change, and invasive alien species. Her current projects involve predicting the impacts of multi-scale environmental change on the biological invasions using both static and dynamic modelling techniques.

The first three Fellowships were highly successful, bringing unique expertise to the Centre and allowing face-to-face interaction that would not otherwise be possible for a range of C•I•B members, from senior researchers to junior post-graduate students. We have had positive feedback from the team and from the Fellows themselves, indicating that this programme should be sustained for as long as possible. Enthusiasm is also shown by the steady stream of applications received from leading researchers, and three further fellowships have already been awarded or are in progress for 2015.

New national networking agreements

The C•I•B signed a new collaboration agreement with BirdLife South Africa to facilitate interactions to perform research and student training on avian invasions in SA. Interactions will centre on identifying research priorities, especially where research is needed to inform or establish a control programme; co-supervising and co-funding student and post-doctoral work on invasive taxa and/or implementation of control programmes, and co-hosting workshops and sabbaticals of researchers and conservationists to assist with the identified priorities.

New international networking agreements

No new international agreements were signed in 2014.

Fig. 26. Partner and collaborating organisations of the C·I·B:

4.2.2 Academic visitors to core team members

Prof. Michael Angilletta, Arizona State University, School of Life Sciences. *Collaborator on thermal biology of ectotherms* (Clusella-Trullas)

Prof. Steven Belmain, Natural Resources Institute, University of Greenwich. *Collaborator and Project Leader of the StopRats project on Ecologically-Based Rodent Management* (Taylor)

Mr Tom Bishop, University of Liverpool. *PhD student on Sani Pass ant diversity project* (Robertson)

Prof. Diane Campbell, Dept. Ecology & Evolutionary Biology, University of California, Irvine, USA. *Fulbright-funded collaboration on studies of natural selection in plant hybrid zones* (Johnson)

Dr Enrico Di Minin, University of Finland, Conservation Biology Informatics Group *Training on decision-making software for conservation* (RobOff *and* Zonation) *used in the context of alien plant management* (Rouget)

Prof. Paul Downey, Canberra University, Institute for Applied Ecology. *Collaborator on assessing and refining the use of strategic adaptive management for invasive species management in SANParks* (Foxcroft)

Prof. Patricia Gibert, CNRS, Lyons, France. *Collaborator on invasive fruit flies in Africa* (Terblanche)

Prof. Alan Hansen, Agricultural & Biological Engineering, University of Illinois, USA. *Science education and post-graduate exchange programmes* (Downs)

John S. Hargrove, University of Florida. *Collaboration on North American sunfish invasions in South Africa* (Weyl)

Prof. Stephen Higgins, University of Otago, New Zealand. (Esler, Richardson)

Prof. Raymond B. Huey, University of Washington, Dept. of Biology. (Clusella-Trullas)

Dr Craig Jackson, Department of Biology, Norwegian University of Science and Technology, Trondheim, Norway. *Collaborator on species distribution and conservation research* (Robertson)

Dr Jesse Kalwij, Institute of Botany, Czech Academy of Sciences, Department of Vegetation Ecology, Brno, Czech Republic. *Collaborator on alien plant distributions across an altitudinal gradient* (Robertson)

Prof. Brendon Larson, Environmental & Resource Studies, University of Waterloo, (Gaertner, Richardson, van Wilgen)

Prof. Donald B. Miles, Ohio University, Dept. of Biological Sciences. (Clusella-Trullas)

Prof. Craig Packer, University of Minnesota, USA. *Carnivore research in Africa* (Downs)

Mr Jörn Pagel, Plant Ecology and Nature Conservation, Institute of Biochemistry and Biology, University of Potsdam, Germany. *Collaborator on Proteaceae: research and management priorities in a changing world* (Esler)

Prof. Dane Panetta, University of Melbourne, School of Land and Environment. *Collaborator on book on incursion response planning* (Wilson)

Dr Kate Parr, University of Liverpool. *Collaborator on Sani Pass ant diversity project* (Robertson)

Prof. Alastair Robertson, Associate Professor in Ecology, Ecology, Institute of Natural Resources. Te Kura Mātauranga o ngā Taonga ā Papatuanuku, Massey University, Palmerston North, New Zealand. *Collaboration on bird nectarivory* (Downs)

Prof. Alastair Robertson, Associate Professor in Ecology, Ecology, Institute of Natural Resources. Te Kura Mātauranga o ngā Taonga ā Papatuanuku, Massey University, Palmerston North, New Zealand. *Collaboration on Allee effects in bird-pollinated plants* , Johnson)

Dr Frank Schurr Plant Ecology and Nature Conservation, Institute of Biochemistry and Biology, University of Potsdam, Germany; and Institut des Sciences de l'Evolution, UMR-CNRS 5554, Université Montpellier II, 34095, Montpellier cedex 05, France. *Collaborator on Proteaceae: research and management priorities in a changing world* (Esler)

Prof. Carla Sgro, Monash University, School of Biological Sciences. *Collaborator on evolution of stress resistance in insects* (Terblanche)

Prof. Jesper Sorensen, Aarhus University, Denmark. *Collaborator: metabolomics and genetics of invasive pest stress tolerance* (Terblanche)

Prof. Anna Traveset, Institut Mediterrani d'Estudis Avançats (IMEDEA), Spain. *Island ecology, the ways that different drivers of global change, including biological invasions, influence the interactions between plants and animals* (Richardson)

Mr Merlin D. Tuttle, Bat Conservation International. *Interactions and joint field work on bats with the Centre for Wildlife Management* (Somers)

Dr Joana Vicente, Research Centre in Biodiversity and Genetic Resources (CIBIO) at the University of Évora (Portugal). *Dr Vicente presented a workshop on 'Using Species Distributions Models to assess and anticipate patterns of invasion', and worked on a joint research project with C•I•B colleagues David Richardson, Mirijam Gaertner, Cang Hui and others* (Gaertner, Richardson)

Prof. Bruce Webber, CSIRO, University of Western Australia. *Collaboration on Acacia taxonomy, physiology and adaptation to climate* (Le Roux).

Prof. Bruce Webber, CSIRO, University of Western Australia. *Collaboration on Biogeography of Australian acacias* (Richardson, Wilson).

4.2.3 Academic visits by core team members to other institutions

Département d'Ecologie et de Gestion de la Biodiversité, Paris, France. Meeting of European funded project INVAXEN with Dr Anthony Herrel, Dr Thierry Backeljau, Dr Dennis Rödder & Prof. Rui Rebelo (Measey)

Department of Environmental Biology, University of Delhi, Delhi, India. *Collaboration on India-SA Invasion related research with Dr Gyan Sharma*. (Esler)

Department of Invasion Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Průhonice, and Charles University in Prague, Czech Republic. *Collaboration on determinants of distribution patterns and spread of plant invasions in protected areas with Prof. Petr Pyšek* (Foxcroft)

Estacao de Biologia Maritima Da Inhaca, Faculdade de Ciencias, Universidade Eduardo Mondlane, Maputo, Mozambique. *Collaboration on local ssp. Xenopus laevis with Dr Cornelio Ntumi and Albano Gabriel* (Measey)

Monash University, Melbourne, Australia. *Discussions with Prof. Melodie McGeoch on developing a collaborative research paper* (Wossler)

SAIAB, Grahamstown, SA. *Collaboration on Sundays River Valley project with Dr Olaf Weyl & Dr Darragh Woodford* (Measey)

School of Natural Resource Management, Nelson Mandela Metropolitan University, George, South Africa. *Collaboration on assessing strategic adaptive management and the efficiency of invasive alien plant management in South African National Parks with Prof. Christo Fabricius* (Foxcroft)

South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510650, China. *Workshop on plant reproductive ecology* (Johnson)

Universidad de Chile, Chile. *Collaboration on developments in ecological niche modelling and phylogeny with Prof. Ramiro Bustamante* (Le Roux)

University of Florida, Florida, USA. *Visit to Prof. Micheal Allen, Fisheries and Aquatic Sciences, School of Forest Resources and Conservation, collaborator on centrarchid fish invasions* (Weyl)

University of Vermont, Vermont, United States. *Marsh Professor-at-Large* (Richardson).

4.2.4 Travel awards to core team members, post-doctoral associates and students

Invited, funded to attend the workshop 'Unifying marine and terrestrial biodiversity at the interplay of macroecology, macrophysiology and macroevolution' at SDiv, Leipzig, Germany. 21-24 Oct 2014, Leipzig, Germany (Clusella-Trullas)

V. Thabethe to attend Tropical Biology Association Course in Uganda (Downs)

DRD Grant to bring Prof. Stephen Higgins to South Africa to engage on vegetation modelling approaches for Paleoscapes Research (Esler)

SESYNC project ('Socioecology of Acacia - Anticipatory governance and societal feedbacks in socio-environmental transitions: multicontinental acacia invasions as a model

system') workshop with Christoph Kueffer and colleagues in Halle, Germany, September 2014 (Gaertner)

DRD Research Travel Fund (Le Roux)

NRF KIC travel award for M. Mokhatla to attend HAA meeting in Gobabeb, Namibia (Measey)

Dr Mhairi Alexander; Dr T. Robinson awarded travel grants by the International Council for Science, Scientific Committee on Oceanic Research, and travelled to travel to China to attend the World Conference on Marine Biodiversity (Robinson)

Dr Mhairi Alexander was also awarded a Post Doc Travel Grant by Stellenbosch University (Robinson)

Society for Experimental Biology Annual Main Meeting, Valencia, Spain (Terblanche)

Terrence Bellingan used his C·I·B travel award (runner up for best PhD presentation at the 2013 ARM) to attend the Southern African Society for Aquatic Sciences Conference at Thaba Nchu, Free State (Weyl)

Faculty of Science travel award (Wossler)

Travel award to post-doctoral associate Dr Natasha Mothapo, from the IUSSI 2014 Congress secretariat (Wossler)

Postgraduate and International student office travel award to Dr Natasha Mothapo (Wossler).

4.2.5 Research collaborations

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

Adaptive dynamics. Collaborator: Dr Ulf Dieckmann, IIASA, Austria (Hui)

Alien fish parasites. Prof. Horst Taraschewski, Karlsruher Institut für Technologie (KIT) Campus Süd, Zoologisches Institut Abt. Ökologie/Parasitologie, Germany. Collaboration on invasive fish parasites (Weyl)

Alien plant clearing prioritisation tool. Collaborators: Prof. Atte Moilanen, Dr Enrico Di Minin, University of Finland, Conservation Biology Informatics Group; and Mr Nicolas Cole, SANPARKS, George (Rouget)

Assessing and refining use of strategic adaptive management for invasive species management in SANParks. Collaborator: Prof. Paul Downey, Canberra University, Institute for Applied Ecology. (Foxcroft)

Assessing risks associated with the breeding and development of new pasture species. Collaborator: Prof. D. Driscoll, Environmental Decisions Hub, National Environmental Research Program, ARC Centre of Excellence for Environmental Decisions, Fenner School of Environment and Society, Australian National University, Australia (Richardson)

Biodiversity and human evolution. Collaborator: Prof. Curtis Marean. Institute of Human Origins, School of Human Evolution and Social Change, PO Box 872402, Arizona State University, Tempe, AZ 85287-2402 USA (Esler).

Biodiversity and human evolution. Collaborator: Prof. Richard Cowling. Department of Botany, University of Port Elizabeth, PO Box 1600, Port Elizabeth 6000, South Africa (Esler)

Biology of Mediterranean-Type Ecosystems (Oxford University Press Book project). Collaborator: Dr Brandon Pratt, Department of Biology, California State University Bakersfield, 9001 Stockdale Highway, Bakersfield, California 93311-1099 (Esler).

Biology of Mediterranean-Type Ecosystems (Oxford University Press Book project). Collaborator: Dr Anna Jacobsen, Department of Biology, California State University Bakersfield, 9001 Stockdale Highway, Bakersfield, California 93311-1099 (Esler).

Black listing invasive species for monitoring and reporting. Collaborators: Prof. Melodie McGeoch, Monash University, Australia; Dr Piero Genovesi, Institute for Environmental Protection and Research, Italy; Dr Richard Gregory, Species Monitoring and Research, RSPB, Cambridge University, UK; Dr Donald Holbern, Global Biodiversity Information Facility, Copenhagen; Prof. Walter Jetz, Department of Ecology and Evolutionary Biology, Yale University, USA; Dr Guillaume Latombe, School of Biological Sciences, Monash University; Prof. Petr Pyšek, Department of Invasion Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Průhonice, and Charles University in Prague, Czech Republic; Prof. Mark J. Costello, Institute of Marine Science, University of Auckland, New Zealand; and Dr Marten Winter, Synthesis Centre for Biodiversity Sciences, Leipzig, Germany (Hui)

Cape vulture movement. Collaborator: Dr Dana Berens, University of Marburg, Germany (Downs)

Cape vultures in the Eastern Cape. Collaborator: Dr Jan Venter, Eastern Cape Parks and Tourism (Downs)

Cape vultures, hooded vultures, ground hornbill and oxpeckers. Collaborators: Andre Botha and Leigh Combrink, Endangered Wildlife Trust (Downs)

Cape vultures, hadeda ibis, and aardvark radio tracking. Collaborator: Ben Hoffman, African Bird of Prey Sanctuary (Downs) Carnivore Reintroduction Biology and effects on biodiversity, 2004-2014 – Collaborators: Prof. Micaela Szykman, Humboldt State University; Dr Dave Wildt & Dr Steve Monfort, Smithsonian Institute; Kelly Marnewick, Endangered Wildlife Trust; Dr Matt Hayward, Bangor University (Somers)

Chromolaena odorata and biodiversity in Hluhluwe-iMfolozi Park, 2011 – 2014. Dr Kate Parr, Oxford University (Somers)

Clarifying definitions of alien and invasive species as used in South African marine science. Collaborators: Dr K. Sink, SANBI; Dr C. Simon, Stellenbosch University; Prof. C.L. Griffiths, University of Cape Town; and Dr M. Alexander, Stellenbosch University

Conservation monitoring of otters in Europe and South Africa, 2011-2014: Zoltán Sallai, Hungarian National Parks; Dr István Lehoczky, HAKI; Dr József Lanszki, University of Kaposvár, Prof. Antoinette Kotze and Thabang Madisha, National Zoological Gardens, Kelly Marnewick, Endangered Wildlife Trust (Somers)

Conservation planning, large-scale restoration planning and global change. Collaborators: Dr Debra Roberts, Mr Errol Douwes, eThekwini Municipality (Rouget)

Crowned eagle research. Collaborator: Ethekweni Municipality (Downs)

Defining impacts of non-native species. Collaborator: Prof. J. Jeschke, Institut Technik-Theologie-Naturwissenschaften (TTN), Technische Universität München, Germany (Richardson)

Detection methods for rare fishes. Prof. Hugh MacIsaac and Dr Dan Heath, NSERC Canadian Aquatic Invasive Species Network, Great Lakes Institute for Environmental Research, University of Windsor, Dr Nicholas Mandrak, Great Lakes Laboratory for Fisheries and Aquatic, Fisheries and Oceans Canada (Weyl)

Determinants of distribution patterns and spread of plant invasions in protected areas. Collaborator: Prof. Petr Pyšek, Department of Invasion Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Průhonice; and Charles University in Prague, Czech Republic. (Foxcroft)

Development of a comparative functional response approach for predicting the risk of impacts of invasive species. Collaborator: Prof. J.T.A. Dick, School of Biological Sciences, Queen's University Belfast, Northern Ireland, UK (Richardson, Robinson)

Ecosystem services. Collaborator: Dr Belinda Reyers, CSIR, Natural Resources and the Environment , PO Box 320, Stellenbosch 7599 (Esler)

Development of a unified classification of alien species based on the magnitude of their environmental impacts. Collaborator: Prof. T.M. Blackburn, Zoological Society of London (Richardson)

Distribution and population dynamics of roadside alien plants. Collaborator: Dr Jesse Kalwij, Institute of Ecology & Earth Sciences, University of Tartu, Tartu, Estonia (Robertson)

Distribution and conservation biology of wild dog and cheetah. Collaborator: Dr Craig Jackson, Department of Biology, Norwegian University of Science and Technology, Trondheim, Norway (Robertson)

Ecology and management of Centrarchid fishes. Prof. Micheal Allen, University of Florida & Prof. Mark Pegg, School of Natural Resources, University of Nebraska (Weyl)

Effective conservation for single species, 2012-2014. Dr Matt Hayward, University of Bangor (Somers)

Effects of land abandonment on plant and animal species richness and abundance. Collaborator Dr Tobias Plieninger, Department of Geosciences and Natural Resource Management, Landscape Architecture and Planning, University of Copenhagen, Denmark (Gaertner)

Examining the dimensions of conflicts of interest in invasive species management, with special reference to invasive tree management. Collaborator: Prof. I.A. Dickie, Landcare Research, Lincoln, New Zealand (Richardson, van Wilgen)

Functional responses and ecology of invasive fishes. Prof. Jaimie T.A. Dick. School of Biological Sciences, Medical and Biological Centre, Queen's University Belfast, N. Ireland, UK. Collaboration on functional responses (Weyl)

Functional responses of the European shore crab in its native and invaded ranges. Collaborators: Dr A. Ricciardi, Simon Frazer University, Canada; Prof. J.T.A. Dick, Queens University, Belfast, N. Ireland; Dr D. O'Neil, Queens University, Belfast, N. Ireland; Ms B. Howard, Simon Frazer University, Canada; and Dr M. Alexander, Stellenbosch University (Robinson)

Genetic status of the African wild cat (*Felis silvestris lybica*) and the potential risk of hybridisation with feral domestic cats (*Felis catus*). Collaborators: Dr Marna Herbst, South African National Parks. (Foxcroft, Le Roux)

Genetics of various species including Cape parrot, serval, Cape vultures, leopard tortoises, crowned eagles and blue swallows. Collaborator: Dr Sandi Willows-Munro, UKZN (Downs)

Herpetological conservation: Collaborator: Dr Krystal Tolley, South African National Biodiversity Institute, Kirstenbosch, Cape Town, South Africa (Measey)

Historical, hybrid and novel ecosystems – applications of these concepts in management. Collaborator: Prof. R.J. Hobbs, School of Plant Biology, University of Western Australia, (Richardson)

Impacts and benefits of alien fish introductions. Dr Leo Nagelkerke, Wageningen University, Aquaculture & Fisheries Group, the Netherlands. Collaborator on work on impacts and benefits of alien fish introductions (Weyl)

Insect Chemoreceptors. Prof. Phil Matthews, University of British Columbia, Vancouver, Canada (Terblanche).

Invasive amphibian modelling. Collaborator: Dr Dennis Rödder, Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany (Measey)

Invasive plants as drivers of regime shifts. Collaborators: Dr Reinette Biggs, Stockholm Resilience Centre, Stockholm University, Sweden; Dr Mariska te Beest, Department of Ecology and Environmental Science, Umea University, Sweden; Prof. Cang Hui, Centre for Invasion Biology, Department of Mathematics, Stellenbosch University, Stellenbosch, South Africa; and Prof. Jane Molofsky, Department of Plant Biology, University of Vermont, Burlington, USA (Gaertner)

INVAXEN. Collaborators: Dr Anthony Herrel, Département d'Ecologie et de Gestion de la Biodiversité, Muséum National d'Histoire Naturelle, Paris, France; Dr Dennis Rödder, Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany; Dr Thierry Backeljau, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Prof. Rui Rebelo, Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal (Measey)

Mammal and bird tracking. Collaborators: Victor Hugo, Animal Track_em (wildlife consultancy) Pietermaritzburg; and Francois Botha, Wireless International, Potchefstroom (Downs)

Mammal, bird and plant identification. Collaborator: Geoff Nicols, Geoff Nichols Horticultural Services (wildlife consultancy), Anerley. (Downs)

Metabolomics of stress resistance in insects. Collaborator: Dr Jesper Sørensen, Aarhus Centre for Environmental Stress Research, Ecology and Genetics, Department of Biological Sciences, University of Aarhus (Terblanche).

Mechanisms and processes associated with tree invasions into treeless areas. Collaborator: Prof. P.W. Rundel, Department of Ecology and Evolutionary Biology University of California Los Angeles CA, USA (Richardson)

Metabolomics of stress resistance in insects. Collaborator: Prof. Vladimir Kostal, Centre for Entomological Sciences, Czech Republic (Terblanche).

Multiple roles of avian endozoochory on seeds invasive Acacia cyclops in South Africa, The. Collaborators Dr Thabiso M. Mokotjomela, and Prof. John H. Hoffmann, Department of Biological Sciences, University of Cape Town (Downs)

Mutualistic interactions and biological invasions. Collaborator: Prof. A. Traveset, Institut Mediterrani d'Estudis Avançats, Spain (Richardson)

Nile crocodile ecophysiology. Collaborator: Dr Jan Myburgh, University of Pretoria (Downs)

Overall research on *Rattus* in South Africa. Collaborators: Dr Armanda Bastos, Department of Zoology and Entomology, University of Pretoria, Pretoria, South Africa; Dr Helene Brettschneider, National Zoological Gardens, Pretoria, South Africa; Dr Volker Schwan, Department of Veterinary Tropical Diseases, University of Pretoria, Pretoria, South Africa; Dr Frikkie Kirsten and Dr Emil von Maltitz, Plant Protection Research Institute (PPRI), Agriculture Research Council, Pretoria, South Africa (Chimimba)

Paleontological environmental reconstruction: Collaborator: Dr Thalassa Matthews, Iziko Museums of Southern Africa, Cape Town, South Africa (Measey)

Physiological modelling of invasive species ranges. Collaborator: Prof. S.I. Higgins, Department of Botany, University of Otago, New Zealand (Richardson)

Predator-prey interactions. Collaborator: Prof. James Vonesh, Department of Biology, Virginia Commonwealth University, USA (Measey)

Predictive framework for invaded communities, A. Collaborator: Prof. Melodie McGeoch, Monash University, Australia (Hui)

Preliminary survey of the invasive alien plants of Angola. Collaborator: Prof. M. Rejmánek, Department of Ecology and Evolution, University of California Davis, CA, USA (Richardson)

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

Quantification of the invasiveness of species. Collaborator: Dr R. Colautti, Botany Department, University of British Columbia, Canada (Richardson)

Rattus in townships, assist in sampling of. City of Johannesburg (Chimimba)

Restoration after alien plant removal. Collaborator: Dr Pat Holmes, Environmental Resource Management Department, City of Cape Town, South Africa (Gaertner)

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

Restoration of Natural Capital. Collaborator: Prof. Sue Milton. RENU KAROO, Prince Albert (Esler)

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

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

Shifts to faster growth strategies in novel ranges of invasive alien plants. Collaborator: Prof. M.L. Leishman, Department of Biological Sciences, Macquarie University, Australia (Richardson)

Small carnivores in space and time, 2012-2014. Dr Emmanual do Linh San, University of Fort Hare; Prof. Jerry Belant, Mississippi State University, USA; Dr Jun Sato, Fukuyama University, Japan (Somers)

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

Socioecology of Acacia - Anticipatory governance and societal feedbacks in socio-environmental transitions: multicontinental acacia invasions as a model system (SESYNC project). Collaborator: Dr Christoph Kueffer, ETH Zurich, Department of Environmental Systems Science, CH-8092 Zürich, Switzerland (Gaertner)

Social parasitism within the Cape honey bees and impacts on the savannah honey bee population. Collaborators: Prof. Ben Oldroyd and Prof. Madeleine Beekman, School of Biological Sciences, University of Sydney, Australia and Mike Allsopp, Bee Research Unit, Plant Protection Research Institute, Agricultural Research Council (Wossler)

South African and introduced megadriles (i.e. earthworms), research into. Dr Sandi Willows-Munro (UKZN); Dr Danuta Plisko (KZN Museum); and others. (Wilson)

South African soils, Research into. Prof. Schalk Louw (U. of Free State) and the Soil Ecosystem Research Grouping. (Wilson)

StopRats: Sustainable technology to overcome pest rodents in Africa through science. ACP-EU Co-operation Programme in Science and Technology (S&T II). Leader: Prof. Steve Belmain, Natural Resources Institute, University of Greenwich. Other collaborator included researchers from University of Swaziland, University of Namibia, Association Vahatra in Madagascar, and Sekoine University of Agriculture in Tanzania (Taylor)

Strategic adaptive management and the efficiency of invasive alien plant management in South African National Parks. Collaborators: Prof. Christo Fabricius and Mr Wynand Loftus, School of Natural Resource Management, Sustainability Research Unit, Nelson Mandela Metropolitan University (Foxcroft)

Unifying marine and terrestrial biodiversity at the interplay of macroecology, macrophysiology and macroevolution, SDiv, Leipzig, Germany. Collaborators:

Miguel Angel Olalla-Tarraga, Rey Juan Carlos University; and Ignacio Morales-Castilla, McGill University (Clusella-Trullas)

Volatile analyses of indigenous fruits and small carnivore secretions. Collaborator: Dr Adam Shuttleworth, UKZN (Downs)

Water relations in riparian vegetation. Dr Cheryl Swift, Department of Biology, Whittier College, Whittier, CA 90608 USA (Esler).

5 Service provision

5.1 International panels and committees

Pan African Ornithological Congress Committee: Member (Downs).

6th Frugivore & Seed Dispersal International Symposium-Drakensberg, SA 2015: Chair (Downs)

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

IUCN Mediterranean-Type Ecosystem Thematic Group: Member (Esler)

Mediterranean Research Managers International Cooperative: Member (Esler)

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

IUCN Species Survival Commission- Conifers Specialist Group: Member (Richardson)

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

IUCN Species Survival Commission- Reintroduction specialist Group: Member (Somers).

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

International Association for Biological Oceanography (IABO) South African National Representative (Griffiths) (resigned position during the year)

Université Catholique de Lyon, Member of panel at PhD examination, April 2014 (Measey)

GBIF Africa Science committee: Member (Rouget)

DIVERSITAS bioDISCOVERY Core Project, Member of the Scientific Committee (Weyl)

International Advisory Board Member for the International Union for the Study of Social Insects (IUSSI) 2014, Cairns (committee member) (Wossler).

5.2 National panels and committees

Member: Steering Committee, Centre of Excellence at the Percy FitzPatrick Institute of Ornithology, University of Cape Town (Chimimba).

Member: Board of Trustees, Green Trust. Member (Chimimba).

Member: Advisory Board, Research Committee, South African National Biodiversity Institute (SANBI) (Chimimba)

Adjudication panel member (Vice Chairperson): National Science and Technology Forum (NSTF) (Chimimba)

Steering Committee to Water Research Commission K5/2185: Member (Downs).

Steering Committee to Water Research Commission K5/2186: Member (Downs).

Zoological Society of Southern Africa: Hon. Treasurer (Downs)

SAEON Fynbos Node Liaison committee: Member (Esler)

HERS Advisory Board: Chair (Esler)

Fynbos Forum Committee: Member (Esler)
Table Mountain Fund Conservation Strategy advice committee: Member (Esler)
Berg River Clearing and Rehabilitation Advisory Committee: Member/Technical Advisor (Esler)
Board member -SADCO (South African Data Centre for Oceanography) 2004- (Griffiths)
Board Member – AfriOceans Conservation Alliance (Griffiths)
Advisory Board South African Institute for Aquatic Biodiversity (SAIAB) 2012- (Griffiths)
National Invasive Animal Forum, Amphibian specialist (Measey)
CAPE Invasive Alien Animals Working Group, Amphibian specialist (Measey)
Examiner, MSc thesis, University of Stellenbosch (Measey)
Examiner, PhD thesis, Northwest University (Measey)
Examiner, MSc thesis, University of KwaZulu-Natal (Measey)
Examiner, PhD thesis, University of Stellenbosch (Measey)
Advisory board of the Southern African Plant Invaders Atlas (Robertson)
Member of the IUCN Wild Dog Advisory Group of South Africa (Somers)
South African Bat Assessment Advisory Panel: Member (Taylor)
Zoological Society of Southern Africa: Council member and former president (Taylor)
Southern African Society for Systematic Biology: Council member (Taylor)
South African Council for Natural Scientific Professions (SACNASP) Qualifications Assessment Commitment: Member (Taylor)
Endangered Wildlife Trust - Healthy Rivers Programme: Panel of Experts (member) (Weyl)
CAPE Invasive Alien Animal Working Group Member (Wilson)
National Invasive Alien Animal Forum Member (Wilson)
Cactus National Working Group Member (Wilson)
Alien Grasses National Working Group Member (Wilson)
Helderberg Nature Reserve Advisory Board committee member (Wossler)
Scientific advisor to DEA (various directorates) (van Vuuren)
Vice Chair of the South African National Committee for the Scientific Committee on Antarctic Research (van Vuuren)
DEA Natural Resource Programmes – Member, Research Advisory Panel (van Wilgen).

5.3 Editorial and refereeing activities

5.3.1 Editor

African Journal of Herpetology (Measey)
African Zoology, Editor-in-Chief (Wossler).
BioInvasions Records (Wilson)
Diversity and Distributions, Editor-in-Chief (Richardson)
Koedoe, Editor-in-Chief (Foxcroft)

5.3.2 Associate/Assistant Editor

African Entomology (Wossler).
African Journal of Aquatic Science (Weyl)
African Zoology (Weyl)

BioInvasions Records (Measey)
Biological Invasions (Hui, Le Roux, Richardson)
Climate Change Responses (Terblanche)
Conservation Biology (van Wilgen)
Conservation Genetics (Le Roux)
Diversity and Distributions (Robertson, Rouget, Wilson)
Fire Ecology (van Wilgen)
Frontiers in Physiology (Terblanche)
Ibis (Downs)
Koedoe. Associate Editor (Somers)
Mammalian Biology. Associate Editor (Somers)
Neobiota (Foxcroft, Richardson)
Ostrich (Downs)
PeerJ (Measey, Somers)
Salamandra (Measey)
South African Journal of Science (van Wilgen)
South *African Journal of Wildlife Research*. Associate Editor (Somers).

5.3.3 Editorial Boards

Acta Chiropterologica. Editorial board member (Taylor)
African Entomology (Terblanche)
African Natural History, Editorial Board member (Griffiths)
African Zoology. Editorial board member (Taylor)
Animals. Editorial Board Member (Griffiths)
Annals of Botany - Plants (Richardson)
Austral Ecology. Editorial board member (Clusella-Trullas)
Austral Entomology (Terblanche)
BioInvasions Records – Associate Editor (Weyl)
Biological Invasions (Hui)
BMC Ecology (Hui)
Cambridge University Press book serices "Ecology, Biodiversity, and Conservation" and "Conservation Biology" (Richardson)
Forest Ecosystems (Richardson)
Frontiers in Invertebrate Physiology. Review editor (Clusella-Trullas)
Journal of Fish Biology - Assistant Editor (Weyl)
Journal of Thermal Biology. Editorial board member (Clusella-Trullas; Terblanche)
Koedoe, Editorial Board member (Griffiths)
Malagasy Nature. Editorial board member (Taylor)
Mammalia. Editorial board member (Taylor)
PeerJ. Editorial Board Member (Esler)
Proceedings of the Royal Society: B (Johnson)
Smithiana, Editorial Board member (Griffiths).

5.3.4 Reviewing

National

African Entomology; *African Journal of Aquatic Science*; *African Journal of Marine Science*; *African Journal of Range and Forage Science*; *African Zoology*; *Koedoe*; *Ostrich*; *South African Journal of Botany*; *South African Journal of Science*; *South African Journal of Wildlife Research*; *Transactions of the Royal Society of South Africa*; *Water SA.*

International

Acta Academica, Acta Herpetologica; *Acta Oecologia*; *Acta Ornithologica*; *Acta Theriologica*; *Acta Zoologica Academiae Sciencarum Hungariace, Acta Zoologica Cracoviensia*; *African Journal of Ecology*; *African Journal of Herpetology*; *African Journal of Research in Mathematics, Science and Technology Education*; *African Zoology*; *American Journal of Botany*; *Amphibia-Reptilia*; *Annals of Botany Plants*; *Aquatic Invasions*; *Austral Ecology*; *Axios*; *Animal Welfare*; *Animal Biology*; *Applied Herpetology*; *Applied Vegetation Science*; *Ardea*; *Auk*; *Behavioral Ecology and Sociobiology*; *Bioinvasions Records*; *Biological Conservation*; *Biological Control*; *Biological Invasions*; *Biological Journal of the Linnean Society*; *Bioscience*; *BMC Evolutionary Biology*; *Bull. BOC*; *Canadian Journal of Zoology*; *Caribbean Journal of Science*; *Chinese Birds*; *Comparative Biochemistry & Physiology*; *Condor*; *Conservation Biology*; *Conservation Letters*; *Current Zoology*; *Conservation Biology*; *Current Opinions in Insect Science*; *Diversity and Distributions*; *Earth Systems and Environmental Science*; *Ecography*; *Ecological Applications*; *Ecological Indicators*; *Ecological Processes*; *Ecology*; *Ecology Letters*; *Emu*; *Environmental Conservation*; *Environmental Management*; *Ethology*; *European Journal of Wildlife Research*; *Evolution*; *Evolutionary Applications*; *Forest Ecology and Management*; *Forest Ecosystems*; *Functional Ecology*; *Global Change Biology*; *Global Ecology and Biogeography*; *Herpetological Conservation and Biology*; *Herpetological Journal*; *Ibis*; *Integrative Zoology*; *International Journal of Primatology*; *International Journal of Science Education*; *Invasive Plant Science and Management*; *International Journal of Wildland Fire*; *Journal of Applied Ecology*; *Journal of Applied Geography*; *Journal of Arid Environments*; *Journal of Biogeography*; *Journal of Chronobiology*; *Journal of Comparative Physiology B*; *Journal of Ecology*; *Journal of Experimental Biology*; *Journal of Experimental Marine Biology and Ecology*; *Journal of Herpetology*; *Journal of Jazan University*; *Journal of Mammalia*; *Journal of the National Museum (Bloemfontein)*; *Journal of the Marine Biological Association (UK)*; *Journal of Natural History*; *Journal of Ornithology*; *Journal of Sustainable Forestry*; *Land Degradation & Development*; *Journal of Thermal Biology*; *Journal of Tropical Ecology*; *Journal of Zoology*; *Journal of Zoology (London)*; *Journal for Nature Conservation*; *Journal of Vegetation Science, Trends in Ecology and Evolution*; *Journal of Evolutionary Biology*; *Landscape and Urban Planning*; *Mammalia, Mammalian Biology, Mammalogy, Management of Biological Invasions*; *Marine Biodiversity*; *Marine Biology Research*; *Marine Environmental Research*; *Molecular Ecology*; *Molecular Phylogenetics and Evolution*; *Nature*; *Nature Communications*; *Neobiota*; *New Phytologist*; *Oecologia*; *Ornis Fennica*; *Parasites and Vectors*; *PeerJ*; *Perspectives in Education*; *Pest Management Science*; *Perspectives in Plant Ecology, Evolution and Systematics*; *Physiology and Behavior*; *Physiological and Biochemistry Zoology*; *Plant Ecology*; *PLoS ONE*; *PLoS Biology*; *Primates*; *Primate Conservation*; *Proceedings of the Royal*

Society B; *Raffles Bulletin of Zoology*; *Regional Environmental Change*; *Reproduction, Revista Mexicana de Biodiversidad*; *Tropical Conservation Science*; *Vulture News*; *Waterbirds*; *Web Ecology*; *Western Indian Ocean Journal of Marine Science*; *Zoomorphology*; *Zoological Studies.*

5.3.5 Grant reviews for external bodies

Australian Antarctic Science Program. Review of project proposal (Wilson)
Austrian Science Fund. FWF – GAČR 2014 Lead Agency Call for Czech-Austrian Joint
Icelandic Research Fund. Review of project proposal (Wilson)
National Geographic (Clusella-Trullas; Downs)
National Geographic Grant Review (Somers)
National Geographic, Expert Review of Funding Proposal x2 (Esler)
National *Parthenium* Strategy and Implementation Plan. Review (Wilson)
National Science Foundation (Downs)
Netherlands Organisation for Scientific Research, Caribbean Research: a multi-disciplinary approach. Review of project proposal (Wilson)
Research Projects. Expert review for funding application (Taylor)
Royal Society of New Zealand (Marsden Fund), Prime Minister's Science Prize (Referee) (Richardson)
University of Wisconsin-Milwaukee's Research Growth Initiative, Expert review of proposal on Enabling Real-Time, Long-Distance Research in an African Great Lake (Weyl)
Whitley Fund for Nature, London. Expert review for funding application (Taylor).

5.3.6 Appointment reviews and committees

King Fahd University, Saudi Arabia: Associate Professorial Appointment (Chimimba)
Stellenbosch University: Career progression of women employees at Stellenbosch University, Project Team (Esler)
Stellenbosch University: Professor appointment (Hui)
Stony Brook University, USA: Promotion to Distinguished Professor (Richardson)
University of Maryland, USA: Promotion to Professor (Richardson)
University of Colorado at Boulder, USA: Professorial Appointment (Richardson)
Université de Neuchâtel, Switzerland: Professorial Appointment (Richardson)
University of Basel, Switzerland: Professorial Appointment (Richardson)
University of Venda: Appointment review (Somers)
Stellenbosch University: Lecturer/Senior Lecturer appointment (Terblanche)
Rhodes University, Research Associate (Weyl).

5.3.7 Consulting and other services rendered

Consultancy products

Leadley, P.W., Krug, C.B., Alkemade, R., Pereira, H.M., Sumaila U.R., Walpole, M., Marques, A., Newbold, T., Teh, L.S.L, van Kolck, J., Bellard, C., Januchowski-Hartley, S.R. and Mumby, P.J. (2014). Progress towards the Aichi Biodiversity Targets: An assessment of biodiversity trends, policy scenarios and key actions. Secretariat of the Convention

on Biological Diversity, Montreal, Canada. Technical Series 78. [C•I•B Research Associate Rainer Krug is listed as a "contributing author"].

Strahm, W. and van Wilgen, B.W. (2014). Recommendations on the management of fire and invasive alien species in the Réunion National Park. IUCN Report to Reunion National Park, 28 pp.

Van Wilgen, B.W., and others. (2014). A National Strategy for dealing with Biological Invasions in South Africa. Report compiled for the Department of Environmental Affairs, 163 pp. (Davies; van Wilgen; Wilson).

Additional reviews

- Prime Minister's Science Prize, New Zealand (Referee) (Richardson)
- Reviewed a release application for a biological control agent to control an alien invasive plant species in South Africa for the Department of Environmental Affairs (Robertson)
- Review of a proposal to release the biological control agent *Catorhintha schaffneri* into the Isimangaliso Wetland Park, on behalf of the Isimangaliso Wetland Park Authority (van Wilgen)
- Review of an application by the Agricultural Research Council-Plant Protection Research Institute for the release nationwide of the biological control agent *Smicronyx lutulentus* on the weed *Parthenium hysterophorus* (van Wilgen).

6 Gender impact of research

The C•I•B gives careful attention to the representation of females in all facets of its work. Although females only represent 355 of the core team (9 out of 26), females are much better represented among the C·I·B staff (94%; 16 out of 17), post-docs (50%; 7 out of 14) and students (58%; 38 out of 65). The Iimbovane project is staffed entirely by women, providing a powerful role model and informal career path guidance for potential young scientists. Iimbovane is increasingly being drawn into hosting learners who wish to do vacation work in the Iimbovane labs, and it is almost invariably young women who volunteer in this way (see also Section 3.2.4).

Fig. 27. Learners who attended the *Big on Biodiversity* workshop use a problem tree analysis to examine global warming.

7 Human resources

7.1 Steering Committee

The C•I•B is advised by a Steering Committee, as stipulated in the 2014 Memorandum of Agreement between the National Research Foundation and Stellenbosch University. The Steering Committee meets twice each year and plays an important role in advising on and approving annual plans and budgets, as well as key report, such as this Annual Report.

Name	Affiliation	Role
Prof. Eugene Cloete	Vice-Rector: Research and Innovation, Stellenbosch University	Chair of the Board; *ex officio* member
Prof. David Richardson	Director, C•I•B, Stellenbosch University	*Ex officio* member
Prof. Louise Warnich	Dean: Faculty of Science, Stellenbosch University	*Ex officio* member
Dr Thandi Mgwebi	Executive Director, Research Chairs and Centres of Excellence (RCCE) Programme	Funding body representative
Mr Bheki Hadebe	Manager, Human Capital, Department of Science and Technology	Funding body representative
Prof. Anne Magurran	Professor, School of Biology, University of St Andrews, UK	Science advisor
Prof. Richard Duncan	Professor of Conservation Ecology, Institute for Applied Ecology, University of Canberra, Australia	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 & Rhodes University	Industry representative
Mr Ahmed Khan	Natural Resources Management Programmes, Department of Environmental Affairs	Industry representative
Prof. Stefan Foord	Associate Professor, Department of Zoology, University of Venda	Core team representative
Dr Sarah Davies	Deputy Director, C•I•B, Stellenbosch University	*Ex officio* member

7.2 Core team members

The C•I•B team is made up of researchers working in ten universities and research institutions around South Africa. The core team members conduct research and student training, as well as networking and service provision, in the field of biological invasions.

Name	Citizenship	Institution	Race	Gender	% Time spent working in CoE
Prof. David Richardson	SA	SU	W	M	100
Ms Sarah Davies	SA	SU	W	F	100
Prof. Chris Chimimba	SA	UP	B	M	10
Dr Susana Clusella-Trullas	Spain	SU	W	F	15
Prof. Colleen Downs	SA	UKZN	W	F	10
Prof. Karen Esler	SA	SU	W	F	30
Prof. Stefan Foord	SA	UniVen	W	M	30
Dr Llewellyn Foxcroft	SA	SANParks	W	M	10
Dr Mirijam Gaertner	Germany	CoCT	W	F	75
Prof. Charles Griffiths	SA	UCT	W	M	10
Prof. Cang Hui	China	SU	B	M	40
Prof. Bettine Jansen van Vuuren	SA	UJ	W	F	5
Prof. Steven Johnson	SA	UKZN	W	M	5
Dr Jaco le Roux	SA	SU	W	M	40
Dr John Measey	UK	SU	W	M	100
Dr Heidi Prozesky*	SA	SU	W	F	5
Prof. Mark Robertson	SA	UP	W	M	15
Dr Tammy Robinson	SA	SU	W	F	30
Prof. Mathieu Rouget	France	UKZN	W	M	10
Prof. Michael Somers	SA	UP	W	M	10
Prof. Peter Taylor	SA	UniVen	W	M	10
Prof. John Terblanche	SA	SU	W	M	10
Prof. Brian van Wilgen	SA	SU	W	M	50**
Dr Olaf Weyl	SA	SAIAB	W	M	25
Prof. John Wilson	SA	SANBI	W	M	75
Prof. Theresa Wossler	SA	SU	W	F	10

*Dr Prozesky resigned from the C•I•B core team during 2014 to take up a management position in another CoE. **This is a part-time position.

Fig. 27. C•I•B core team members considering 'horizon scanning' for invasion biology at a meeting held in preparation for the Strategic Plan and Partners' Conference (June 2014).

7.3 Research associates

The C·I·B's research associates are individuals who are expert in or interested in matters related to biological invasions, working within academic and non-academic organisations. The research associate network allows the Centre to extend its reach and 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.

Name	Institution
Prof. Tim Blackburn	Department of Genetics, Evolution & Environment, University College London
Prof. Jane Carruthers	Professor Emeritus, Dept. History, UNISA
Prof. Steven Chown	School of Biological Sciences, Monash University, Australia
Mr John Cooper	Agreement on the Conservation of Albatrosses and Petrels (ACAP, www.acap.aq)
Dr Franz Essl	Austrian Environment Agency; University of Vienna
Dr Sjirk Geerts	Cape Peninsula University of Technology
Prof. Jan Giliomee	Dept. Botany and Zoology, Stellenbosch University
Dr Patricia Holmes	Environmental Resource Management, City of Cape Town
Dr Brian Huntley	SABONET
Ms Ulrike Irlich	Invasive Species Unit, City of Cape Town
Dr Charlene Janion-Scheepers	School of Biological Sciences, Monash University, Australia
Dr Jesse Kalwij	Institute of Botany, Academy of Sciences of the Czech Republic
Dr Rainer Krug	None
Dr Christoph Kueffer	Department of Environmental Systems Science, ETH Zurich
Dr David Le Maitre	Natural Resources and Environment, CSIR, Stellenbosch
Prof. Melodie McGeoch	School of Biological Sciences, Monash University, Australia
Dr John Measey*	Dept. Zoology, Nelson Mandela Metropolitan University
Mr Dave Pepler	None
Dr Heidi Prozesky	Dept. Sociology and Social Anthropology, Stellenbosch University
Prof. Petr Pyšek	Institute of Botany, Academy of Sciences of the Czech Republic
Dr Nicola van Wilgen	SANParks
Dr Antoinette Veldtman	CapeNature
Dr Darragh Woodford	SAIAB

*Dr Measey was a research associate of the C·I·B until 31 March 2014 prior to becoming a core team member and full staff members of the Centre in April 2014.

7.4 Post-doctoral associates

Post-doctoral associates who worked in the Centre during 2014, including those who resigned or completed their work during the year

Name	Citizenship	Institution	Race	Gender	Status
Dr Mhairi Alexander	UK	SU	W	F	Continuing
Dr Shelley Edwards	SA	SU	W	F	Continuing
Dr Bruce Ellender	SA	SAIAB	W	M	Continuing
Dr Michelle Jackson	UK	UP	W	F	Continuing
Dr Matthew Hill	Australia	SU	W	M	Continuing
Dr Heidi Hirsh	Germany	SU	W	F	Continuing
Dr Michael Logan	USA	SU	W	M	Continuing
Dr Sabrina Kumschick	Switzerland	SU	W	F	Continuing
Dr Matthew McConnachie	SA	CSIR	W	M	Continuing
Dr Natasha Mothapo	SA	SU	B	F	Continuing
Dr Ana Novoa Perez	Spain	SU	W	F	Continuing
Dr Vernon Visser	SA	SU	W	M	Continuing
Dr Ryan Wasserman	SA	SAIAB	W	M	Continuing
Dr Feng Zhang*	China	SU	B	M	Resigned

*Dr Zhang was not supported in 2014, as he resigned and departed very early in the year. Therefore he does not appear in the Service Level Agreement targets.

7.5 Students supported

Students supported fully or in part by the Centre as well as those who are independently funded but receive other forms of support from the Centre and are included in our events and activities are included in the table below.

Name	Citizenship	Institution	Gender	Race	Status	Funding
Honours						
Ms Debbie Du Preez	SA	NMMU	F	White	Completed	Full
Ms Jamaine Krige	SA	SU	F	White	Completed	Full
Mr Devon Larkin	SA	NMMU	M	White	Completed	Full
Ms Nombuso Ngubane	SA	SU	F	Black	Completed	Full
Ms Audrey Raidani	SA	UNIVEN	F	Black	Completed	Independent
Ms Hannah Raven	SA	SU	F	White	Completed	Partial
Mr Cavin Shivhambu	SA	UNIVEN	M	Black	Completed	Full
Ms Christien Steyn	SA	UP	F	White	Completed	Full
Ms Lise-Mari Van Zyl	SA	SU	F	White	Completed	Partial
Masters						
Mr Stuart Barrow	SA	SU	M	White	Completed	Partial
Ms Patricia Begwa	SA	UNW	F	Black	Continuing	Partial
Mr Casey Broom	SA	SU	M	White	Continuing	Independent
Ms Laura Caetano	SA	SU	F	Black	Continuing	Full
Ms Susan Canavan	Ireland	SU	F	White	Continuing	Partial
Mr André de Villiers	SA	SU	M	White	Continuing	Partial
Mr Brendon Dredge	SA	Rhodes	M	White	Continuing	Partial
Mr Muhamed Gardee	SA	SU	M	Black	Continuing	Independent
Ms Claire Giovanelli	SA	SU	F	White	Resigned	Partial
Mr Stuart Hall	SA	SU	M	White	Upgraded	Full

Name	Citizenship	Institution	Gender	Race	Status	Funding
Mr Llewellyn Jacobs	SA	SU	M	Black	Continuing	Independent
Mr Jacques van Rensburg	SA	SU	M	White	Continuing	Independent
Ms Asiashu Lithole	SA	UP	F	Black	Continuing	Independent
Ms Amy Liu	SA	SU	F	Black	Continuing	Independent
Ms Joy Mangachena	Zimbabwe	CPUT	F	Black	Continuing	Partial
Mr Mashudu Mashau	SA	SU	M	Black	Continuing	Independent
Ms Vanessa Matukana	SA	UniVen	F	Black	Resigned	Independent
Mr Lubabalo Mofu	SA	Rhodes	M	Black	Continuing	Full
Ms Elana Mostert	SA	SU	F	White	Continuing	Full
Ms Mukundi Mukundamago	SA	SU	F	Black	Continuing	Full
Mr Vuledzani Mukwevho	SA	SU	M	Black	Continuing	Partial
Mr Phathu Netshabumu	SA	SU	M	Black	Continuing	Full
Mr David Phair	SA	SU	M	White	Continuing	Partial
Ms Kerushka Pillay	SA	UKZN	F	Black	Continuing	Full
Ms Haley Pope	USA	SU	F	White	Submitted	Independent
Ms Elsje Schreuder	SA	SU	F	White	Completed	Full
Mr Ross Shackleton	SA	SU	M	White	Upgraded	Full
Mr Ntaki Senoge	SA	UKZN	M	Black	Continuing	Partial
Ms Rebecca Shinner	UK	SU	F	White	Completed	Partial
Mr Vernon Steyn	SA	SU	M	White	Continuing	Partial
Ms Daisy Thononda	SA	UniVen	F	Black	Resigned	Independent
Mr Mark Turnbull	SA	UJ	M	White	Continuing	Partial
Ms Kerry Ann Van der Walt	SA	Rhodes	F	White	Completed	Independent
PhDs upgraded						
Ms Jessica Allen	SA	SU	F	White	Continuing	Partial
PhD						
Mr Antoine Bahizi	Rwanda	SU	M	Black	Continuing	Full
Mr Terence Bellingan	SA	Rhodes	M	White	Continuing	Full
Mr Ryan Blanchard	SA	SU	M	Black	Completed	Independent
Mr Chrispian Cheney	SA	SU	M	White	Continuing	Independent
Ms Sarah Davies	SA	SU	F	White	Completed	Independent
Ms Genevieve Diedericks	SA	SU	F	White	Continuing	Full
Ms Katelyn Faulkner	SA	UP	F	White	Continuing	Independent
Ms Rolanda Julius	SA	UP	F	Black	Continuing	Partial
Ms Clova Jurk	UK	SU	F	White	Continuing	Partial
Ms Sandra MacFadyen	SA	SU	F	White	Continuing	Independent
Ms Mandisa Mgobozi	SA	UKZN	F	Black	Resigned	Independent
Ms Ingrid Minnaar	SA	SU	F	White	Continuing	Partial
Ms Onivola Minoarivelo	Madagascar	SU	F	Black	Continuing	Independent
Mr Mohlamatsane Mokhatla	SA	SU	M	Black	Continuing	Independent
Ms Desika Moodley	SA	UKZN	F	Black	Continuing	Independent
Mr Caswell Munyai	SA	UniVen	M	Black	Continuing	Independent
Ms Savannah Nuwagaba	Uganda	SU	F	Black	Continuing	Independent
Ms Koebraa Peters	SA	SU	F	Black	Continuing	Partial
Ms Unjinee Poonan	SA	Wits	F	Indian	Continuing	Independent
Ms Saachshaini Sadchatheeswaran	Canada	UCT	F	Black	Continuing	Independent
Mr Matthys Strydom	SA	SU	M	White	Continuing	Full
Mr Giovanni Vimercati	Italy	SU	M	White	Continuing	Partial

7.6 Administrative staff

This table includes all staff who worked in the Centre in 2014, including those who resigned or completed their contracts during the year.

Name	Institution	Position	Race	Gender
Ms Sarah Davies	SU	Deputy Director	W	F
Ms Karla Coombe-Davis	SU	Database Manager	W	F
Ms Josephine De Mink	SU	Wiley-Blackwell Editorial Assistant	B	F
Ms Melanie de Morney *	SU	Iimbovane Technical Assistant	B	F
Ms Dorette Du Plessis	SU	Chief Technical Officer: Outreach	W	F
Ms Chantal Ferriera	UP	Technical Officer & Admin. Assistant	W	F
Ms Anél Garthwaite	SU	PA to the Director	W	F
Ms Megan Koordom	SU	Molecular Lab. Technical Assistant	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 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
Staff employed by other organisations but hosted by the C•I•B:				
Dr Mirijam Gaertner	CoCT	Restoration Ecologist	W	F
Prof. John Wilson	SANBI	Invasive Species Scientist	W	M

*Ms de Morney resigned during 2014 to take up a position with a partner organisation.

7.7 Resources in the market place

This section is intended to include only C·I·B graduates and post-doctoral associates employed or engaged in subsequent activities. However, following the NRF's and our Board's request, we are now reporting on all graduates, regardless of whether they are 'in the market place' or not. This means that students who continue to another degree or a post-doc are included in the table below.

Full name	Level	Supervisor/Host	Position/Organisation
Ms Debbie Du Preez	Honours	Prof. Eileen Campbell	*Unknown*
Ms Jamaine Krige	Honours	Prof. Gawie Botma	Intern, SABC Radio News
Mr Devon Larkin	Honours	Prof. Eileen Campbell	*Unknown*
Ms Nombuso Ngubane	Honours	Prof. Karen Esler	Registered for MSc at SU
Ms Audrey Raidani	Honours	Prof. Stefan Foord	Natural Resource Management Officer, Dept Env. Affairs
Ms Hannah Raven	Honours	Dr Tammy Robinson	Intern, SAEON
Mr Cavin Shivhambu	Honours	Prof. Stefan Foord	ISP Intern, SANBI
Ms Christien Steyn	Honours	Prof. Mark Robertson	Registered for MSc at UP
Ms Lise-Mari Van Zyl	Honours	Dr Jaco Le Roux	*Not in the scientific field*
Mr Stuart Barrow	Masters	Dr Olaf Weyl	Junior Scientist, Blue Science
Ms Elsje Schreuder	Masters	Dr Susana Clusella-Trullas	Marion Island over-wintering team, Dept Env. Affairs
Ms Becky Shinner	Masters	Dr Susana Clusella-Trullas	Secondary School Teacher, London
Ms Kerry Van der Walt	Masters	Dr Olaf Weyl	Intern, SAEON
Dr Ryan Blanchard	PhD	Prof. David Richardson	Researcher, CSIR

8 Outputs

8.1 Books

None in 2014

8.2 Book chapters

Allsopp, N., Anderson, P.M., Holmes, P.M., Melin, A. and O'Farrell, P.J. (2014). People, the Cape Floristic Region, and sustainability. In: Fynbos: ecology, evolution, and conservation of a megadiverse region. Allsopp, N., Colville, J.F. and Verboom, G.A. (eds.). Oxford University Press, Oxford. pp. 337-360.

Colville, J.F., Potts, A.J., Bradshaw, P.L., Measey, G.J., Snijmann, D., Picker, M.D., Procheş, Ş., Bowie, R.C.K. and Manning, J.C. (2014). Floristic and faunal Cape biochoria: do they exist? In: *Fynbos: ecology, evolution, and conservation of a megadiverse region.* Allsopp, N., Colville, J.F. and Verboom, G.A. (eds.). Oxford University Press, Oxford. pp. 73-93.

Irlich, U.M., Richardson, D.M., Davies, S.J. and Chown, S.L. (2014). Climate change and alien species in South Africa. In: *Invasive species and global climate change.* Ziska, L.H. and Dukes, J.S. (eds.). CAB International, Wallingford, UK. pp. 129-147.

Kraaij, T. and van Wilgen, B.W. (2014). Drivers, ecology and management of fire in fynbos. In: *Fynbos: ecology, evolution, and conservation of a megadiverse region.* Allsopp, N., Colville, J.F. and Verboom, G.A. (eds.). Oxford University Press, Oxford. pp. 47-72.

Marean, C.W., Cawthra, H.C., Cowling, R.M., Esler, K.J., Fisher, E., Milewski, A., Potts, A.J., Singels, E. and De Vynck, J. (2014). Stone Age people in a changing South African Greater Cape Floristic Region. In: *Fynbos: ecology, evolution, and conservation of a megadiverse region.* Allsopp, N., Colville, J.F. and Verboom, G.A. (eds.). Oxford University Press, Oxford. pp. 164-199.

Tolley, K.A., Bowie, R.C.K., Measey, G.J., Price, B.W. and Forest, F. (2014). The shifting landscape of genes since the Pliocene: terrestrial phylogeography in the Greater Cape Floristic Region. In: *Fynbos: ecology, evolution, and conservation of a megadiverse region.* Allsopp, N., Colville, J.F. and Verboom, G.A. (eds.). Oxford University Press, Oxford. pp. 143-163.

Wilson, J.R.U., Gaertner, M., Griffiths, C.L., Kotzé, I., Le Maitre, D.C., Marr, S.M., Picker, M.D., Spear, D., Stafford, L., Richardson, D.M., van Wilgen, B.W. and Wannenburgh, A. (2014). Biological invasions in the Cape Floristic Region: history, current patterns, impacts, and management challenges. In: *Fynbos: ecology, evolution, and conservation of a megadiverse region.* Allsopp, N., Colville, J.F. and Verboom, G.A. (eds.). Oxford University Press, Oxford. pp. 273-298.

8.3 Articles in peer-reviewed journals

This section includes two papers - marked * - which formally acknowledge the C•I•B, but where the C•I•B does not appear in the address line.

Alexander, M.E., Dick, J.T.A., Weyl, O.L.F., Robinson, T.B. and Richardson, D.M. (2014). Existing and emerging high impact invasive species are characterized by higher functional responses than natives. *Biology Letters* **10**, 20130946, 4 pages. DOI: 10.1098/rsbl.2013.0946

Allen, J.L., Clusella-Trullas, S. and Chown, S.L. (2014). Thermal tolerance of *Cyrtobagous salviniae*: a biocontrol agent in a changing world. *BioControl* **59**, 357-366.

Andresen, L., Everatt, K.T. and Somers, M.J. (2014). Use of site occupancy models for targeted monitoring of the cheetah. *Journal of Zoology* **292**, 212-220.

Aronson, M.F.J., La Sorte, F.A., Nilon, C.H., Katti, M., Goddard, M.A., Lepczyk, C.A., Warren, P.S., Williams, N.S.G., Cilliers, S., Clarkson, B., Dobbs, C., Dolan, R., Hedblom, M., Klotz, S., Kooijmans, J.L., Kühn, I., MacGregor-Fors, I., McDonnell, M., Mörtberg, U., Pyšek, P., Siebert, S., Sushinsky, J., Werner, P. and Winter, M. (2014). A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. *Proceedings of the Royal Society B: Biological Sciences* **281**, 20133330, 8 pages. DOI: 10.1098/rspb.2013.3330.

Azarkina, G.N. and Foord, S.H. (2014). A revision of the Afrotropical species of *Festucula* Simon, 1901 (Araneae: Salticidae) : Arachnida. *African Invertebrates* **55**, 351-375.

Barrios-O'Neill, D., Dick, J.T.A., Emmerson, M.C., Ricciardi, A., MacIsaac, H.J., Alexander, M.E. and Bovy, H.C. (2014). Fortune favours the bold: a higher predator reduces the impact of a native but not an invasive intermediate predator. *Journal of Animal Ecology* **83**, 693-701.

Barton, M.G. and Terblanche, J.S. (2014). Predicting performance and survival across topographically heterogeneous landscapes: the global pest insect *Helicoverpa armigera* (Hübner, 1808) (Lepidoptera: Noctuidae). *Austral Entomology* **53**, 249-258.

Bishop, T.R., Robertson, M.P., van Rensburg, B.J. and Parr, C.L. (2014). Elevation–diversity patterns through space and time: ant communities of the Maloti-Drakensberg Mountains of southern Africa. *Journal of Biogeography* **41**, 2256-2268.

Blackburn, T.M., Essl, F., Evans, T., Hulme, P.E., Jeschke, J.M., Kühn, I., Kumschick, S., Marková, Z., Mrugala, A., Nentwig, W., Pergl, J., Pyšek, P., Rabitsch, W., Ricciardi, A., Richardson, D.M., Sendek, A., Vilá , M., Wilson, J.R.U., Winter, M., Genovesi, P. and Bacher, S. (2014). A unified classification of alien species based on the magnitude of their environmental impacts. *PLoS Biology* **12**, e1001850, 35 pages. DOI: 10.1371/journal.pbio.1001850.

Blackburn, T.M., Su, S. and Cassey, P. (2014). A potential metric of the attractiveness of bird song to humans. *Ethology* **120**, 305-312.

Blomefield, T.L. and Giliomee, J.H. (2014). Validation of the phenology model for the codling moth, *Cydia pomonella* (Lepidoptera: Tortricidae), in South African pome fruit orchards. *African Entomology* **22**, 30-48.

Caffrey, J., M., Baars, J.-R., Barbour, J., H., Boets, P., Boon, P., Davenport, K., Dick, J.T.A., Early, J., Edsman, L., Gallagher, C., Gross, J., Heinimaa, P., Horrill, C., Hudin, S.,

Hulme, P.E., Hynes, S., MacIsaac, H., J., McLoone, P., Millane, M., Moen, T., L., Moore, N., Newman, J., O'Conchuir, R., O'Farrell, M., O'Flynn, C., Oidtmann, B., Renals, T., Ricciardi, A., Roy, H., Shaw, R., Weyl, O., F., Williams, F. and Lucy, F., E. (2014). Tackling invasive alien species in Europe: the top 20 issues. *Management of Biological Invasions* **5**, 1-20.

Caplat, P., Hui, C., Maxwell, B.D. and Peltzer, D.A. (2014). Cross-scale management strategies for optimal control of trees invading from source plantations. *Biological Invasions* **16**, 677-690.

Chapman, D.S., Haynes, T., Beal, S., Essl, F. and Bullock, J.M. (2014). Phenology predicts the native and invasive range limits of common ragweed. *Global Change Biology* **20**, 192-202.

Clusella-Trullas, S., Boardman, L., Faulkner, K.T., Peck, L.S. and Chown, S.L. (2014). Effects of temperature on heat-shock responses and survival of two species of marine invertebrates from sub-Antarctic Marion Island. *Antarctic Science* **26**, 145-152.

Clusella-Trullas, S. and Chown, S.L. (2014). Lizard thermal trait variation at multiple scales: a review. *Journal of Comparative Physiology B* **184**, 5-21.

Coetzee, B.W.T., Gaston, K.J. and Chown, S.L. (2014). Local scale comparisons of biodiversity as a test for global protected area ecological performance: A meta-analysis. *PLoS ONE* **9**, e105824. 11 pages. DOI: 10.1371/journal.pone.0105824.

Colautti, R., Parker, J.D., Cadotte, M.W., Pyšek, P, Brown, C.S., Sax, D.F. and Richardson, D.M. (2014). Quantifying the invasiveness of species. *Neobiota* **21**, 7–27 DOI: 10.3897/neobiota.@@.5310.

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Zylstra, M.J., Knight, A.T., Esler, K.J. and Le Grange, L.L.L. (2014). Connectedness as a core conservation concern: An interdisciplinary review of theory and a call for practice. *Springer Science Reviews* **2**, 119-143.

8.4 Published conference proceedings and abstracts

Colautti, R.I., Parker, J.D., Cadotte, M.W., Pyšek, P., Brown, C.S., Sax, D.F. and Richardson, D.M. (2014). Quantifying the invasiveness of species. In: *7th NeoBiota conference.* Pontevedra, Spain. (eds. Capdevila-Arguelles, L. and Zilletti, B.). **21,** pp. 7-27.

Mothapo, N.P., Vorster, C. and Wossler, T.C. (2014). Argentine ants don't like it hot: long-term effects of fire on Argentine ant abundance and distribution. In: *XVII International Union for the Study of Social Insects Congress.* Cairns. p. 243.

Wossler, T.C. and Mothapo, N.P. (2014). Some like it sweet: floral nectar fuels Argentine ant success. In: *XVII International Union for the Study of Social Insects Congress.* Cairns. p. 52.

8.5 Published conference abstracts

See Published conference proceedings above.

8.6 Products / artefacts / patents

None

8.7 Conferences / meetings attended

8.7.1 International plenary/keynote addresses

Richardson, D.M. Invasiveness in Acacia: Can we minimize environmental risks? Plenary address at Conference on 'Sustaining the Future of Acacia Plantation Forestry', Hue, Vietnam, March 2014 (Richardson)

Richardson, D.M. Challenges and opportunities in invasion science: Insights from South Africa. Plenary address at 13th International Conference on Mediterranean-Type Ecosystems (MEDECOS): 'Crossing boundaries across disciplines and scales', Olmué, Chile, October 2014 (Richardson)

Weyl, O.L.F. 2014. Transferring research results into management: examples from Lake Liambezi. Ministry of Fisheries and Marine Resources, Science Forum: Towards the sustainable utilisation of freshwater fisheries in Namibia. Kamutjonga Fisheries Research Institute (KIFI), Namibia. August 2014 (Weyl).

8.7.2 National plenary/keynote addresses

Esler, K.J. Ecological restoration: scaling up, drilling down. Plenary address at 2nd Annual Conference of the Land Rehabilitation Society of Southern Africa, Muldersdrift, Gauteng, South Africa, September 2014 (Esler)

Esler, K.J. Ecological restoration: scaling up, drilling down. Plenary address at Arid Zone Ecology – Thicket Fusion Forum, Grahamstown, September 2014 (Esler)

Esler, K.J. Trans-disciplinarity in ecological restoration: scaling up, drilling down. Plenary address at 2nd National Conference on Global Change, Port Elizabeth, December 2014 (Esler)

Foxcroft, L.C. (2014) Ecosystems: the nexus between soil, weeds, production and protected areas. Combined Congress of the Southern African Weed Science Society, Soil Science Society of Southern Africa, South African Society of Crop Production and South African Society for Horticultural Sciences, Grahamstown, South Africa, January 2014 (Foxcroft)

Van Wilgen, B.W. A national strategy for dealing with biological invasions in South Africa. Opening keynote speaker, 42nd Annual Symposium on the management of invasive alien plants, Karridene, KwaZulu/Natal (van Wilgen).

8.7.3 International oral contributions

Alexander M.E., Adams, R., Dick J.T.A. & Robinson T.B. Predicting and explaining impacts of invasive mussels in South Africa World Marine Biodiversity Conference, Qingdao, China, October 2014 (Robinson)

Boardman, L. & Terblanche, J.S. Oxygen limitation and thermal tolerance in insects: testing the roles of supply and demand. SEB Annual Main Meeting Manchester, UK, 2014 (Terblanche)

Clusella-Trullas, S. Macrophysiology: a review of recent advances. Unifying marine and terrestrial biodiversity at the interplay of macroecology, macrophysiology and macroevolution, SDiv workshop. 21-24 Oct 2014, Leipzig, Germany (Clusella-Trullas)

Combrink, X., Warner, J., Taylor, R. & Downs, C.T. Movements and activity levels of Nile Crocodiles in the Lake St Lucia estuarine system, South Africa. IUCN-SSC Crocodile Specialist Group May 2014, McNeese State University, Louisiana, USA (Downs)

Cowling, R.M., De Vynck, J., Singels, E. & Esler, K.J. Climate stability, biodiversity and the evolution of modern humans on South Africa's Cape south coast. XIII Mediterranean Ecosystems International Conference, Olmué, Chile, October 6-9 (Esler)

De Villiers, A., Altwegg, A & Measey, G.J. The survival and dispersal of Cape *Xenopus* (Anura: Pipidae) 12th Conference of the Herpetological Association of Africa, Gobabeb, November 2014 (Measey)

Edwards, S., Tolley, K., Vanhooydonck, B., Measey, G.J. & Herrel, A. Is dietary niche breadth linked to morphology and performance in sandveld lizards Nucras (Sauria: Lacertidae)? 12th Conference of the Herpetological Association of Africa, Gobabeb, November 2014 (Measey)

Eiseb, S. J., Zeller, U., Taylor, P. J., Nicolas, V. & Denys, C. Evidence for recent adaptation and speciation linked with drainage evolution in a rare African rodent. 5th International Conference on Rodent Biology & Management, Zhengzou, China, August 2014 (Taylor)

Ellender, B.R., Woodford, D.J., Weyl, O.L.F. & Cowx, I.G. Managing conflicts arising from fisheries enhancements based on non-native fishes in Southern Africa, The Fisheries Society of the British Isles, Annual International Symposium, University of Hull, United Kingdom, June 2014 (Weyl)

Esler, K.J. Ecological restoration: scaling up, drilling down. XIII Mediterranean Ecosystems International Conference, Olmué, Chile, October 6-9 (Esler)

Esterhuizen, N., Clusella-Trullas, S., van Daalen, C.E., Schoombie, R.E., Boardman, L. & Terblanche, J.S. Effects of within-generation thermal history on flight performance of *Ceratitis capitata*: Colder is better. SEB Annual Main Meeting Manchester, UK, 2014 (Terblanche)

Foxcroft, L.C. Invasive alien plants in protected areas: Global patterns and the South African experience. 6th IUCN World Parks Congress, Sydney, Australia, 12-19 November 2014. (Invited presentation) (Foxcroft)

Hill, M.P. & Terblanche, J.S. How common are adaptive niche shifts in insect invasions? European Congress of Entomology, York, U.K., 2014 (Terblanche)

Holmes, P.M., Gaertner, M., Esler, K.J. & Hall, S. Exploring thresholds to restoration in alien-invaded fynbos shrublands. XIII Mediterranean Ecosystems International Conference, Olmué, Chile, October 6-9 (Esler)

Hui, C., Ramanantoanina, A., Nuwagaba, S. & Minoarivelo, H.O. Long-tongued pollinators shed light on coevolutionary dynamics and network emergence. Evolutionary Biology Meeting (EBM18), Marseilles, France (Hui)

Hui, C. Mathematical models in global change biology. International Workshop on Mathematical and Numerical Ecology, Guangzhou, China. (Hui)

Johnson, S.D. Using ecotypes to reveal the role of niche shifts in plant radiations. New Phytologist Symposium: Evolutionary Radiations, Zurich, Switzerland, July 2014 (Johnson)

Johnson, S.D. Pollen transfer efficiency in petaloid monocots: the effects of floral traits and pollinators. 5th National Conference and International workshop on evolutionary ecology and plant reproductive biology. Guangzhou, China (Johnson)

Le Roux, J.J. Home sweet home: resolving biogeographic uncertainties of invasive balloon vines in the genus Cardiospermum. XIVth International Symposium on Biological Control of Weeds, Skukuza, South Africa, March 2014 (Le Roux)

Le Roux, J.J. Genetic insight from invasive Australian acacias. Conference on 'Sustaining the Future of Acacia Plantation Forestry', Hue, Vietnam, March 2014 (Le Roux)

Le Roux, J.J. Invasive Australian acacias do not infiltrate highly modular legume-rhizobial network. MEDECOS, Olmué, Chile, October 2014 (Le Roux)

Matthews, T. & Measey, G.J. Evolutionary and palaeoenvironmental implications of fossil frog assemblages from the South African west and south coasts. 12th Conference of the Herpetological Association of Africa, Gobabeb, November 2014 (Measey)

Measey, G.J. de Villiers, A., Vogt, S. & Edwards, S. Assessing the threats against the Cape Platanna. 12th Conference of the Herpetological Association of Africa, Gobabeb, November 2014 (Measey)

Minoarivelo, H.O., Hui, C., Terblanche, J.S., Kosakovsky Pond, L. & Scheffler, K. (2014) Detecting phylogenetic signal in mutualistic interaction networks using a Markov process. Models in Population Dynamics and Ecology (MPDE), University of Turin, Italy (Hui)

Mitchell, K.A., Clusella-Trullas, S. & Terblanche, J.S. The influence of hydration and nutritional status on estimates of thermal tolerance in *Ceratitis* spp. SEB Annual Main Meeting Manchester, UK, 2014 (Terblanche)

Mokhatla, M.M., Rödder, D. & Measey, G.J. Assessing the effects of changing climate on distributions of the endemic amphibian fauna of the Cape Floristic Region. 12th Conference of the Herpetological Association of Africa, Gobabeb, November 2014 (Measey)

Mzumara, T., Perrin, M.R., & Downs, C.T. 2014. Threats to Lilian's Lovebird *Agapornis lilianae* in Malawi: Disease, predators & waterhole poisoning. International Ornithological Congress, Japan (Downs)

Ramanantoanina, A., Ouhinou, A. & Hui, C. Spatial assortment of mixed propagules explains the acceleration of range expansion. Models in population dynamics and ecology (MPDE), University of Turin, Italy (Hui)

Ramesh, T. & Downs, C.T. Importance of wetland, forest and patch richness for a population of servals in a fragmented landscape in South Africa. The Wildlife Society 21st Annual Conference, Pittsburgh, Pennsylvania, USA (Downs)

Robinson, T.B., Pope, H.R., Hawken, L. & Binneman, C. Has low biotic resistance enabled the spread of the alien barnacle *Balanus glandula* along the South African coast? World Marine Biodiversity Conference, Qingdao, China, October 2014 (Robinson)

Taylor, P. J., Munyai, A., Gaigher, I & Baxter, R. Afromontane small mammals do not follow the hump-shaped rule: elevational variation in a tropical biodiversity hotspot (Soutpansberg mountains, South Africa). 5th International Conference on Rodent Biology & Management, Zhengzou, China, August 2014 (Taylor)

Terblanche, J.S. Exploring respiratory thermal adaptation in insect gas exchange: patterns and mechanisms. International Congress of Respiration Science, Bonn, Germany, 2014 (Terblanche)

Thompson, L. Brown, M & Downs, C.T. Seasonal variation in basal metabolic rate, respiratory quotient and evaporative water loss in the Cape White-eye, *Zosterops pallidus*. 5th International Symposium on the Physiology and Pharmacology of Temperature Regulation, Skukuza (Downs)

Thompson, L. Brown, M & Downs, C.T. Seasonal variation in basal metabolic rate, respiratory quotient and evaporative water loss in the Cape White-eye, *Zosterops pallidus*. International Ornithological Congress, Japan (Downs)

Tolley, K.A., Harvey, J., Blackburn, D.C., Dreyer, S. & Measey, G.J. Little frogs and big surprises: phylogenetics of the widespread species *Arthroleptis wahlbergii*. 12th Conference of the Herpetological Association of Africa, Gobabeb, November 2014 (Measey)

Verberk, W.C.P., Overgaard, J., Ern, R., Bayley, M., Wang, T., Boardman, L., Terblanche, J.S. Does oxygen limit thermal tolerance in arthropods? A critical review of current evidence. SEB Annual Main Meeting Manchester, UK, 2014 (Terblanche)

Vimercati, G., Davies, S.J. & Measey, G.J. Exploring the invasion of *Amietophrynus gutturalis* (Anura: Bufonidae): a multidisciplinary approach. 12th Conference of the Herpetological Association of Africa, Gobabeb, November 2014 (Measey)

Weyl, O.L.F. History, status and management of Black bass (*Micropterus*) species in South Africa. Southern Division of the American Fisheries Society, Spring Meeting, Charleston, USA. January 2014 (Weyl)

Wilson, J.R. Managing invasions from old wattle plantings (2014) Conference on 'Sustaining the Future of Acacia Plantation Forestry', Hue, Vietnam, March 2014 (Wilson)

Woodford, D.J., Barrow, S., Esler, K.J., Finlayson, B., Impson, N.D. & Weyl, O.L.F. Control of invasive smallmouth bass in South African River systems: overcoming practical and socio-economic factors. 144th Meeting of the American Fisheries Society, Québec City, Canada. October 2014 (Weyl)

Wossler, T.C. and Mothapo, N.P. Some like it sweet: floral nectar fuels Argentine ant success. XVII International Union for the Study of Social Insects Congress, Cairns, July 2014 (Wossler).

8.7.4 National oral contributions

Alexander, M.E., Dick, J.T.A., Weyl, O.L.F., Robinson, T.B., Richardson, D.M. 2014 Existing and emerging high impact invasive species are characterised by higher functional responses than natives Southern African Society of Aquatic Scientists, Thaba Nchu, Bloemfontein, South Africa, June 2014 (Robinson, Weyl)

Alexander ME, Adams, R, Dick JTA, Robinson TB Predicting and explaining impacts of invasive mussels in South Africa Southern African Marine Symposium, Stellenbosch, South Africa, July 2014 (Robinson)

Barrow, S., Weyl, O.L.F., Esler, K. & Jordaan, M. 2014. Economic impact of smallmouth bass sport fishing provides invasive species management insight. Southern African Society of Aquatic Scientists Conference, Southern African Society of Aquatic Scientists Conference, Thaba Nchu, South Africa. June 2014 (Weyl)

Bellingan, T.A., Jackson, M., Woodford, D.J., Villet, M.H.V. & Weyl, O.L.F. 2014. Community and food web structures in the Keiskamma River System, Eastern Cape, South Africa. Southern African Society of Aquatic Scientists Conference, Thaba Nchu, South Africa. June 2014 (Weyl)

Cockburn, J., Rouget, M., Cundill, G., Koopman, V., Memela, B., Ground, L. & Theron, T. Stewardship: what does it mean? Symposium of Contemporary Conservation Practice, Howick, South Africa, November 2014 (Rouget)

Cockburn, J., Rouget, M., Boon, R., Douwes, E., Ray-Mukherjee, J., Mukherjee, S., O'Donoghue, S., Roberts, D. & Slotow, R. Evaluating a transdisciplinary research partnership: what matters more –tangible or intangible outcomes? Symposium of Contemporary Conservation Practice, Howick, South Africa, November 2014 (Rouget)

Combrink, X., Warner, J., Taylor, R. & Downs, C.T. 2014. Home range of Nile Crocodiles in the Lake St Lucia estuarine system, South Africa. Symposium of Contemporary Conservation Practice, EKZNW, Pietermaritzburg (Downs)

Dredge, B.N., Weyl, O.L.F., Cochrane, K.L. & Impson, N.D. 2014. Species composition and relative abundance of fishes in four dams and a natural lake in the Western Cape. Southern African Society of Aquatic Scientists Conference, Thaba Nchu, South Africa. June 2014 (Weyl)

Ellender, B.R., Weyl, O.L.F., Woodford, D.J., Alexander, M.E., Luger, A.M., & Nagelkerke, L.A.J. 2014. Using multiple lines of evidence to understand the vulnerability of headwater stream fishes to non-native predatory fish impacts. Southern African Society of Aquatic Scientists Conference, Thaba Nchu, South Africa. June 2014 (Weyl)

Esler, K.J., Marais, K.M., Jacobs, S., Jacobsen, A. & Pratt, B. (2014) Post-fire regeneration of resprouting mountain fynbos shrubs. Fynbos Forum, Knysna, August 2014 (Esler)

Faulkner, K.T., Robertson, M.P., Rouget, M. & Wilson, J.W.R. The pathways of introduction for alien species in South Africa and the consequences for management. 2nd Annual Symposium on the Management of Invasive Alien Plants, Durban, June 2014 (Rouget)

Foord, S.H., Dippenaar-Schoeman, A.S. 2014. Surrogates of spider diversity, leveraging the conservation of a poorly known group in the Savanna Biome of South Africa. Symposium of Contemporary Conservation Practice, 3-7 November 2014 Fern Hill Conference Centre, Howick, KwaZulu-Natal, South Africa (Foord)

Foxcroft, L.C., MacFadyen, S., Pyšek, P., Richardson, D.M., Rouget, M., and Hui, C. (2014) Patterns and drivers of alien plant invasions. 12th Annual Savanna Science Network Meeting, Skukuza, South Africa, March 2014 (Foxcroft)

Griffiths CL, Reimers B & Hoffman MT. Repeat photography as a tool for monitoring historical changes in South African coastal ecosystems. 15th South African Marine Sciences Symposium, Stellenbosch, July 2104 (Griffiths)

Hall, S., Newton, R.J., Holmes, P.M., Gaertner, M. & Esler, K.J. (2014) Heat-pulse treatment as an effective germination cue in different Sand Fynbos species and its implication for restoration. Fynbos Forum, Knysna, August 2014 (Esler)

Jackson, M.C., Woodford, D.J., Bellingan, T., Chimimba, C. & Weyl, O.L.F. 2014. Do invasive trout alter aquatic energy flux to riparian consumers? Southern African Society of Aquatic Scientists Conference, Southern African Society of Aquatic Scientists Conference, Thaba Nchu, South Africa. June 2014 (Weyl)

Kimberg, P.K, Woodford, D.J., Roux, H. & Weyl, O.L.F. 2014. Species-specific impacts of introduced largemouth bass in the Groot Marico Freshwater Ecosystem Priority Area. Southern African Society of Aquatic Scientists Conference, Southern African Society of Aquatic Scientists Conference, Thaba Nchu, South Africa. June 2014 (Weyl)

Marneweck, D.G., Druce, D.J., Marnewick, K.A., Somers, M.J. & Kelly, C. Demography and space use of a fenced population of African wild dogs (*Lycaon pictus*) in Hluhluwe - iMfolozi Park: implications for metapopulation management. Southern African Wildlife Management Association annual symposium Port Elizabeth, South Africa, September 2014 (Somers)

Mauda, E.V., Foord, S.H. 2014. 2014. Ant diversity in an arid peri-urban landscape of the Vhembe Biosphere, South Africa. Symposium of Contemporary Conservation Practice, 3-7 November 2014 Fern Hill Conference Centre, Howick, KwaZulu-Natal, South Africa (Foord)

McPherson, S., Brown, M., & Downs, C.T. 2014. The Ecology of Urban Crowned Eagles of KwaZulu-Natal. Ethekweni Symposium, Durban. Chosen as best student presentation (Downs)

Modiba, RV, Foord, SH. The impact of riparian alien vegetation removal on benthic macroinvertebrates and adult Odonata of the catchment in the eastern Soutpansberg, Limpopo Province. 7th SAEON-GSN Indibano, Ibyayi Town Lodge, Port Elizabeth (5-8 September 2014) (Foord)

Modiba, RV, Foord, SH. The impact of riparian alien vegetation removal on benthic macroinvertebrates and adult Odonata of the catchment in the eastern Soutpansberg, Limpopo Province. 2nd National Conference on Global Change, NMMU (30 November- 04 December 2014) (Foord)

Mugwedi, L., Rouget, M. & Ray-Mukherjee, J. Restoration planning for Buffelsdraai landfill site in the eThekwini Municipality. Symposium of Contemporary Conservation Practice, Howick, South Africa, November 2014 (Rouget)

Peters, K., Griffiths, C.L., & Robinson, T.B. Patterns and drivers of marine bioinvasions in eight Western Cape harbours. 15th South African Marine Sciences Symposium, Stellenbosch, July 2104 (Griffiths, Robinson)

Pfeiffer, M., Venter, J. & Downs, C.T. 2014. Foraging range and habitat use of adult Cape Vultures *Gyps coprotheres* in communal farmland in South Africa. Endangered Wildlife Trust, Namibia (Downs)

Pfeiffer, M., Venter, J. & Downs, C.T. 2014. Foraging range and habitat use of adult Cape Vultures *Gyps coprotheres* in communal farmland in South Africa. Southern African Wildlife Management Association, Port Elizabeth (Downs)

Renteria, J.L., Rouget, M. & Wilson, J.W. Potential distribution and habitat susceptibility of emerging invasive alien plant species in South Africa. Symposium of Contemporary Conservation Practice, Howick, South Africa, November 2014 (Rouget)

Robertson, M.P., Bishop, T.R. van Rensburg, B.J., Parr, C.L. Ant diversity across an altitudinal gradient in the Maloti-Drakensberg. Symposium of Contemporary Conservation Practice, Howick, November 2014 (Robertson)

Robertson, M.P. Using atlas datasets for making more informed conservation decisions. Symposium of Contemporary Conservation Practice, Howick, November 2014 (Robertson)

Robinson, T.B., Pope, H.R., Hawken, L., Binneman, C. Has low biotic resistance enabled the spread of the alien barnacle *Balanus glandula* along the South African coast? South African Marine Science Symposium, Stellenbosch, South Africa, July 2014 (Robinson)

Rouget, M. et al. Managing threatened ecosystems in urban environments: Implementation of a science-action partnership. Symposium of Contemporary Conservation Practice, EKZNW, Pietermaritzburg (Downs)

Rouget, M., Jewitt, G., Egoh, B., Hughes, C., Zunckel, K., de Winnaar, G., Dini, D. & Hay, D. Mapping ecological infrastructure in the uMngeni catchment. Symposium of Contemporary Conservation Practice, Howick, South Africa, November 2014 (Rouget)

Sadchatheeswaran, S., Branch, G.M., Robinson, T.B. Changes in habitat complexity resulting from sequential invasions of a rocky shore: implications for community structure. Southern African Marine Science Symposium, South Africa, July 2014 (Robinson)

Simba, L.D., Foord, S.H., Seymour, C.L. 2014. Change in flower visitor communities along a gradient from natural vegetation and into mango orchards (*Mangifera indica*, Anacardiaceae) orchards, in North-Eastern South Africa. 2nd National Conference on Global Change, NMMU (30 November- 04 December 2014) (Foord)

Taylor, P. J., Foord, S. & Fouche, P. Linking foundational biodiversity knowledge with end-user needs: University of Venda's SARChI Chair on Biodiversity Value & Change in

the Vhembe Biosphere Reserve. 11th Conference of the Southern African Society for Systematic Biology, Hogsback, April 2014 (Taylor)

Taylor, P. J. Speciation & extinction in small mammals across the Afromontane archipelago. 11th Conference of the Southern African Society for Systematic Biology, Hogsback, April 2014 (Taylor)

Thompson, L. Brown, M & Downs, C.T. 2014. Seasonal variation in basal metabolic rate, respiratory quotient and evaporative water loss in the Cape White-eye, *Zosterops pallidus*. Birdlife SA Flock, Drakensberg (Downs)

Treurnicht, M., Pagel, J., Nottebrock, H., Esler, K.J., Schutte-Vlok, A., Schurr, F. (2014): Environmental drivers of range-wide variation in the demography of serotinous South African Proteaceae. Fynbos Forum, Knysna, August 2014 (Esler)

Weyl, O.L.F, Woodford, D.J. & Ellender, B.R. 2014. Present status and future management of black bass (*Micropterus spp.*) in South Africa. Southern African Society of Aquatic Scientists Conference, Thaba Nchu, South Africa. June 2014 (Weyl)

Wilson, J.R. An update on SANBI's Invasive Species Programme Research (2014) KZN Invasive Alien Species Forum, Krantzkloof Nature Reserve, 13 Aug (Wilson)

Wilson, J.R. Eradication as a SMART management goal (2014) CAPE Invasive Alien Animal Working Group, Tokai, Cape Town, 15 May (Wilson)

Wilson, J.R. Priorities for the prevention of new introductions & Priorities for post-border risk assessment (2014) Invasive alien species strategy: Workshop on prioritization and funding, CSIR, Stellenbosch, 6-7 Feb (Wilson)

Woodford, D.J., Measey, J., Jackson, M.C., Hui, C., Richardson, D.M. & Weyl, O.L.F. 2014. The Lower Sundays River System: A natural laboratory for investigating the ecology of fish invasions. Southern African Society of Aquatic Scientists Conference, Southern African Society of Aquatic Scientists Conference, Thaba Nchu, South Africa. June 2014 (Weyl).

8.7.5 International posters

Clusella-Trullas, S. Seasonality, but not latitude, predicts the plasticity of thermal tolerance in squamates at a global scale. Unifying Ecology across Scales: the role of Nutrients, Metabolism and Physiology, Gordon Research Conference, University of New England, Biddeford, Maine, USA, July 20-25, 2014 (Clusella-Trullas)

Clusella-Trullas, S. The behavior-physiology nexus: plastic responses within and between seasons. Unifying ecology across scales: the role of nutrients, metabolism and physiology. Gordon Research Conference, University of New England, Biddeford, Maine, USA, July 20-25, 2014 (Clusella-Trullas)

Mothapo, N.P., Vorster, C. and Wossler T.C. Argentine ants don't like it hot: long-term effects of fire on Argentine ant abundance and distribution. XVII International Union for the Study of Social Insects Congress, Cairns, July 2014.

Nengovhela, A., Taylor, P. J. & Baxter, R. Present and future distribution of cryptic species of vlei rats (*O. auratus*, *O. irroratus s.s* and *O. angoniensis*) in South Africa, with a focus in

the northern Great Escarpment. 5th International Conference on Rodent Biology & Management, Zhengzou, China, August 2014 (Taylor)

Pfeiffer, M., Venter, J. & Downs, C.T. 2014. Foraging range and habitat use of adult Cape Vultures *Gyps coprotheres* in communal farmland in South Africa. The Wildlife Society 21st Annual Conference, Pittsburgh, Pennsylvania, USA (Downs)

Telford, N.S., Measey, G.J. & Channing, A. The invasive Guttural Toad, *Amietophrynus gutturalis* (Anura: Bufonidae) of Cape Town, South Africa: Where do they come from? *12th Conference of the Herpetological Association of Africa, Gobabeb, November 2014* (Measey)

Vogt, S., de Villiers, A., Measey, J. Ihlow, F. & Rödder, D. Diet and niche differentiation of *Xenopus laevis* and *X. gilli* . Querschnittsthema: Tropical Research (Measey)

8.7.6 National posters

Foxcroft, L.C., Pyšek, P., Richardson, D.M., Pergl, J. and Hulme, P.E. Impacts – the bottom line. Threats posed by alien plant invasion to protected areas. 12th Annual Savanna Science Network Meeting, Skukuza, South Africa, March 2014 (Foxcroft)

Keith, M. Nembudani, L. N., Kirsten, F., Maltitz, E., Taylor, P. J. & Swanepoel, L. H. Conservation implications of rodent pest management in different agricultural matrices. South African Wildlife Management Association, Reconciling the Contradictions of Wildlife Management in Southern Africa, Port Elizabeth, September 2014 (Taylor)

Mofu, L., Woodford, D.J. & Weyl, O.L.F. 2014. Assessing the biology of the river goby as a proxy to understand global goby invasions. Southern African Society of Aquatic Scientists Conference, Thaba Nchu, South Africa. June 2014 (Weyl)

Pope, H.R., Robinson, T.B., Alexander, M.E. The effects of changing substratum temperature on the settlement, mortality, recruitment and growth of the invasive barnacle, *Balanus glandula*, and its' native comparator, *Chthamalus dentatus*. Southern African Marine Science Symposium, Stellenbosch, South Africa, July 2014 (Robinson)

Robertson, M.P. Biogeo – a new free R package for point data cleaning. *Symposium of Contemporary Conservation Practice, Howick, November 2014* (Robertson)

Scott, E., Grünschloss, S. & Somers, M.J. Trophic overlap between three semi - aquatic carnivores in a Bankenveld ecotone reserve. Southern African Wildlife Management Association annual symposium Port Elizabeth, South Africa, September 2014 (Somers)

Swart, C., Robinson, T.B. Distribution and impact of the alien anemone *Sagartia ornata* in the West Coast National Park. *South African Marine Science Symposium, Stellenbosch, South Africa, July 2014* (Robinson).

8.8 Other relevant outputs

International workshops

Richardson, D.M. Invited participant; workshop on 'Biodiversity and ecosystem services', SESYNC, Annapolis, Maryland, USA, February 2014.

Richardson, D.M. Invited participant; MEDECOS Conference, Olmué , Chile, October 2014.

8.8.1 Popular articles and talks

Articles

Matthews, S. 2014. Ecological restoration – giving back to SA's watercourses. *The Water Wheel*. March 2014, pp. 22-25.

Pfeiffer, M., Botha, A., Venter, J. & Downs, C. 2014. Silent Slaughter of Africa's Vultures: How mass poisonings are putting the birds at risk. *The Wildlife Professional*. Spring 2014.

Taylor, P. J. & Steyn, J. N. 2014. New perspectives in demonstrating biological control and management of pest insects by bats in macadamia orchards. *Southern African Macadamia Growers Association Yearbook*. pp. 6-11.

Talks

Davies, S.J. *Over the garden fence*. Presentation to Durbanville Garden Club, April 2014

Downs, C.T. 2014. Postgraduate supervision. UKZN Induction Programme, UKZ, Pietermaritzburg.

Downs, C.T. 2014. *The importance of ecology and physiology in a changing world: Wahlberg´s epauletted Fruit Bat (Epomophorus wahlbergi) as an example*. Amber Conservancy Howick, February 2014.

Downs, C.T. 2014. *Biodiversity in a changing world*. Golden Key Biodiversity Day, UKZN, Pietermaritzburg.

Downs, C.T. 2014. *Women in Science*. National Science Week Programme, Durban Natural Science Museum, Durban.

Foxcroft, L.C. *Biological invasions in Kruger National Park*. Organization for Tropical Studies Lecture Series, Skukuza, February 2014.

Hui, C. 2014. *Self-organization in nature*. iThemba Labs Public Lecture, Somerset West.

Vimercati, G. 2014. *The guttural toad invasion in Cape Town*. Wednesday Talk, Kirstenbosch National Botanical Garden, Cape Town, November 2014.

Weyl O.L.F. 2014. *Freshwater fish research in South Africa*. University of Florida, Florida, USA, January 2014.

Weyl O.L.F. 2014. *History, status and management of black bass (Micropterus) species in South Africa*. SAIAB/DIFS Seminar Series, Grahamstown, March 2014.

Weyl O.L.F. 2014. *State of fisheries research in South Africa: Role of scientists, environmental practitioners, conservationists and managers.* Water Research Commission, Pretoria, August 2014.

Weyl O.L.F. 2014. *Using multiple information sources to make sense of fish invasions.* University of Florida, Florida, USA, January 2014.

8.9 NRF Service Provision

8.9.1 Rating and project proposal reviews

NRF rating applications in 2014 (Foord 1, Le Roux 1, Measey 1, Richardson 3, Rouget 1)

NRF proposal reviews in 2014, including SA National Antarctic programme (Downs 6; Esler 2; Foord 1; Griffiths 1; Robertson 1; Somers 1; Taylor 1; van Wilgen 1)

8.9.2 Panel and committee service

None

8.10 Media interactions

8.10.1 Newspaper articles

Anonymous. 2014. New Centres of Excellence to advance interdisciplinary research. *Mail and Guardian,* 27 June 2014.

Anonymous. 2014. Two SU ecologists among the most influential in the world in their fields. *Eikestad News,* 10 July 2014.

Duvenage, E. 2014. Guide to caring for valuable fynbos reserves. *Bolander*, 7 January 2014.

Le Roux, J.J. 2014. Bugging puzzle resolved. *Eikestad News*, June 2014.

Van Wilgen, B. 2014. SA trout industry is swimming against the tide of biodiversity priorities. *Weekend Argus,* 22 June 2014.

Van Wilgen, B.W and Richardson, D.M. 2014. Why those who call us ecofascists are wrong. *The Witness*, 16 June 2014.

Watkins, K. 2014. A toad hunting we will go. *Constantia Bulletin,* 28 August 2014.

Yeld, J. 2014. The Western Cape's great hotspot. *Cape Argus,* 22 August 2014.

Yeld, J. 2014. The Western Cape's great hotspot. *Mail & Guardian*, 22 August 2014.

8.10.2 Newsletters

Hill, M.P. & Terblanche, J.S. 2014. *Understanding the invasion of Bactrocera invadens into South Africa*. SubTrop Newsletter.

8.10.3 Articles published by Stellenbosch University

Anonymous. 2014. Botanists unravel 139-year-old mystery. Matieland Issue 2, pp. 59.

Anonymous. 2014. SU ecologists among most influential. Matieland Issue 2, pp. 42.

Clusella-Trullas, S. 2014. How crustaceans respond to climate change. *Research at Stellenbosch University: showcasing research excellence 2013*.

8.10.4 Electronic sources

Anonymous. 2014. The 41st annual symposium on management of invasive alien plants. Invasive Species South Africa, [online] 10 May 2014. Available at: http://www.invasives.org.za/press/item/465-the-41st-annual-symposium-on-management-of-invasive-alien-plants.html>

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Anonymous. 2014. Protected areas proven to conserve biodiversity. University of Exeter, [online] 29 August 2014. Available at: <http://www.exeter.ac.uk/news/research/title_408824_en.html>

Anonymous. 2014. Protected areas proven to protect biodiversity. EurekAlert!, [online] 27 August 2014. Available at: <http://ekaweb02.eurekalert.org/pub_releases/2014-08/mu-pap082714.php>

Anonymous. 2014. Protected areas proven to protect biodiversity. Geography Report, [online] 03 September 2014. Available at: <http://www.geographyreport.com/research/Protected_areas_proven_to_protect_biodiversity.asp

Anonymous. 2014. Protected areas proven to protect biodiversity. Monash University, [online] 28 August 2014. Available at: < http://monash.edu/news/releases/show/protected-areas-proven-to-protect-biodiversity>

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Fourie-Basson, W. 2014. Today's pasture tomorrow's headache, warns specialists. SU News, [online] 10 November 2014. Available at: < http://www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=1974>

Fourie-Basson, W. 2014. Twee US ekoloë van die invloedrykster ter wêreld in hul vakgebied. US Nuus, [aanlyn] 27 Junie 2014. Beskikbaar by: http://www.sun.ac.za/afrikaans/Lists/news/DispForm.aspx?ID=1523

Fourie-Basson, W. 2014. Two SU ecologists among most influential in the world in their discipline. SU News, [aanlyn] 27 Junie 2014. Beskikbaar by: < http://www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=1596>

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Hunter-Husselmann, M. 2014. Vice-Rector (Research and innovation) honours researchers. SU News, [online] 09 December 2014. Available at: <http://www.sun.ac.za/english/List/news/DispForm.aspx?ID=2083>

Marris, E. 2014. Tree hitched ride to island. Nature, [online] 18 June 2014. Available at: <http://www.nature.com/news/tree-hitched-a-ride-to-island-1.15419>

McDonald, D. 2014. Spending cuts on protected areas 'worrying'. News24 [online] 02 September 2014. Available at: < http://m.news24.com/news24/Green/News/Spending-cuts-on-protected-areas-worrying-20140902>

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8.10.5 Radio and Television

Le Roux, J. Interview on Classic FM (Classic Lifestyle), Botanists solve 139-year-old mystery, July 2014.

Shelton, J. Interview on Cape Talk (John Maytham Show), Are trout South African? July 2014.

9 Stage progress

This CoE is currently in **Stage 5**.

Timeframes

The pending Gate review (Gate 5) shall take place during February or March 2015
Gate review scheduled for 18 March 2015

Two CoE Steering Committee (virtual or real) meetings should take place per annum during this Stage, typically during March and November of each year
2012: Steering Committee meetings were held on 15 March and 1 November
2013: Steering Committee meetings were held on 28 March and 17 October
2014: Steering Committee meetings were held on 26 March and 12 November

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
2012: Student lists were provided on 28 March (provisional) and 3 July (final) 2012
2013: Student lists were provided to the NRF in April and July as requested
2014: Student lists were provided to the NRF in April and July 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.
2012: Nuggets were sent to the NRF on 23 April, 20 July and 5 December 2012
2013: Vignettes were sent to the NRF on 8 April, 5 July and 1 October 2013
2014: Vignettes were sent to the NRF on 10 April, 18 August and 20 October 2014 and 13 January 2015

Financial responsibilities

The CoE shall present an audited set of financial statements annually at the March Steerign Committee meeting reflecting the financial situation of the CoE during the previous financial year
2012: Audited statements were approved on 28 March 2013
2013: Audited financial statements were approved on 26 March 2014
2014: Audited financial statements were approved by the Steering Committee on 18 March 2015

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
2012: Monthly cash flow statements were submitted for January to December
2013: Monthly cash flow statements were submitted for January to December
2014: Monthly cash flow statements were submitted for January to December

Reports due in this Stage
The CoE shall submit an Annual Progress Report by no later than end March each year, including the Stage 5 Gate Review Documentation by no later than March 2015 to be reviewed by the CoE Steering Committee
2012: The Annual Progress Report for 2012 was approved on 28 March 2013
2013: The Annual Progress Report for 2013 was approved on 26 March 2014
2014: The Annual Progress Report for 2014 was approved on 18 March 2015

The CoE shall submit a Statement of Compliance by no later than March 2015 referring to Stage 5
The Statement of Compliance for Stage 5 was signed on 18 March 2015

Standard Output Targets per annum in the Current Stage
Total number of students supported ≥ 50 on average per annum
2012: 91, including post-doctoral fellows
2013: 88, including post-doctoral fellows
2014: 79, including post-doctoral fellows

Woman students ≥ 50% of all students on average per annum
2012: 55% (50 women)
2013: 58% (51 women)
2014: 57% (45 women)

Black students ≥ 50% of all students on average per annum
2012: 56% (51 students)
2013: 47% (41students)
2014: 41% (32 students)

Number of social science students ≥ 2 on average per annum
2012: 2
2013: 2
2014: 2

Average duration of submitted Masters degrees (post Honours) ≤ 2.5 years at end of stage
2012: 3.5 years
2013: 2.5 years
2014: 2.1 years

Average duration of submitted PhD degrees (post Masters) ≤ 3.5 years at end of stage
2012: 4.2 years
2013: 4.7 years
2014: 5.7 years

Average duration of submitted PhD degrees (upgraded from Masters) ≤ 5 years at end of stage
2012: 4.6 years
2013: No upgrades completed
2014: No upgrades completed

Post-doctoral researcher ≥ 10% of all students at end of stage
2012: 14%
2013: 14%
2014: 17%

Each core team member must undertake at least one scientific review per annum on behalf of the NRF (postal peer review process or panel)
2012: 29
2013: 27
2014: 25

Number of patents ≥ 1
2012: None
2013: None
2014: None

Number of peer reviewed publications ≥ 60 on average per annum
2012: 103
2013: 135
2014: 145

Number of peer reviewed publications ≥ 1 with an impact rating of ≥ 15 on average per annum
2012: 2
2013: 1
2014: 0

Number of peer reviewed publications ≥ 10 with an impact rating of ≥ 4.0 on average per annum
2012: 31
2013: 26

2014: 29

Number of national conference presentations ≥ 20 on average per annum
2012: 41 (no invited, plenary and keynote; 37 oral; 4 poster)
2013: 47 (3 plenary/keynote addresses; 40 oral; 4 poster)
2014: 57 (5 plenary/keynote addresses; 45 oral; 7 poster)

Number of international conference presentation ≥ 10 on average per annum
2012: 34 (4 invited, plenary and keynote; 21 oral; 9 poster)
2013: 50 (11 plenary/keynote addresses; 34 oral; 5 poster)
2014: 52 (3 plenary/keynote addresses; 41 oral; 8 poster)

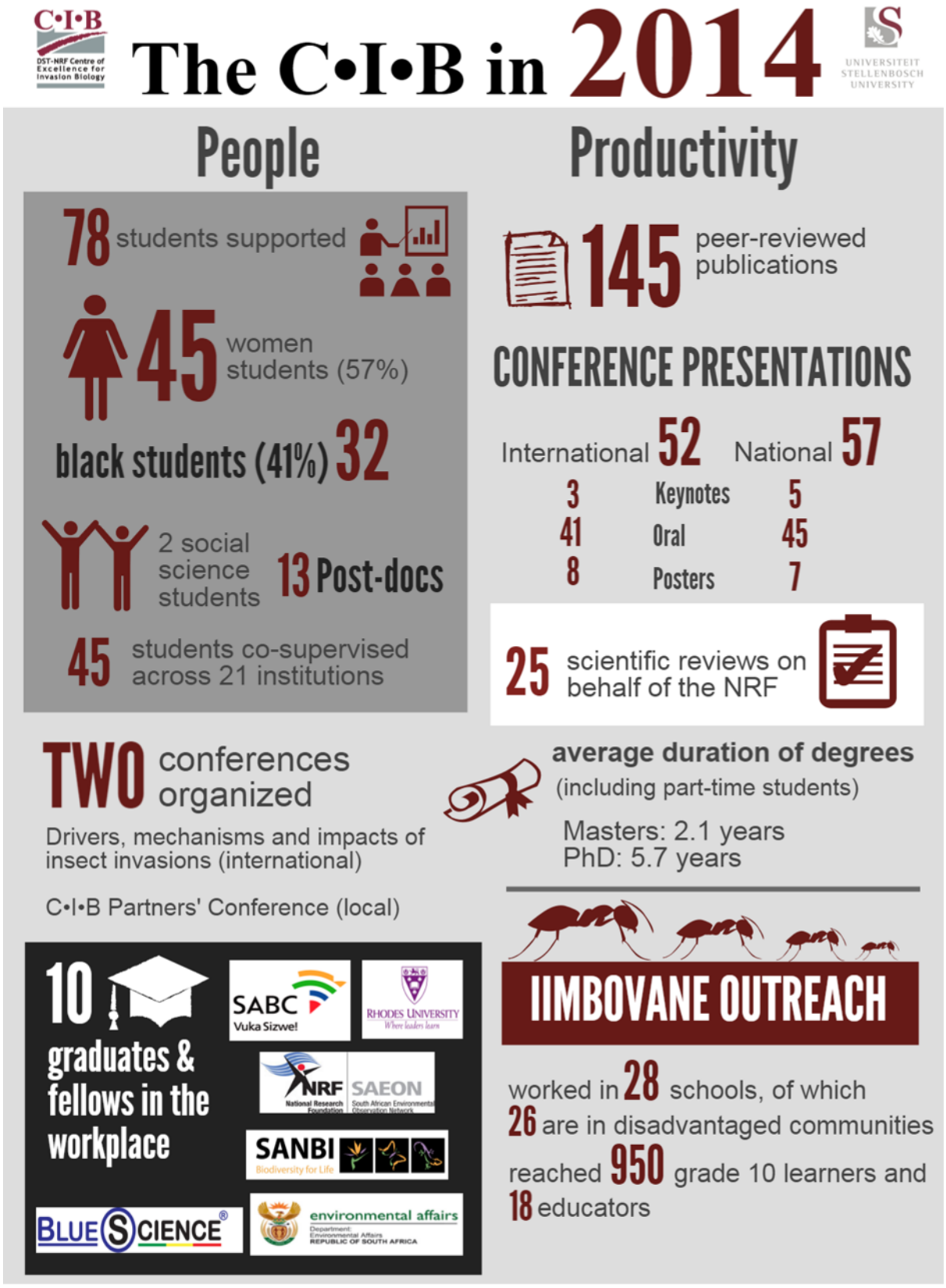
Number of joint venture student training initiatives ≥ 20 on average per annum
2012: 27
2013: 47
2014: 45

Number of local conferences organized ≥ 1 at end of stage
2012: 1 (Rapid Response, Early Detection, and Risk Assessment, Stellenbosch)
2013: None
2014: 1 (Partners' Conference, Stellenbosch)

Number of international conferences organized ≥ 1 at end of stage
2012: 1 (Tree Invasions, Bariloche, Argentina)
2013: 2 (Observation & Ecology; Invasion in Aquatic & Terrestrial Ecosystems, Stellenbosch)
2014: 1 (Drivers, mechanisms and impacts of insect invasions workshop, Stellenbosch)

Special Output Targets for the Current Stage
At least one full CoE team activity per annum
2012: Annual Research Meeting, 15-16 November, 2012
2013: Mid-year Core Team Member Meeting, 6-7 August, 2013; Annual Research Meeting, 28-29 November
2014: Mid-year Core Team Member Meeting, 24-25 June, 2014; Annual Research Meeting, 27-28 November, 2014

Successful continuation of Iimbovane outreach project to schools in the WCED region
2012: 28 participating schools (17 rural/11 urban; 18 full participation/10 subscription)
2013: 28 participating schools (23 rural/5 urban; 18 full participation/10 subscription)
2014: 28 participating schools (17 rural/11 urban of which 26 are serving previously disadvantaged communities; 18 full participation/10 subscription).


The C•I•B in 2014
People
78 students supported
45 women students (57%)
black students (41%) 32
2 social science students
13 Post-docs
45 students co-supervised across 21 institutions
Productivity
145 peer-reviewed publications
CONFERENCE PRESENTATIONS
International 52 National 57
3 Keynotes 5
41 Oral 45
8 Posters 7
25 scientific reviews on behalf of the NRF
TWO conferences organized
Drivers, mechanisms and impacts of insect invasions (international)
C•I•B Partners' Conference (local)
average duration of degrees
(including part-time students)
Masters: 2.1 years
PhD: 5.7 years
10 graduates & fellows in the workplace
SABC Vuka Sizwe!
RHODES UNIVERSITY
NRF SAEON
SANBI Biodiversity for Life
BLUESCIENCE
environmental affairs
IIMBOVANE OUTREACH
worked in 28 schools, of which 26 are in disadvantaged communities
reached 950 grade 10 learners and 18 educators

10 Conclusion

2014, the final year of the current development stage of the C•I•B, was successful in all respects. The Centre produced more papers in peer-reviewed journals (145) than in any previous year. Our papers continued to appear in all the top-rated ecology journals and received many citations, much attention in the media, and in many cases fed into management and policy, such as the NEMBA regulations on invasive alien species, finally published in 2014, and the national strategy to deal with invasions. The special issue of *Biological Invasions* on "*Tree Invasions – Patterns & Processes, Challenges & Opportunities*" was a highlight of our primary research contributions; of the 17 papers in the special issue, 12 had C•I•B -affiliated co-authors. Collaborations formed during the workshop that gave rise to this special issue have generated considerable further networking opportunities that will lead to additional student projects over the next few years.

The C•I•B supported 65 students (58% women; 48% Black) and 13 post-doctoral associates; post-docs make up 17% of the body of young researchers involved in the Centre. The average time for completion of Masters degrees for 2014 was 2.1 years – a marked improvement over previous years. Unfortunately the same cannot be said of the time taken to complete PhD degrees – this rose to an average of 5.7 years in 2014, as several part-time students finally completed their degrees, raising the overall average time to completion. We anticipate that this trend will be widespread in South Africa in future, as we raise the number of PhD graduates by involving students who are employed in full-time jobs.

The C•I•B continues to make substantial contributions to policy relating to biological invasions and associated issues in South Africa and internationally. Various measures clearly show that the Centre is widely acknowledged as a global centre of excellence in this field. We continue to seek new partnerships to ensure involvement of all geographic and thematic areas in South Africa. Our partnerships with the Natural Resources Management Programmes, the South African National Biodiversity Institute, the South African Institute for Aquatic Biodiversity and the City of Cape Town were especially productive during 2014. Options for expanding and improving collaborations were debated at the Centre's first Partners' Conference in September 2014 and in several follow-up meetings. Insights from these meetings and a workshop of the core team in June 2014 fed into the C•I•B's revised strategic plan for 2015-2019. The plan allows for a slight shift in focus to address key issues of national importance and to better accommodate the key skills available in the core team and our growing network of research associates. The C•I•B Fellowship initiative is now firmly in place and is attracting top international researchers to work with core team members.

Overall, we are in an excellent position to enter the challenging five-year phase that now faces us, in which we aim to ensure the sustainability of the C•I•B over the long term and make it indispensable to its partners.

Appendix: Audited financial statements

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

ANNUAL FINANCIAL STATEMENTS - 31 DECEMBER 2014

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

ANNUAL FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 DECEMBER 2014

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

.....

.....2015
DATE

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF FINANCIAL POSITION AT 31 DECEMBER 2014

	Notes	2014	2013
		R	R
ASSETS			
NON-CURRENT ASSETS		671 386.76	797 022.45
Equipment and vehicles	2	671 386.76	797 022.45
CURRENT ASSETS		7 227 789.52	6 583 091.20
Trade and other receivables	3	9 435.76	2 299.65
Stellenbosch University	4	7 218 353.76	6 580 791.55
TOTAL ASSETS		**7 899 176.28**	**7 380 113.65**
EQUITY AND LIABILITIES			
CAPITAL AND RESERVES		7 548 744.98	6 958 353.69
Accumulated funds		7 548 744.98	6 958 353.69
CURRENT LIABILITIES		350 431.30	421 759.96
Trade and other payables	5	350 431.30	421 759.96
TOTAL FUNDS AND LIABILITIES		**7 899 176.28**	**7 380 113.65**

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF COMPREHENSIVE INCOME FOR THE YEAR ENDED 31 DECEMBER 2014

	Notes	2014	2013
		R	R
Revenue		8 926 926.00	8 501 834.00
Other income		3 087 420.37	1 982 097.50
Operating expenses	7	(11 944 010.03)	(9 593 334.80)
Operating profit		70 336.34	890 596.70
Finance income		524 603.94	327 543.94
Finance cost		(4 548.99)	(213.98)
Surplus for the year		590 391.29	1 217 926.66
Other comprehensive income		-	-
Total comprehensive income for the year		590 391.29	1 217 926.66

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF CHANGES IN EQUITY FOR THE YEAR ENDED 31 DECEMBER 2014

	2014	2013
	R	R
ACCUMULATED FUNDS		
At the beginning of the year	6 958 353.69	5 740 427.03
Total comprehensive income for the year	590 391.29	1 217 926.66
At the end of the year	**7 548 744.98**	**6 958 353.69**

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF CASH FLOWS FOR THE YEAR ENDED 31 DECEMBER 2014

	2014	2013
	R	R
CASH FLOWS FROM OPERATING ACTIVITIES		
Net surplus for the year	590 391.29	1 217 926.66
Adjustment for:		
Interest received	(524 603.94)	(327 543.94)
Interest paid	4 548.99	213.98
Exchange rate loss	2 855.77	-
Depreciation	305 002.25	334 058.60
Profit on sale of equipment and vehicles	(7 456.14)	(53 508.73)
Operating profit before working capital adjustments	370 738.22	1 171 146.57
Working capital adjustments	(81 320.54)	484 912.22
(Increase)/Decrease in trade and other receivables	(7 136.11)	254 270.00
(Decrease)/Increase in trade and other payables	(74 184.43)	230 642.22
Cash generated from operations	289 417.68	1 656 058.79
Interest received	524 603.94	327 543.94
Interest paid	(4 548.99)	(213.98)
NET CASH FLOWS FROM OPERATING ACTIVITIES	809 472.63	1 983 388.75
CASH FLOWS FROM INVESTMENT ACTIVITIES		
Equipment and vehicles purchased	(179 366.56)	(488 317.87)
Proceeds on the sale of fixed assets	7 456.14	164 123.00
Increase in amount owed by Stellenbosch University	(637 562.21)	(1 659 193.88)
NET CASH FLOWS FROM INVESTMENT ACTIVITIES	(809 472.63)	(1 983 388.75)
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	-	-

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

NOTES TO THE ANNUAL FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 DECEMBER 2014

1. ACCOUNTING POLICY

BASIS FOR PREPARATION

The annual financial statements are prepared on the historical cost basis in accordance with International Financial Reporting Standards. The following are the principal accounting policies of the organisation which are consistent in all material respects with those applied in the previous year.

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 carried 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 are carried 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.

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 and any prior adjustments to reflect fair value that had been recognised in equity 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.

STANDARDS, INTERPRETATIONS AND AMENDMENTS NOT YET EFFECTIVE

The following standards and amendments to existing standards have been published and are mandatory for the centre's accounting periods beginning on or after 1 January 2015 or later periods, but which the centre has not early adopted.
Management is of the opinion that these amendments will not have a material effect on the financial statements.

IFRS 9 – Financial Instruments (2009) (1 January 2018)
IFRS 9 – Financial Instruments (2010) (1 January 2018)
Amendments to IFRS 9 – Financial Instruments (2011) (1 January 2018)
IFRS 14 – Regulatory deferral accounts (1 January 2016)
Amendment to IAS 19 regarding defined benefit plan (1 July 2014)
Amendment to IFRS 11 - 'Joint arrangements' on acquisition of an interest in a joint operation (1 January 2016)
Amendment to IAS 16 - 'Property, plant and equipment' and IAS 38 - 'Intangible assets', on depreciation and amortisation (1 January 2016)
IFRS 15 – Revenue from contracts with customers (1 January 2017)

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 2014			
Carrying amount at the beginning of the year	410 516.72	386 505.73	797 022.45
Cost	3 019 378.45	494 105.01	3 513 483.46
Accumulated depreciation	(2 608 861.73)	(107 599.28)	(2 716 461.01)
Additions during the year	179 366.56	-	179 366.56
Transfers	-	-	-
Cost	10 376.98	-	10 376.98
Accumulated depreciation	(10 376.98)	-	(10 376.98)
Disposals	-	-	-
Cost	(40 334.91)	-	(40 334.91)
Accumulated depreciation	40 334.91	-	40 334.91
Depreciation for the year	(258 108.21)	(46 894.04)	(305 002.25)
Carrying amount at the end of the year	331 775.07	339 611.69	671 386.76
Cost	3 168 787.08	494 105.01	3 662 892.09
Accumulated depreciation	(2 837 012.01)	(154 493.32)	(2 991 505.33)
31 December 2013			
Carrying amount at the beginning of the year	525 889.05	227 488.40	753 377.45
Cost	2 939 793.79	432 535.56	3 372 329.35
Accumulated depreciation	(2 413 904.74)	(205 047.16)	(2 618 951.90)
Additions during the year	150 526.32	337 791.55	488 317.87
Disposals	(125.43)	(110 488.84)	(110 614.27)
Cost	(70 941.66)	(276 222.10)	(347 163.76)
Accumulated depreciation	70 816.23	165 733.26	236 549.49
Depreciation for the year	(265 773.22)	(68 285.38)	(334 058.60)
Carrying amount at the end of the year	410 516.72	386 505.73	797 022.45
Cost	3 019 378.45	494 105.01	3 513 483.46
Accumulated depreciation	(2 608 861.73)	(107 599.28)	(2 716 461.01)

	2014 R	2013 R
3. TRADE AND OTHER RECEIVABLES		
Trade receivables	7 136.11	-
Other	2 299.65	2 299.65
	9 435.76	2 299.65
The ageing of these receivables are as follows:		
Up to 2 months	9 435.76	2 299.65
2 to 6 months	-	-
	9 435.76	2 299.65

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 2014 was 5.90% (2013: 5.10%). The loan has no fixed terms of repayment.

	2014 R	2013 R
5. TRADE AND OTHER PAYABLES		
Leave pay provision	111 544.17	127 709.46
Other creditors	751.16	40 838.00
Income received in advance	126 460.00	201 485.00
Provision for audit fees	111 675.97	51 727.50
	350 431.30	421 759.96

6. INCOME TAX

The centre is exempt from income tax in terms of article 10(1)(cA)(i) of the Income Tax Act.

7. OPERATING EXPENSES

Operating expenses includes the following disclosable amounts:

Audit fees - audit	59 948.47	51 727.50
Depreciation	305 002.25	334 058.60
Foreign exchange loss	2 855.77	-
Salaries	4 367 107.62	4 332 830.02
Team member research cost	6 088 571.41	3 877 242.14
Other	1 120 524.51	997 690.52
	11 944 010.03	9 593 548.78

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.

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. The reason is that collectability has never been a problem in the past. 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.

Cash flow and fair value interest rate risk

As at 31 December 2014 and 2013, 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 R70 168.69 (2013: R65 807.92). The other financial instruments are not exposed to interest rate risk.

8. FINANCIAL INSTRUMENTS (continued)

Fair values

At 31 December 2014 and 2013 the carrying amounts of receivables, loans and payables approximated their fair values due to the short-term maturities of these assets and liabilities.

	Carrying value	Contractual cash flows	< 1 year	1 - 5 years	> 5 years
	R	R	R	R	R
Financial liabilities					
31 December 2014					
Trade and other payables	350 431.30	350 431.30	350 431.30	-	-
Net financial liabilities	350 431.30	350 431.30	350 431.30	-	-
31 December 2013					
Trade and other payables	421 759.96	421 759.96	421 759.96	-	-
Net financial liabilities	421 759.96	421 759.96	421 759.96	-	-

Capital risk management

The centre manages its capital to ensure that it will be able to continue as a going concern while maximising the return to stakeholders through the optimisation of the debt and equity balance. The capital structure of the centre consists of reserves as disclosed in the statement of changes in equity. The directors review the capital structure on an annual basis. As part of this review, they consider the centre's commitments, availability of funding and the risks associated with each class of capital. The centre's overall strategy remains unchanged from the prior year.

DST-NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

DETAIL INCOME STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2014

	2014 R	2013 R
INCOME	12 538 950.31	10 811 475.44
National Research Foundation grant	8 926 926.00	8 501 834.00
Other income	2 187 271.23	1 078 405.77
SU contribution	892 693.00	850 183.00
Interest received	524 603.94	327 543.94
Profit/(Loss) on sale of equipment	7 456.14	53 508.73
EXPENDITURE	11 948 559.02	9 593 548.78
Operational expenses	7 581 451.40	5 260 718.76
Advertisements	24 670.31	104 798.57
Audit fees - current year	54 675.97	51 727.50
- previous year under provision	5 272.50	-
Consumables	40 683.19	35 549.87
Copying and stationery	38 722.77	57 377.94
Depreciation	305 002.25	334 058.60
Entertainment	8 733.99	13 772.66
Foreign exchange loss	2 855.77	-
Interest paid	4 548.99	213.98
Insurance	4 965.73	3 600.00
Indirect cost recovery	141 820.67	28 618.98
Membership and affiliation fees	20 510.00	14 921.80
Non-capitalised books	-	242.44
Small capital works: not capitalised	52 142.41	14 325.96
Postage, telephone and fax	106 736.80	85 530.06
Safety clothing	1 294.43	2 121.00
Rent paid for facilities	18 278.63	24 640.00
Repairs	86 519.12	32 642.37
Software and internet	20 386.34	19 378.82
Sundry expenses	54 285.57	18 207.76
Team member research costs	6 088 571.41	3 877 242.14
Transport and accommodation	327 365.59	292 468.25
Workshops	173 408.96	249 280.06
Personnel expenses	4 367 107.62	4 332 830.02
Salaries	4 367 107.62	4 332 830.02
SURPLUS FOR THE YEAR	590 391.29	1 217 926.66