C·I·B

DST-NRF Centre of Excellence for Invasion Biology

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Annual Progress Report 2013






National Research Foundation

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

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C•I•B Annual Report, 2013

Published by the DST-NRF Centre of Excellence for Invasion Biology, Faculty of Science, Stellenbosch University, South Africa

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March 2014

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ANNUAL REPORT 2013

Reporting period from 1 January 2013 to 31 December 2013

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: 12 March 2014
	:	Financials: 12 March 2014

Summary of progress against our five Key Performance Areas (KPAs).

Research

2013 was the most productive year in the C·I·B's 10-year history in terms of research outputs, with 139 papers in peer-reviewed journals, 28 chapters in edited volumes and two books. These outputs show a good mixture of problem-directed ("applied") and basic research. Such a mixture is crucial for understanding the many dimensions of problems associated with invasions. Many of the research products have direct and immediate application to problems related to biological invasions in South Africa. Most also contribute important insights to the global phenomenon of invasions. Regular citations to C·I·B work internationally, many invitations to C·I·B associates to collaborate or participate in international forums, and the increasing number of academic visitors to the C·I·B from around the world attest to the global relevance of the C·I·B's research. A large proportion of products have co-authors from institutions outside the immediate C·I·B network in South Africa, and many have international co-authors.

An exciting focus of research in 2013 was the study of plant invasions in protected areas around the world. This resulted in a book in the Springer series *Invading Nature*. This project was led by C·I·B core team member Dr Llewellyn Foxcroft and represents an important collaboration in research between the C·I·B and one of our key partners, South African National Parks.

Education and Training

Seventy students were at least partly funded by the C·I·B during 2013: eight at the Honours level, 35 at the Masters level and 27 at PhD level. Eleven post-doctoral associates were supported. The high quality of student training was recognized through awards to several students and post-docs. For example, C·I·B post-doctoral associate Dr Darragh Woodford won the prize for the best poster at the Freshwater Invasives: Networking for Strategy (FINS) conference in Galway, Ireland, in April 2013. Several students received travel awards to attend international conferences and courses, and the C·I·B travel awards made for the best

oral or poster presentations at the Annual Research Meeting were used to support travel to international meetings or to work with international researchers.

During 2013 we successfully renewed our research collaboration "Integrated management of invasive alien species in South Africa" with the Department of Environmental Affairs' Environmental Programmes directorate (formerly the Working for Water Programme). This agreement provides for a five-year collaboration and the training of more than twenty post-graduate students and post-doctoral associates. The first students were recruited in 2013.

Networking

A highlight of 2013 was a three-day working session involving researchers and students from the C·I·B and the Canadian Aquatic Invasive Species Network (CAISN). This was the first of several planned collaborative ventures between these organizations following the signing of an MOU between the C·I·B and CAISN earlier in the year.

Another networking highlight was the hosting by the C·I·B, in August 2013, of the inaugural meeting of the National Working Group on Alien Grasses. Alien grasses have been poorly studied in South Africa and this group, led by C·I·B post-doctoral fellow Dr Vernon Visser, is launching much-needed research to develop a better understanding of the status of alien grasses and to consider scenarios and implications for management.

The C·I·B is represented at most forums relating to biological invasions in South Africa. An example is the annual Savanna Science Network Meeting, one of the premier conservation and ecology conferences in South Africa, which attracts many of the world's most prominent savanna ecosystem scientists. The 11th meeting in this series was held in March 2013 and was attended by several C·I·B affiliates, including one core team member, two research associates, and three students. The C·I·B is also represented on the CAPE Invasive Alien Animals Working Group, and the nascent National Invasive Species Forum.

Information Brokerage

The Iimbovane Outreach Project maintained its class-leading, innovative performance during 2013 and branched out with several new ways of popularising science and research amongst young South Africans and received more accolades.

The C·I·B's Information Retrieval and Submission System (IRSS) now contains a total of 1240 items. These include 93 long-term project dataset, 892 core team member research outputs, 153 datasets and theses, and 102 post-doc and student outputs.

The C·I·B's website continues to provide a crucial avenue for the dissemination of research outputs and other interventions. 32 nuggets and 6 highlighted papers were posted on the web site in 2013. The C·I·B also ventured into the social media with the launch, in July, 2013, of a Facebook page. During the remainder of 2013 we have accumulated 104 "likes", there were 34 Posts submitted (of which 7 were by C·I·B core team members), and each post/submission "reached" (was viewed by) an average of 48 people.

Service Provision

The key intervention during 2013 was a major contribution, as co-lead contractor with the CSIR, to the co-ordination of the *National Strategy for Dealing with Biological Invasions in*

South Africa for the Department of Environmental Affairs. C·I·B affiliates contributed to numerous internal panels, committees, and boards: including 16 international panels and committees, and 34 such national bodies. Core team members are involved as Editors-in-Chief, Editors, Associate Editors, or serve on the editorial boards of 27 journals. Importantly, four C·I·B core team members and research associates are Associate Editors of the journal *Biological Invasions*.

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

Gender equity forms a major theme underlying the C·I·B's activities. One hundred percent of the C•I•B's administrative personnel, 100% of the outreach team, 56% of the student body, and 33% of the both our core team members, and Research Associates are female.

Red Flags

Two attempts to recruit a senior researcher during 2012 and 2013, involving extensive international advertising, failed to secure an appointment. We believe that this reflects an acute shortage of human capital in this field in South Africa, and underscores the difficulty of attracting top international talent to South Africa, particularly for a fixed-term contract position. The alternative that is currently being explored is the establishment of a C·I·B Research Fellowship Programme to support short-term visits by top international researchers.

General Comments

During 2013 the Centre was evaluated by the NRF (full-term review). The outcomes of the review have yet to be formally communicated but the Centre's progress continues to receive positive comments from funders and reviewers, as well as partners and collaborators, students and post-docs.

We are immensely grateful for the continued support of the DST, NRF, Stellenbosch University and Working for Water who make the most substantial financial contributions to our operations and allow us to support world-class researchers and develop South Africa's research capacity.

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, but the overarching goal is to undertake world-class research in biology that draws on South Africa's unique biodiversity heritage and environmental problems, with a strong focus on providing practical solutions to these problems. Permanent transects in three of South Africa's mountain ranges historically made up the bulk of the C•I•B's long-term research. In addition, in 2013 we initiated an additional, strongly partnered, new initiative to assist the City of Cape Town to design and implement a long term monitoring programme for alien invasive plants and animals in the Cape Town metropole.

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 more significant in terms of shedding light on species provenance. 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 reflect investigations across a wide range of disciplines, taxa, and spatial and temporal scales that embrace a variety of scientific approaches (Fig. 1). As in previous years C•I•B research spanned the range from basic to applied science. The reports that appear below deal largely with research outputs that were formally published in 2013, with this year having been the most productive year in the C•I•B's ten-year history in terms of publications in journals and books. We published 139 papers in peer-reviewed journals which appeared in 88 journals, in addition to two books and 28 edited book chapters. 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 relating to the biology of key invasive species, key aspects of invaded ecosystems, invasion processes, and many facets of the human dimensions of invasions.

Fig. 1. Word cloud compiled from the titles of peer-reviewed papers published by C•I•B affiliates during 2013.

1.2 Progress

1.2.1 Long-term research

LONG-TERM CHANGE IN INSECT ASSEMBLAGES

Work continued on the three long-term transects maintained by the C•I•B in the Cederberg, Drakensberg (Sani Pass) and Soutpansberg ranges. These aim to identify the response of biological communities to global change drivers. Data collection on the Cederberg transect was terminated at the end of 2013, although climate data will still be collected. A decade's worth of invertebrate biodiversity data has been collected and is being analysed by former C•I•B Director Prof. Steven Chown.

The Soutpansberg database now comprises a five-year continuous sequence of climate, habitat structure and soil variables with pitfall data of the 132 ant species along the transect. Although ants (the focus of C•I•B PhD student Mr Caswell Munyai's research) form the focus of the study, data have also been collected on spiders and beetles (C•I•B MSc student Ms Daisy Thononda), and small mammals and bats (Taylor *et al.* 2013; *S. Afr. J. Wildl. Res*. 43: 12–26). Work on this transect will continue under the auspices of the SARChI chair at University of Venda which is co-hosted by the C•I•B. Considerable progress was been made with the analysis of ant and spider assemblage data from the Sani Pass transect during 2013. One product of this work was the MSc thesis of C•I•B student Ms Wilna Jansen.

LONG-TERM CHANGES TO THE PRINCE EDWARD ISLANDS ECOSYSTEM

Work on this aspect is being phased out of the C•I•B research programme, following the departure of Profs Steven Chown and Melodie McGeoch. A 2013 publication looked at human activities, propagule pressure and alien plants in the sub-Antarctic as tests of generalities and evidence in support of management. Despite concerns about the richness of

plant invaders on islands, and their likely effects on local systems, impacts of these species seem to be small. However, this may be due to an absence of information on impacts, including changing species occupancy and forecast occupancy, rather than lack of impact. C•I•B post-doctoral associate Dr Peter Le Roux and co-authors used the plant invaders on the sub-Antarctic Prince Edward Islands and spatially explicit modelling of presence/absence survey data to demonstrate that the geographic extent of many invasives is increasing, and further is forecast to lead to occupancy of >60% of the islands' surface area by 2060, with ongoing climate change (Le Roux *et al*. 2013; *Biol. Conserv*. 161: 18-27). In keeping with theory, proximity to human activity, neighbouring populations (i.e. propagule pressure) and residence time, along with more minor contributors such as elevation, explain >50% of the variation in the occupancy of each of the six main invasive species on the islands. Human disturbance and changing climates seem to have led to recent increases in the rate of range expansion. The results suggest that impacts of island plant invaders may be more significant than previously estimated, largely owing to prior data deficiency. More specifically they also suggest that control plans for the Prince Edward Islands (and other Southern Ocean Islands) should first target less widely distributed species, which are invasive elsewhere. They also indicate that for the other Southern Ocean Islands, and for Antarctica, surveillance and anticipatory control plans should be in place.

LONG-TERM MONITORING OF INVASIONS IN THE CITY OF CAPE TOWN

Part of the developing collaboration between the C•I•B and the City of Cape Town involves interactions towards the establishment of a long-term monitoring strategy for the City's Environmental Resource Management Department. Rivers are a key part of the management focus of this department, and recent work on the Eerste River, which runs through Stellenbosch and therefore offers good opportunities for research and student involvement, is part of the C•I•B's contribution in this area.

PLANT COMMUNITIES ALONG THE EERSTE RIVER DESCRIBED

Riparian plant communities fulfil many functions, including the provision of corridors linking protected areas and other zones of high conservation value. Across much of South Africa's Cape Floristic Region (CFR), especially in the lowlands, these habitats have been heavily influenced and degraded by human activities. There is increasing interest in the restoration of degraded riparian zones and the ecosystem services they provide to enhance the conservation value of landscapes.

Previous studies of riparian vegetation in the CFR focused on pristine headwater systems, and little is known about human-modified communities that make up most of the riparian vegetation in downstream areas. More information is needed on the composition of these plant communities to establish a baseline for management intervention. The riparian zone of the Eerste River provides a good opportunity to study the features of riparian vegetation along the entire gradient, from pristine in a protected area through different levels of human-mediated degradation. Continuing previous work done on the plant communities of the Eerste River, C•I•B-funded student Mr Clifton Meek surveyed plant communities in 150 plots along

the entire length of the Eerste River (Meek *et al.* 2013; *Koedoe* 55 doi: 10.4102/koedoe.v55i1.1099).

Ten distinct plant communities were identified, including several novel communities dominated by alien plant species. Diagnostic, constant and dominant species are listed and the major structural and ecological characteristics of each community were described. This work forms the basis for a permanent transect along the Eerste River which will be used to gauge changes in plant communities and ecosystem functioning over time, and also for teaching students aspects of riparian ecology and the role of invasive plants in these ecosystems.

1.2.2 Short-term research

BIODIVERSITY FOUNDATIONS

Biological invasions and the consequences of human activities are not clearly separable from other natural processes. Consequently, the impacts of biological invasions on biodiversity cannot be understood without a sound knowledge of the patterns and mechanisms that structure biodiversity. The development of comprehensive understanding and predictive capability of biological invasions requires information from a wide variety of fields

Fire and invasive species management in eastern coastal fynbos

C•I•B core team member Prof. Brian van Wilgen was involved (as a co-supervisor of the PhD thesis of Ms Tineke Kraaij) in several studies to improve understanding of fire regimes in eastern coastal fynbos shrublands, and to provide guidelines for ecologically sound management of fire in the area. Conventional knowledge of fynbos fire ecology has until now been based on insights from the summer-autumn fire regimes of the western CFR where the climate is truly Mediterranean. The climate in the eastern coastal CFR is milder, and rainfall occurs year-round, with presumed effects on fire regimes. The Garden Route National Park (GRNP) was recently established in the region, in a landscape where indigenous forests, fire-prone fynbos shrublands and fire-sensitive plantations of invasive alien trees are interspersed. The park faces considerable challenges related to fire management, including pressure from the plantation industry through invasion by alien trees (largely *Pinus* species originating from plantations) and pressure to reduce wildfire hazards by burning fynbos at short intervals.

Historically, plantation protection enjoyed priority over fynbos conservation in the area that is now the GRNP. Ms Kraaij found that fynbos close to plantations has most likely been compromised by frequent and low-intensity burning in the past, as well as by invasion by alien trees. In terms of area burnt (1900–2010), natural (lightning-ignited) fires dominated the fire regime, particularly in the east, whereas prescribed burning was relatively unimportant. Typical fire return intervals (FRIs; 8–26 years; 1980–2010) were comparable to those in other fynbos protected areas and appeared to be shorter in the eastern Tsitsikamma than in the western Outeniqua parts of the study area. Proteaceae juvenile periods (4–9 years) and post-fire recruitment success (following fires in $\geqslant 7$ year-old vegetation) suggested that for biodiversity conservation purposes, fire return interval should be no less than nine years in moist, productive fynbos (Kraaij *et al.* 2013; *Appl. Veg. Sci*. 16: 84–94).

Increases in the total area burnt annually (since 1980) were correlated with long-term increases in average fire danger weather, suggesting that fire regime changes may be related to global change. Collectively, findings on the seasonality of actual fires and the seasonality of fire danger weather, lightning, and post-fire proteoid recruitment suggested that fires in eastern coastal fynbos are not limited to any particular season, and for this reason managers do not need to be concerned if fires occur in any season (Kraaij *et al.* 2013; *Int. J. Wildl. Fire* 22: 277–287; *Int. J. Wildl. Fire* 22: 288–295). The ecological requirements for higher fire intensity may nonetheless be constrained by safety considerations. These findings have been used to define ecological thresholds pertaining to the different elements of the fire regime in eastern coastal fynbos, to guide adaptive management of fire in the GRNP.

Do fleshy fruited alien shrubs compete more effectively for avian dispersal services than indigenous shrubs?

Almost a third of the 224 terrestrial bird species present in southern Africa have migrated into the Cape Floristic Region in response to the introduction and spread of alien trees and shrubs. These birds have presumably also contributed to the expansion of alien plant distributions though seed dispersal. This was the topic of the PhD of Mr Thabiso Mokotjomela.

To determine whether fleshy-fruited alien shrubs compete more effectively for bird dispersal services than indigenous shrubs, Mr Mokotjomela conducted a series of comparative studies of bird foraging activity on fruits of alien and native plants was conducted. Indeed, fruits of some established alien plants (e.g. *Solanum mauritianum*) were more attractive to birds than those of nearby native fleshy fruited species, supporting the notion that frugivorous birds concentrate their activities where resources are most abundant and fruits are more nutritious (Mokotjomela *et al.* 2013. *Plant Ecol*. 214: 49-59). When fleshy fruited emerging invasive plants were included, it was found that birds visited these species more often than both established and native species (Mokotjomela *et al.* 2013; *S. Afr. J. Bot.* 86: 73-78). Seeds of established alien plants had dispersal distances (based on bird ring recapture records, flight speeds and seed gut retention time) much greater than previously reported (Mokotjomela *et al.* 2013; *Plant Ecol.* 214: 1127-1137). To limit preferential fruit consumption and consequent dispersal of emerging aliens into natural areas, plant control measures should focus on eradicating localised populations of emerging aliens. To mitigate disruption of natural seed dispersal patterns, selected native plants with similar fruiting attributes should be identified as suitable replacements for aliens in eradication and restoration programmes.

Long-tongued pollinators shed light on coevolutionary dynamics

Plants and pollinators have co-evolved physical characteristics that make them more likely to interact successfully. For example, long-proboscid flies, whose tongues are twice the length of their bodies, are able to reach the nectar resources stored deep inside flowers with long straw-like tubes. In turn, this interaction is beneficial to the plant because while accessing the nectar, these specialised pollinators pick up pollen and move it to other flowers of the same species.

In a recent publication (Zhang *et al.* 2013; *Evolution* 67: 548-560), C•I•B post-doctoral fellow Dr Feng Zhang and colleagues tackled the mechanism behind the longstanding puzzle that has attracted attention ever since Darwin: how reciprocal interactions between long-proboscid pollinators and long-tubed flowers lead to diverse coevolutionary dynamics. Based on the framework of adaptive dynamics, they presented a model for the coevolving pollination system of long-proboscid fly (*Moegistorhynchus longirostris*) and long-tubed iris (*Lapeirousia anceps*) in the Cape Floristic Region.

The model successfully demonstrated many widely observed patterns of trait polymorphism in Darwin's coevolutionary race. Overall, the model highlights the importance of non-random interactions and the balance of costs incurred by coevolving species as factors that determine the eventual combination of phenotypes following coevolution, and indicates new avenues for experimental studies aimed at testing Darwin's coevolutionary hypothesis. This work is of interest not only to empirical and theoretical researchers in the field of coevolutionary dynamics and general evolutionary biology, but also to scientists in the fields of adaptive dynamics and mathematics.

Assemblage rules in biological communities revealed by invasive species

Environmental managers need to understand the factors that control community composition at different spatial and temporal scales to formulate appropriate guidelines for management. To this end, community assemblage rules explain how species are 'packed' into communities, and how community composition is related to the niches and traits of species. Early theories gave special attention to the role of competition and predation in structuring biotic communities. More recent biogeographical treatments emphasize the regional "top-down" control of unsaturated local communities, as portrayed in the influential unified neutral theory of biodiversity and biogeography proposed by Stephen Hubbell, where community assemblage patterns emerge from the interplay of ecologically identical species.

Collaboration between the C•I•B and researchers from the Czech Republic has resulted in an important contribution to understanding how communities are structured (Hui *et al.* 2013 *Nature Comm.* 4: 2454). They utilized a unique data set on the distribution of more than 2000 vascular plant species in 300 nature reserves in the Czech Republic. These species were divided into natives, archaeophytes and neophytes according to their residence time in central Europe (Fig. 2). Native vascular plants colonized the region after the last glaciation. Archaeophytes are species introduced to Europe through human activity between the initiation of agricultural activities during the Neolithic period (ca. BC 4000) and the European exploration of the Americas (ca. AD 1500). Neophytes are species introduced to Europe after AD 1500. This extraordinary data set offered the opportunity to amplify the signals of structural changes in regional assemblages that are often weak or unidentifiable in studies conducted over a short period.

The group built a co-distribution network for each assemblage that showed species overlaps and turnovers and used a network analytic approach to identify highly connected nodes. Specifically, given a network with nodes connected by edges, this approach partitions nodes

into non-overlapping clusters so that the number of within-cluster connections relative to random expectation is maximized; that is, similar nodes are likely connected in a network. From this network analysis, they identified four to six network clusters for each assemblage. By comparing the species composition, phylogenetic structure and habitat characteristics of these network clusters, they tested the following two hypotheses on how biological invasions affect assemblage structures and how a community assemblage evolves.

First, native species should show stronger signals of matching between their habitat requirements and the characteristics of inhabited sites, indicating a 'lock-and-key' relationship. In other words, species and sites in older assemblages are expected to belong to distinct functional clusters, with species matching the habitat within the cluster. In contrast, more recent introductions should have a poorer match as many species are initially introduced by chance to sub-optimal sites. This effect was named the settling-down hypothesis of diminishing effect of stochasticity with residence time.

Second, species coexistence can be achieved by being either ecologically identical or distinctive, forming niche-differentiated clusters that comprise species with rather similar niche within each cluster. Species within neutral clusters are ecologically identical, and thus species composition, evolutionary divergence and habitat characteristics of different clusters should be the result of purely stochastic factors. In contrast, species between clusters have different functional roles, leading to modules with distinct taxonomic composition, evolutionary units and habitat characteristics, reflecting a deterministically and/or functionally driven species assemblage. With an increase in residence time, there should be a shift from an initially neutral or stochastic assemblage to a niche-based functional-driven multi-cluster assemblage. This second hypothesis was named the niche-mosaic hypothesis of inlaid neutral clusters in the regional species assemblage.

The intensity of compartmentalization in plants occurring in Czech reserves increased when moving from young to mature assemblages, supporting the settling-down hypothesis. Comparisons between clusters and assemblages revealed fingerprints of over- and under-representation for different plant families. For instance, more true grasses (Poaceae) were introduced before 1500 AD than expected from random draws, whereas fewer true grasses but more legumes (Fabaceae) were introduced after 1500 AD. Phylogenetic analysis and habitat comparisons gave consistent results, supporting the niche-mosaic hypothesis.

The lock-and-key relationship between species invasiveness and site invasibility identified in the above analysis paves the way for objective prioritization of sites with particular characteristics for management, based on factors that make them particularly susceptible to invasion by species with matching traits. Refined conservation plans should be designed for each functional cluster. For instance, daisies (Asteraceae) prefer reserves with cold winters, whereas legumes (Fabaceae), mustards (Brassicaceae) and mints (Lamiaceae) prefer the western parts of the country which has warmer winters. Reserves with cold winters and older establishment seem to resist the invasion of archaeophytes and neophytes. Future research at the C•I•B will seek to build on these results. Ways of using the network methodology for

prioritizing management actions will be sought. Further testing of the niche-mosaic hypothesis as a framework for understanding species packing in novel ecosystems is planned for different taxonomic groups and at different spatial scales.

Fig. 2. Examples of natives, archaeophytes and neophytes in central Europe, as well as the four modules identified from species co-distribution networks (four red boxes). Natives (first row): *Urtica dioica, Betula pendula, Sorbus aucuparia, Picea abies, Dactylis glomerata, Plantago lanceolata, Hieracium pilosella, Coronilla varia*; archaeophytes (second row): *Chelidonium majus, Linaria vulgaris, Chenopodium bonus-henricus, Tanacetum parthenium, Cirsium arvense, Plantago major, Arrhenatherum elatius, Echium vulgare*; neophytes (third row): *Impatiens parviflora, Sarothamnus scoparius, Epilobium ciliatum, Digitalis purpurea, Trifolium hybridum, Aesculus hippocastanum, Robinia pseudacacia, Pinus nigra.* From Hui *et al.* 2013.

Making the case for weed biological control

Weed biological control against invasive alien plants has delivered substantial returns on investment in South Africa, yet the practice is discouraged by some ecologists, who argue that it is too risky a practice to consider. Work by C•I•B core team member Prof. Brian van Wilgen and co-workers shows that there have been few and mostly transient instances of non-target attack, and that these have been very rare when judged against the numbers of WBC agent species and introductions made worldwide (Van Wilgen *et al.* 2013; *Environm. Manage*. 52: 531–540). This work suggests that it is not justified to draw conclusions about the safety of weed biological control from analyses of data sets which include a relatively

small sub-set of entries on weed biological control among numerous examples from insect biological control. This is a common practice that has often led to misleading but pervasive statements about the implementation, efficacy and, particularly, the safety of weed biological control. This becomes extremely misleading when the term 'biological control' is equated with the use of generalist vertebrate predators or herbivores that have historically been used in misguided attempts to control pests or undesirable vegetation, mostly with highly detrimental outcomes.

Risks were assessed through reference to key papers that lay out the risks and benefits involved in practising weed biological control. This showed that the current emphasis on risk has become counter-productive: it has led to potential problems being exaggerated; the effect of inaction being underplayed; no alternative strategies are proposed if biological control is judged too risky; and it has also led to arguably unrealistically stringent safety and approval requirements with consequent delays or complete log-jams. The issue of risk aversion was explored in some detail because default risk aversion arises from a failure to realise that doing nothing is a conscious decision and also carries risks, which is very pertinent when dealing with an invasive weed. Three types of behaviour were identified that could arise in dealing with invasive alien plants and biological control: 1) certainty bias, where one option is described in a way that makes it seem the safest option (e.g. not releasing cf. releasing an agent); (2) status quo bias, which favours the status quo (e.g. not to release) because all outcomes are uncertain; and 3) discounting, where immediate risks (non-target effects) are given greater weighting than something that happens later (the weed spreading).

Biological control is not the only management tool that carries risks for society, and the researchers argue that other control options (including a lack of action) should be subjected to critical risk and sustainability assessments. while restoration of pristine ecosystems is often an unrealistic aim, weed biological control may offer the most cost-effective means for protecting or partially restoring invaded ecosystems. Where ecosystems are severely and irreversibly degraded, giving undue weight to risks of using biological control is misleading, and even unethical. A practical example is given in the following section.

Species well-travelled: understanding balloon vine biogeography

The native geographic distribution of the cosmopolitan genus *Cardiospermum* (balloon vines) is poorly known. In many parts of the world balloon vines are variously considered to be native, invasive or of unknown origin (Fig. 3). A review paper by C•I•B Masters student Ms Enelge Gildenhuys and her co-authors (Gildenhuys *et al.* 2013; *Neobiota* 19: 45-65) showed that part of the problem lies with the extensive movement of balloon vines around the world by humans for medicinal and ornamental use.

Although at least one species (*C. grandiflorum*) is considered a serious invader in South Africa, two sister species, *C. corindum* and *C. halicacabum*, are of unknown native/alien status. This uncertainty has prevented the release of identified biological control agents in South Africa, because of concerns that such agents may also affect the possibly native sister species. Ms Gildenhuys also used phylogenetic methods to demonstrate that *C. halicacabum*

is probably also alien to southern Africa, while *C. corindum* may have arrived in Africa through natural long-distance dispersal and should therefore be considered native. These findings imply that biological control agents capable of feeding on *C. corindum* should not be released in South Africa.

Prevention is better than cure for invasive species management, and eradication become less and less feasible as invasions progress. A crucial step in prevention is determining which areas are suitable for establishment of alien species. Ms Gildenhuys also applied a computer model to identify areas from which balloon vines are currently absent, but which have suitable climate conditions, and may be colonised in future. She found several such areas adjacent to currently occupied areas, suggesting that balloon vines have the potential to spread further in already occupied parts of Australia, Africa and Asia. The accuracy of this commonly-employed modelling method was assessed, showing that species distribution modelling often exaggerates predicted suitable ranges, and that factors other than climate frequently influence establishment potential. This study opens the door to an improved understanding of the global biogeography of balloon vines, with direct implications for invasive species management and future research.

ACACIAS AS MODEL SYSTEMS FOR UNDERSTANDING INVASIONS AND IMPACTS

Australian acacias (1012 recognized species native to Australia, previously grouped in *Acacia* subgenus *Phyllodineae*) are an exceptional model system for gaining insight into a wide range of factors influencing invasiveness, invasibility, and the human dimension of invasive species. About 70 species have been introduced to South Africa, most of them more than 150 years ago; some have commercial and other values; 14 species are invasive, causing substantial ecological and economic damage. The C•I•B has undertaken a wide range of studies and continues to explore diverse aspects of the invasion ecology of this model group.

Elucidating the native sources of an invasive tree species reveals unexpected native range diversity and structure

Invasion biology studies are often initiated because of the problems that species cause in the introduced range, for example, impacts on native plant of animal species. However, the insights gained from introduced areas may in some instances also provide important insights into dynamics in the native range. Using phylogeographic approaches C•I•B PhD student Ms Joice Ndlovu and her co-workers (Ndlovu *et al.* Ann. Bot. 111: 995-904) set out to determine the native provenance of invasive South African populations of Australia's national flower the golden wattle, *Acacia pycnantha* (Fig. 4) This required the reconstruction of the evolutionary relationships between lineages of *A. pycnantha* from throughout Australia.

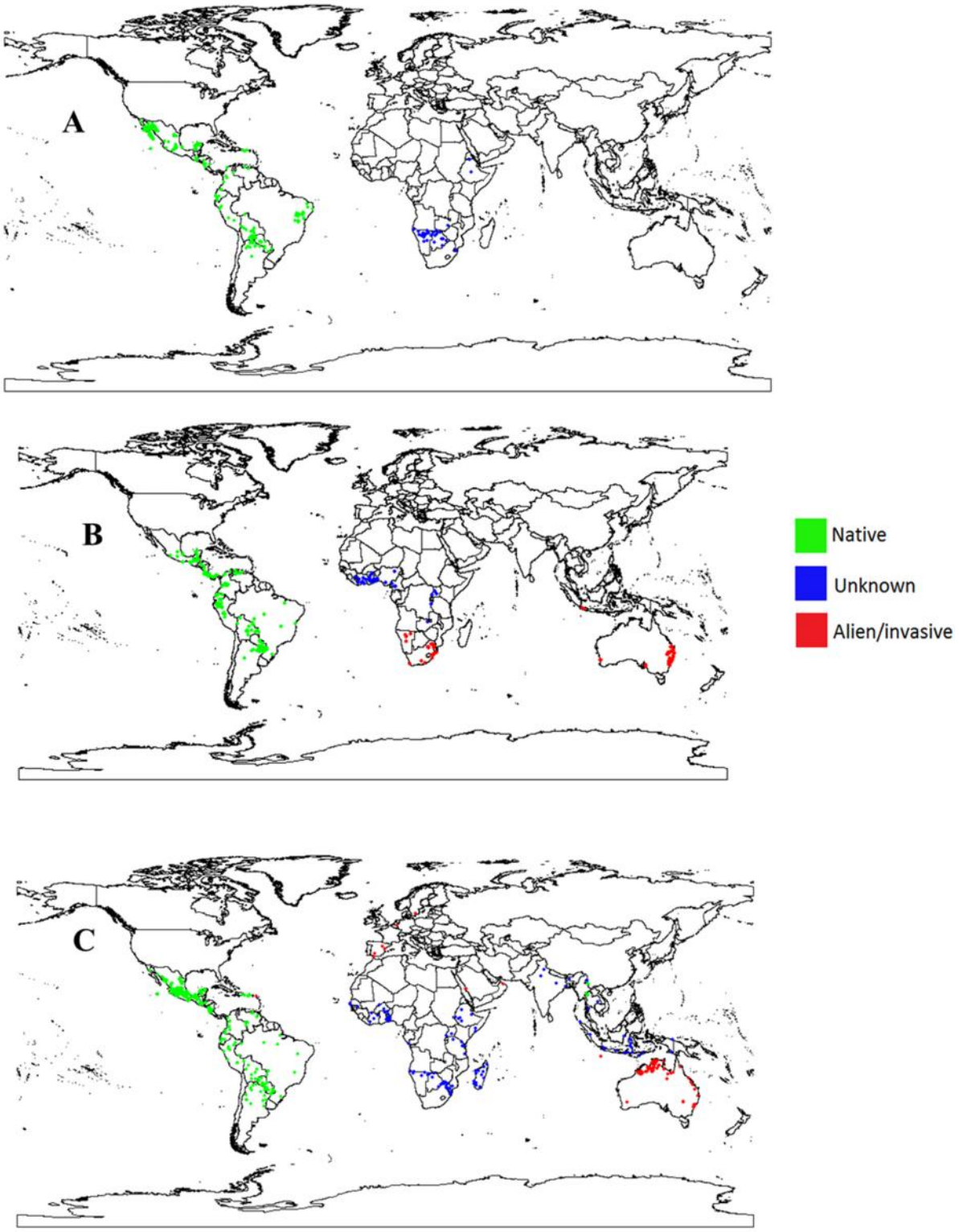

Fig. 3. Distribution of Cardiospermum species. Global distribution of A) *C. corundum*; B *C. grandiflorum*; and C) *C. halicacabum* in native, unknown and alien or invasive regions. From Gildenhuys *et al.* 2013.

The study showed that native Australian populations of *A. pycnantha* appear to be structured into two lineages (wetland and dryland forms). While these two forms have not been formally described, this study opens the door for a taxonomic revision of the group in Australia. Moreover, phylogenetic dating suggested that habitat fragmentation during the Pleistocene epoch probably gave rise to these two morphological forms. The work also showed that most invasive populations of golden wattle in South Africa originated from South Australia and the wetter regions of Victoria, corresponding to the wetland form of *A. pycnantha*. While these findings have implications for future research directed towards the management of this species in South Africa, they also have important implications for the conservation of the species in Australia.

Fig. 4. Golden wattles (*Acacia pycnantha*) are native to Australia. This species, like many other wattles that are invasive in South Africa, was introduced for agroforestry and dune reclamation purposes.

Golden Wattle's promiscuous relationships ensure invasion success

The invasion success of aliens such as the golden wattle in South Africa's fynbos biome might have something to do with fraternising with the right kinds of local and imported bacteria. One of the main conclusions of another study by Ms Ndlovu was that *A. pycnantha* is a 'promiscuous' plant, associated with at least six different types of beneficial soil bacteria, or rhizobia (Ndlovu *et al.* 2013; *J. Biogeogr*. 40: 1240-1251). Rhizobia are capable of entering the roots of acacias and inducing the development of nodules where biological nitrogen fixation takes place. Organic forms of reduced atmospheric nitrogen produced by the bacteria are utilized by the host plant and ultimately enter the earth's food webs. In exchange, bacterial symbionts acquire carbohydrates from their host plants. Like many other interactions, rhizobial-legume mutualisms can be general or highly specific. It is therefore conceivable that the ability of Australian acacias to nodulate and fix nitrogen must have been a substantial factor contributing to their success in South Africa's fynbos biome, which is characterized by soils that are generally poor in nutrients, especially nitrogen. The study found that *A. pycnantha* brought most, if not all, of its rhizobial symbionts along from Australia. This means that invasive populations of *A. pycnantha* may also be spreading non-indigenous bacteria in South African soils. This study also indicated that *A. pycnantha* was

associated with growth-promoting bacteria from the genus *Burkholderia* in both its native and invasive ranges. This finding is interesting as *Burkholderia* is unlike conventional rhizobia and has only recently been found to nodulate legumes and to fix nitrogen. In addition to the nitrogen-fixing services obtained from rhizobia, *A. pycnantha* also harnesses the benefits of being associated with *Burkholderia* species which may include larger root systems (thereby offering more opportunities for the rhizobia to form root nodules), more and larger leaf hairs, steadier stems, higher lignin deposits around the vascular system, larger amounts of chlorophyll, increased levels of those plant hormones that promote the division of cells, and increased levels of resistance against pathogens. These attributes may be important in promoting *A. pycnantha* invasion in South Africa.

DETECTION, DEMONSTRATION, RESPONSES AND REMEDIATION

Once alien species have established and become invasive, their impacts on biodiversity, ecosystem functioning and society are often very high. Consequently, early detection of potentially invasive species, and the development of cost-effective strategies for documenting changes in abundances and distributions are crucial requirements for reducing the rates, extent and impacts of biological invasions. Demonstrating that invasive species have both substantial biodiversity impacts (often obvious and dramatic, but frequently subtle yet influential), and that control can restore system structure and functioning, are crucial for justifying management. Determining which remediation options are most effective for restoring function is also essential. These aspects were again important foci for C•I•B-funded research in 2013.

Stopping the next wave of biological invasions

South Africa is a world leader in the science and management of biological invasions, but has been lagging behind in eradication of invasive species. As of 2010, South Africa had ~8750 introduced plant taxa, 660 recorded as naturalised, 198 included in invasive species legislation, but only 64 subject to regular control. There is only one documented example of a successful eradication programme in continental South Africa – against the Mediterranean snail (*Otala punctata*) in Cape Town. A paper by C•I•B core team member Dr John Wilson and co-authors details the early successes of a unit launched to combat the threats posed by emerging invaders and reviews the current understanding of how best to tackle emerging invasive species (Wilson *et al.* 2013; *S. Afr. J. Sci.* 109(5/6), Art. #0111, 13 pages. http://dx.doi.org/10.1590/sajs.2013/20120111). The South African National Biodiversity Institute's Invasive Species Programme (SANBI ISP), established in 2008, is designed to 1) detect and document new invasions, 2) provide reliable and transparent post-border risk assessments and 3) provide the cross-institutional coordination needed to successfully implement national eradication plans. SANBI ISP is funded by the Working for Water Programme (WfW) of the Department of Environmental Affairs, and plays a leading role in national biosecurity, helping protect our economy and natural resources. At the end of 2012, the ISP had an annual budget of R36 million, employed 33 staff, supported 10 postgraduate students, hosted 35 interns (including those as part of a drive to collect DNA barcodes for all invasive taxa) and had created over 50 000 days of work as part of government poverty alleviation programmes. The unit has worked towards full risk assessments for 39 plant taxa

and has developed eradication plans for seven species; the unit is now helping implement these plans. By focusing on science-based management and policy, SANBI ISP can play a leading role in preventing introduced species from becoming widespread invaders (Fig. 5).

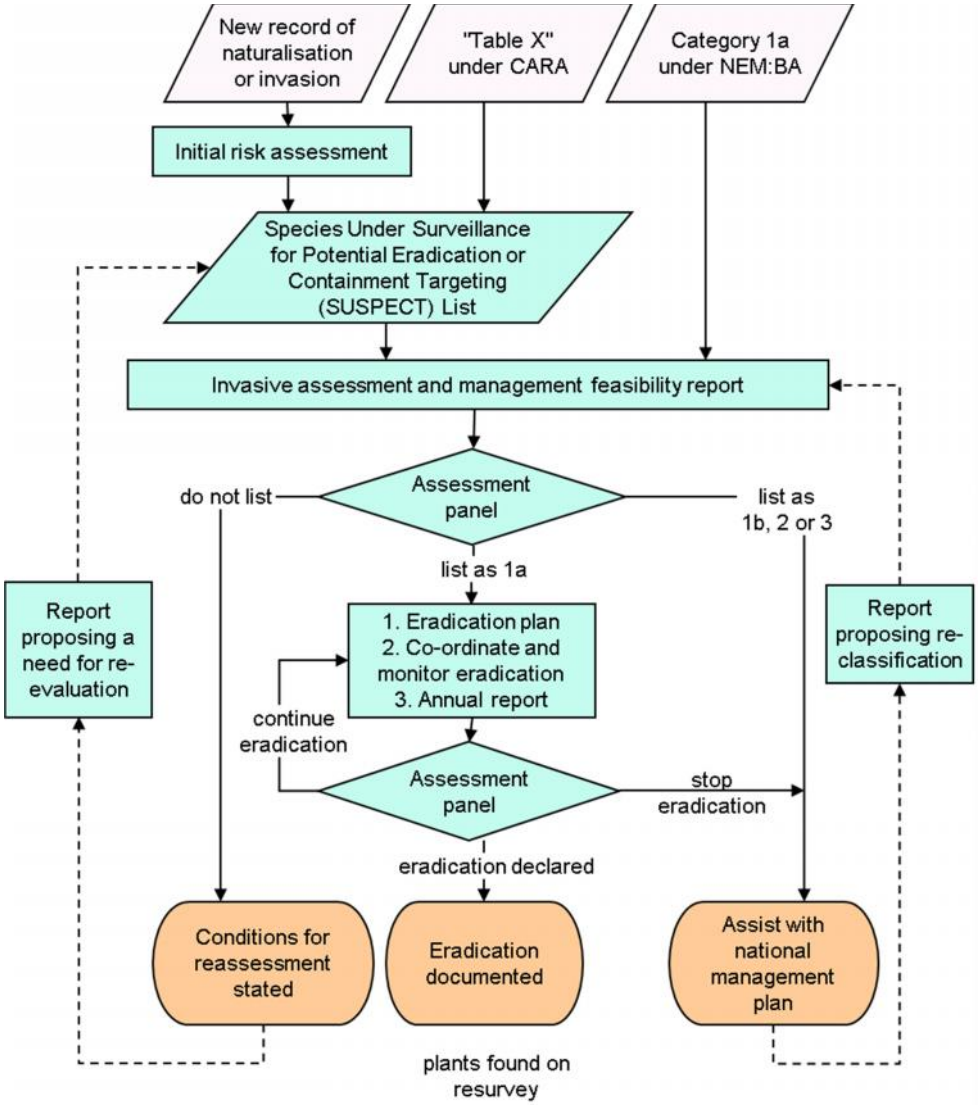

Fig. 5. A proposed process for managing new plant invaders. The categories listed are as per the National Environment Management: Biodiversity Act (10/2004): *Draft Alien and Invasive Species Regulations* 2009[3]. A separate process of evaluation, not described here, is required pre-border and is part of prevention. The success of the programme can be measured by how species are fed through each step of this process. From Wilson *et al.* 2013.

Traits determining invasion success in woody plants — the case of Proteaceae

A major aim of invasion ecology is to identify the characteristics that make invasive species successful, and this understanding is essential for the prevention of future invasions. As part of her MSc thesis, C•I•B masters student Ms Desika Moodley looked at the characteristics of plants in the protea family, many of which are endemic to, and emblematic of, South Africa. This fascinating plant family has many taxa that have been widely distributed and grown by humans around the world, but few species are known to have become invasive.

All members of the protea family globally were categorised as introduced, naturalized or invasive and then the data set was analysed to determine the factors that are important for determining invasion status. As with many other plant groups, species that were widespread (i.e. with large native ranges) were more likely to be introduced, to naturalize, and to become invasive (Moodley *et al.* 2013; *PLoSOne* 8: e75078). Interestingly, species that had a naturally high resistance to *Phytophthora*, a root rot fungus, were more likely to become naturalised or invade successfully; on the other hand, species that were highly resistant to this pathogen posed a low invasion risk. This finding underlines the importance of diseases in the invasion process. The purpose for which a species is planted also influences its likelihood of becoming invasive. For example, plants used as barriers or windbreaks are typically planted on the edges of farms and are more likely to spread into neighbouring natural vegetation. In addition, the plant's exposure to fire may result in increased opportunity to invade, as many Proteaceae only release seeds in response to fire. Therefore, species that are usually planted in gardens are unlikely to invade because they are protected from fires.

This study highlights how invasion ecology can go a long way to providing accurate predictive risk assessments by understanding: 1) which traits are correlated with introduction, naturalization and invasion success; 2) what are the mechanisms behind such correlations; and 3) under which conditions invasions are favoured.

Why are some plants not widespread invaders?

One of the clearest generalisations in invasion biology is that invasiveness in one region is a good predictor of invasiveness elsewhere. But this is not always the case, and much can be gained by understanding the mechanisms behind invasions. C•I•B researchers led by post-doctoral associate Dr Sjirk Geerts, found that although Spanish broom (*Spartium junceum*) is a major invader in Mediterranean-type ecosystems around the world, and is common on road-sides in South Africa, it has failed to invade native vegetation. Given its wide distribution and large seed banks Spanish broom will require management, but the lack of significant threat suggests that it should not be a major priority. Montpellier broom (*Genista monspessulana*), on the other hand is only known from a few sites but appears to be spreading into native vegetation. As such it poses a major risk and should be targeted for eradication (Geerts *et al.* 2013; *S. Afr. J. Bot*. 87: 134–145).

Dr Geerts also led an investigation of the Australian protea *Banksia ericifolia*, which is not known to be invasive anywhere in the world. Over a decade ago, C•I•B Director Dave Richardson predicted that it was the most likely banksia to invade South Africa. Geerts *et al.* 2013 (*Austral Ecol*. 38: 931–941) documented the invasion that has occurred since then and found that while at least one population is invading, most other plantations of *B. ericifolia* have not even naturalised. The study found that this was due to the planting context and management regime. If plants are planted in areas that burn, seeds of this serotinous species are released, disperse, and readily recruit. Yet without fire, recruitment levels are low. Most of the plantings were for flower (or seed-pod) production, so were not allowed to burn. The only invasive population to date was on land whose management had changed to conservation, and to a more natural fire regime. Given these specific requirements, and the

lack of any long-distance dispersal it seems that this is a species that can be readily managed. So while it is advisable to remove unused populations, there is the possibility to cultivate the plant without much threat of environmental damage.

Documenting and understanding specific cases of plant invasion in South Africa will be a continued focus of research, as it promises to deliver assessments based on a sound understanding of the mechanisms of invasion rather than environment correlates.

Restoration in riparian ecosystems following removal of invasive eucalypts

Riparian ecosystems in South Africa's fynbos biome are heavily invaded by alien woody plants. Negative impacts of alien plant invaders on native ecosystems are widely acknowledged, although the evidence is sometimes speculative, especially in riparian zones. Two C•I•B student projects investigated the impacts of *Eucalyptus* invasion and post-clearing restoration along the Berg River, with support from WfW (Fig. 6). C•I•B PhD student Ms Farai Tererai investigated the effects of *Eucalyptus* invasion on native vegetation community diversity, stand structure and composition. Species richness, diversity and structural attributes of the native plant community decreased consistently along the invasion gradient and invasion was associated with changes in native plant species composition (Tererai *et al.* 2013; *For. Ecol. Manage*. 297: 84-93). The results suggest that invasion of eucalypts in riparian zones is a major threat to the conservation of native biological diversity in South Africa. Mr Tererai's study therefore recommends the control of this species in riparian systems.

Large-scale clearing of invasive eucalyptus species is underway, but the assumption that native vegetation will self-repair after clearing had not been thoroughly tested. C•I•B PhD student Mr Sheunesu Ruwanza investigated native species recovery following clearing of invasive *Eucalyptus* species. To provide guidelines for optimising restoration techniques Ruwanza investigated native species recovery following passive restoration - i.e. thinning (40-50% alien cover removal) and complete clearing (100% removal) - and the establishment of native species re-introduced through sowing (active restoration). Native species recovery in passively restored sites was nil two years after clearing but improved four years after clearing (Ruwanza *et al.* 2013; *Appl. Veg. Sci.* 16: 193-204; Ruwanza *et al.* 2013; *S. Afr. J. Bot.* 88: 132-141). Germination of reintroduced native species was very low, and the study concluded that failure of native seeds to germinate under field conditions, secondary invasion of alien herbs and graminoids, the lack of native species in the soil-stored seed bank, and dry summer conditions hamper seedling establishment and recovery on sites cleared of dense stands of alien eucalyptus trees.

Another interesting and novel aspect of Mr Ruwanza's PhD was a study of the effect of *Eucalyptus camaldulensis* invasion and different control methods, namely completely clearing and thinning, on soil water repellency, soil moisture and water infiltration. Mr Ruwanza conducted the study in the laboratory using soils collected along the Berg River. Soil moisture was higher in invaded and natural sites compared to completely cleared and thinned sites (Ruwanza *et al.* 2013; *Geoderma* 200-201: 9-17). Soil water repellency differed with invasion status and restoration condition, but had no impact on soil infiltration rates. Mr

Ruwanza concluded that the removal of invasive *Eucalyptus* species has potential to restore soils to a non-repellent state, thus improving soil related ecosystem functions, which will facilitate the restoration of indigenous species, vegetation composition and structure.

Fig. 6. C•I•B PhD student Sheunesu Ruwanza (left), core team member Mirijam Gaertner (middle) and PhD student Farai Tererai (right) at one of the field sites on the Berg River. Photo: Engela Duvenage.

Detection of second marine mytilid mussel invasion

Until recently the only known invasive alien mussel in South African waters was *Mytilus galloprovincialis*. An Honours project carried out by C•I•B-funded student Mr Kimon De Greef documented the existence of very dense beds of the small Pacific mussel *Semimytilus algosus* blanketing the lower intertidal zone along several hundred kilometres of the west coast (De Greef *et al.* 2013; *Afr. J. Marine Sci.* 35: 307–313). This invasion is highly significant, not only because of the massive densities (Fig. 7) and wide range of the invasion, but because the mussels displace some other species, provide refuge for others and greatly increase food resources for yet others, including commercially important rock-lobsters (i.e. they are ecosystem engineers in several respects). The new species is also much smaller than the commercially cultured *Mytilus galloprovincialis* and when it settles on the commercial mussel ropes, as is happening, it never reaches usable size, but reduced the commercial yield of the farms.

Fig. 7. Dense beds of the small Pacific mussel *Semimytilus algosus* blanketing the lower intertidal zone. Photo: Charles Griffiths.

Frogs on the march

Range expansion can modify the functioning of recipient ecosystems through alterations in biotic interactions such as trophic relationships. The recent range expansion of painted reed frogs (*Hyperolius marmoratus*; Fig. 8) in the Western Cape provides an unusually data-rich study system for quantifying the spatial and temporal dynamics of range expansion. The range expansion of the painted reed frog began at the boundary between the Eastern Cape and the Western Cape, also the boundary of the Tsitsikamma coastal forest belt, in 1997 or early 1998. Before this, no painted reed frogs had ever been noticed in the Western Cape Province (that is, no museum or other formal records existed before this time). These frogs are now widespread in Western Cape ponds and dams, stretching right across to the Cape Peninsula in the west.

C•I•B PhD student and core team member Sarah Davies and co-authors at Stellenbosch and Monash Universities (Davies *et al.* 2013. *Aust. Ecol*. 38, 851-863) found that the frogs' rate of spread through their novel range was highly variable over time and space, suggesting that the frogs had dispersed in two ways: between neighbouring water bodies independently, and over longer distances by human agency (e.g. as eggs attached to water plants distributed to

nurseries). The strongest evidence for human-mediated dispersal was the separation of the novel range into two distinct units east and west of the Riviersonderend mountains, with at least 100 km of unoccupied terrain between them (Fig. 9). This distribution pattern indicates that the frogs were only able to cross the mountain range from east to west by means of human transport ('jump dispersal').

Comparing the habitat characteristics of areas with and without invasive painted reed frog populations confirmed that the frogs are usually not present in areas with very low humidity and high evaporation in summer, cold winters (conditions that are common in Cape Fold mountain ranges such as the Riviersonderend) and the absence of fringing vegetation around water bodies. Overall, painted reed frogs were only present in about a quarter of the water bodies surveyed, suggesting that there is much potential for further range expansion within the network of ponds and dams available. This pattern of range expansion relying on human mediated transport and artificial habitats is common to many species of 'urban exploiters', such as house sparrows (*Passer domesticus*) and feral pigeons (*Columba livia*). The unspecialized habitat requirements, rapid spread and high local population sizes of painted reed frogs suggest that they might compete with endemic Western Cape frogs and hamper the conservation of these range-restricted amphibians.

Fig. 8. The painted reed frog *Hyperolius marmoratus*. Photo: Sarah Davies

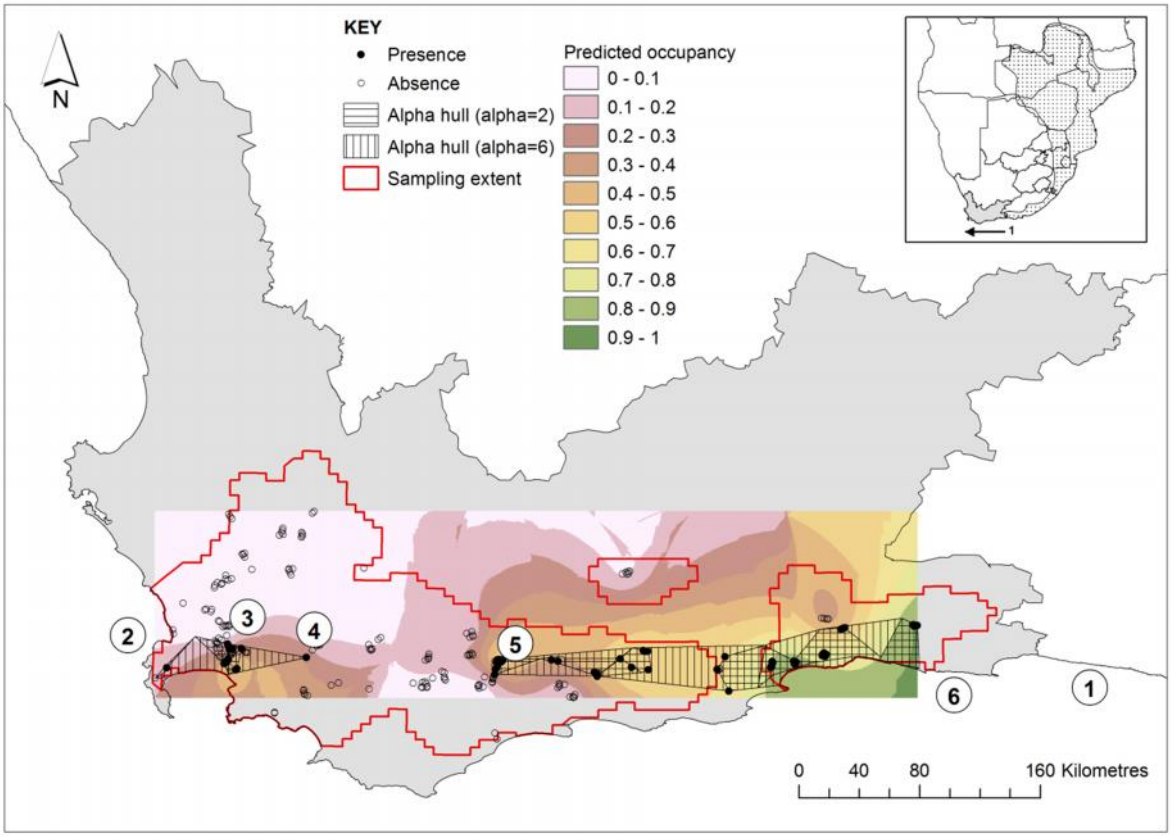

Fig. 9. Distribution of the painted reed frog in the Western Cape (hatched areas). Inset shows the historical range redrawn from Channing (2001; Amphibians of central and southern Africa. Cornell University/Protea Bookhouse); arrow shows general direction of range expansion from the putative origin (Tsitsikamma). Localities: 1- Tsitsikamma (national park headquarters), 2 - Cape Town, 3 - Stellenbosch, 4 - Villiersdorp, 5 -Swellendam, 6 - Knysna. Map projections: Geographic; datum: WGS 84. Shaded areas represent predicted occupancy from a habitat model. From Davies *et al.* 2013.

Unlocking the bottleneck

Geographic range expansions by plants and animals have presented a number of puzzles to scientists. The first of these is known as Reid's paradox: species ranges often expand much faster than expected from normally observed dispersal rates. This paradox was solved by a theory suggesting that the rate of dispersal of individual animals and plants should increase towards the front of an expanding geographic range. Subsequently, researchers have shown an increase in dispersal abilities towards the expanding range front for invasive cane toads in Australia. Toads at the invasion front have longer legs, and thus higher dispersal abilities, compared to individuals from core populations. Since then, many other studies have confirmed this phenomenon based on morphological data. It is therefore widely believed that dispersal can change during the course of range expansion. While these studies have immensely contributed to our understanding of how dispersal operates, measurements of morphological traits cannot dismiss the influence of phenotypic plasticity in trait variations observed, i.e. longer legs in cane toads may simply reflect environmental influence rather than have a genetic and heritable basis.

The second puzzle surrounding geographic range expansions is how genetic diversity is maintained across an expanding range. Standard models of dispersal as a pure-diffusion process (army-like dispersal) predict the erosion of genetic diversity at the expanding range margin due to successive bottlenecks (founder events) and also an increase in deleterious mutations (expansion load), which is obviously disadvantageous from an evolutionary point of view. However, recent models including a fat-tailed dispersal kernel (i.e. modelling dispersal with many short distance but also a few long-distance dispersal events) show a radically different result: instead of genetic erosion, a combination of short and long distance dispersal could actually result in an increase in genetic diversity at the expanding range front and a decrease of the expansion load. While these modelling results are compelling, their manifestation remains to be demonstrated in nature.

C•I•B post-doctoral fellow Dr Cecile Berthouly-Salazar provided one of the first studies as empirical evidence for the theory proposed to explain this second puzzle. They showed both an increase in dispersal and genetic diversity towards the expanding range front of the invasive starling, *Sturnus vulgaris*, in South Africa (Berthouly-Salazar *et al.* 2013; *Mol. Ecol.* 22: 5793-5804). Not only did they support theoretical predictions on the fate of genetic diversity, but their landscape genetic approach also showed that this acceleration can be partly explained by the response of individuals encountering unfavourable environmental conditions during range expansion. Genetic diversity is not only conserved across the expansion range but also brought forward to the front by frequent long-distance dispersal. The findings of Berthouly-Salazar's work fit neatly into the known expansion of starlings in South Africa from Cape Town eastwards based on occurrence record data.

Biological invasions are a fundamental element of environmental change, thanks to human-mediated introduction, while climate change will further complicate the shuffling of species in the future. The findings of this research will therefore be of great importance for the fields of evolutionary biology, global change biology, biogeography, invasion ecology and conservation.

Collaboration is key: ecological restoration is best tackled by multi-disciplinary teams

Ecological restoration, the process of assisting the recovery of ecosystems that have been degraded, damaged, or destroyed, is now internationally recognised as a key priority, alongside conservation initiatives, in the quest for sustainable social-ecological systems. The science and practice of restoration has progressed rapidly over the past few decades, but substantial challenges remain, particularly with respect to scaling-up and financing of large scale initiatives. How can our research ensure the best outcomes? In South Africa, politically driven social grants and legislative drivers (amongst others) have resulted in a range of restoration initiatives, providing fertile ground for a meta-analysis of the ecological, hydrological, and economic impacts of restoration across a range of contrasting sites and contexts. In a recently completed study, involving C•I•B core team member Prof. Karen Esler, the following question was asked: can markets (i.e. systems for valuation and payment) provide support for ecological restoration, and if so, under what conditions? The team's strategy was to partner multi-disciplinary teams of students who worked collaboratively and

considered eight case studies. Student-supervisor teams assessed the impact of ecological restoration on a suite of ecosystem goods and services and on the economy though improved returns on the restored land, enhanced income and job creation. For example, work on one such site in the Kromme River catchment showed how restoration could help to meet national government's Growth Plan targets while simultaneously securing long-term sustainable water supply for the City of Port Elizabeth.

These data were distilled into a systems dynamic model that allowed the team to conceptualise a risk/return economic decision-making framework which could be used to provide support for restoration. Monetary value and markets are not the only decision-making drivers for restoration and it is not always possible to derive meaningful monetary values for certain ecosystem services. However, it is possible to identify conditions under which markets could potentially leverage funding for restoration though a system of payments for ecological goods and services. By conducting research in a multi-disciplinary, team-based and collaborative way, this study not only developed an evidence-based approach to integrating economic evaluation and ecosystem dynamics, but is inspiring a new generation of students to tackle the challenging problems of ecological restoration (Blignaut *et al.* 2013, *Curr. Opin. Environm. Sustain*. 5, 94-101).

GLOBAL ENVIRONMENTAL CHANGE AND ECOSYSTEM SERVICES

Climate change, habitat alteration, overexploitation, pollution and other facets of global change all interact with biological invasions to bring about fundamental changes to the structure and functioning of ecosystems and therefore the services they deliver. Much work at the C•I•B is addressing these interactions.

Water canals as invasion highways for alien fish species

Unique species assemblages are increasingly being overwhelmed by large numbers of introduced species, and freshwater fish invasions are a major source of biotic homogenisation around the world. While active human-mediated introductions contribute to this process, there are also many passive pathways of fish introductions. Inter-basin Water Transfer (IBWT) schemes provide such a pathway, which transfers water from one river basin to another via a network of canal systems. These canal systems behave as corridors, allowing fish species to move from one catchment to another. South Africa, being a water-stressed country, is one of the world's biggest users of IBWT to transfer water resources to areas with high water demand for agriculture and industry. The socio-economic importance of these schemes makes managing them for the ecological integrity of the receiving catchments especially challenging.

Research into the effects of water transfer schemes as an invasion pathway for alien fishes was recently completed in the Eastern Cape Province, South Africa. C•I•B post-doctoral researcher Dr Darragh Woodford, working with core team members Dr Olaf Weyl, Dr Cang Hui and Prof. David Richardson assessed the effect of continuous propagule pressure delivered by a canal network, on fish invasions in farm dams (Woodford *et al.* 2013; *Ecol. Appl*. 23: 1926–1937) (Fig. 10). By surveying fish communities in a series of farm dams with

known ages and filling histories, together with the number of fish entering them through the canal network, estimates of propagule pressure (the number of fish transported per unit volume of water in the canals) and establishment rate (the time taken for fish populations to become established within the ponds) could be produced.

The experiment showed that propagule pressure is a significant driver of establishment. Fish species are more likely to establish populations in new habitats with increased propagule pressure, and the speed of establishment increases asymptotically with increased propagules (Fig. 11). A more troubling outcome of the experiment was that all species collected in the canal network were found in one or more surveyed ponds, showing there are no barriers to arrival within the canal invasion pathway. This highlights the dangers posed by IBWT infrastructure for increasing freshwater fish community homogenisation. The irrigation network provided the researchers with an unprecedented opportunity to quantitatively assess the number of propagules involved in the establishment of introduced fish populations. This natural experiment empirically demonstrated the long-held theory that the magnitude of propagule pressure can determine the success or failure of an invasion, provided the invader is capable of reproducing in the receiving environment.

Fig. 10. The Sundays Valley water-transfer canal, which distributes water and fishes from the Orange-Fish-Sundays Inter-Basin Water Transfer Scheme to hundreds of irrigation ponds used for citrus farming. Photo: Darragh Woodford.

Fig. 11. The River Goby (*Glossogobius callidus*) was a rapid coloniser of most surveyed ponds, and received far more propagules from the irrigation network than it needed to successfully establish populations. Photo: Darragh Woodford.

Velvet revolution triggers rapid expansion of rose chafer beetles in Europe

Human-mediated changes in climate and land use can impact species' survival and distribution. While many species are being negatively affected by these changes, some species (both native and introduced) can rapidly expand their original or historical ranges which were previously restricted by dispersal and ecological barriers. Compared to many invasive alien species whose range expansion represents the process of filling empty niches, extralimital species (i.e. domestic exotics) can expand their ranges either by filling new habitats created by environmental changes (climate and land use changes) or by outburst due to accumulating local propagule pressure.

Central Europe witnessed a dramatic change in land cover after World War II when industrialisation transformed large areas of grasslands into agricultural land and industrial zones. Land use trends were further altered after the Velvet Revolution in 1989 when the use of fertile land started to intensify and unproductive areas were being converted back to grasslands and commercial forests. An international team, including C•I•B core team member Dr Cang Hui and former C•I•B post-doctoral associate Dr Nuria Roura-Pascual, examined the expansion of the rose chafer beetle *Oxythyrea funesta* (Fig. 12), in Central Europe, during the decade before (pre-1990) and after (post-1990) the Velvet Revolution when expansion suddenly sped up (Horak *et al.* 2013; *Naturwissenschaften* 100: 327-336.

The study found that the slow spread of *O. funesta* before 1990 changed to a phase of rapid expansion after 1990 which was driven not only by changes in the environment (climate and land use) but also by the accumulation of local propagule pressure. Climate was found to play a significant role but only during the niche filling stage before 1990, whilst land use became important during the phase of rapid expansion after 1990. Both the build-up of local propagule pressure and the land-use change after the political regime shift contributed to the sudden rapid range expansion of this important pollinator and scavenger species in Central Europe.

Fig. 12. The Rose Chafer Beetle (*Oxythyrea funesta*). Photo: J. Horak

Plant responses to climate change — insights from plant invasion ecology

Plants are moving as their habitats change due to climate change. For species to persist they must adapt or move somewhere else. Species dynamics are extremely hard to predict, making global change research a challenging enterprise. There is, however, no shortage of cases of alien plants spreading following their introduction to new areas by humans. Many plant invasions have been studied in great detail, and this research has yielded many new insights on the processes that mediate such range changes and how the addition of new species to an ecosystem can radically change many aspects of its functioning.

These issues have been studied in various ways at the C•I•B in recent years. C•I•B Director Dave Richardson participated in a workshop at the Ecological Society of America's 2011 annual conference in Austin, Texas, which explored how emerging insights from plant invasion ecology could inform strategies for dealing with rapid climate change A synthesis paper that grew from this workshop was published in 2013 (Caplat *et al.* 2013; *Oikos* 122: 1265–1274). It discusses how concepts from invasion biology can contribute to answering questions in climate change research. Many of these concepts (see Fig. 13) deal with the properties that a plant needs to be able to track environmental conditions or to adapt to new conditions. The colonisation of new environments emphasizes the role of dispersal, which has been intensely studied in invasion biology. Invasion processes are not entirely analogous with plant movements in response to climate change but they do present some useful examples and a large volume of data which could be synthesised to shed light on ecological, evolutionary and social processes that are involved when plants move.

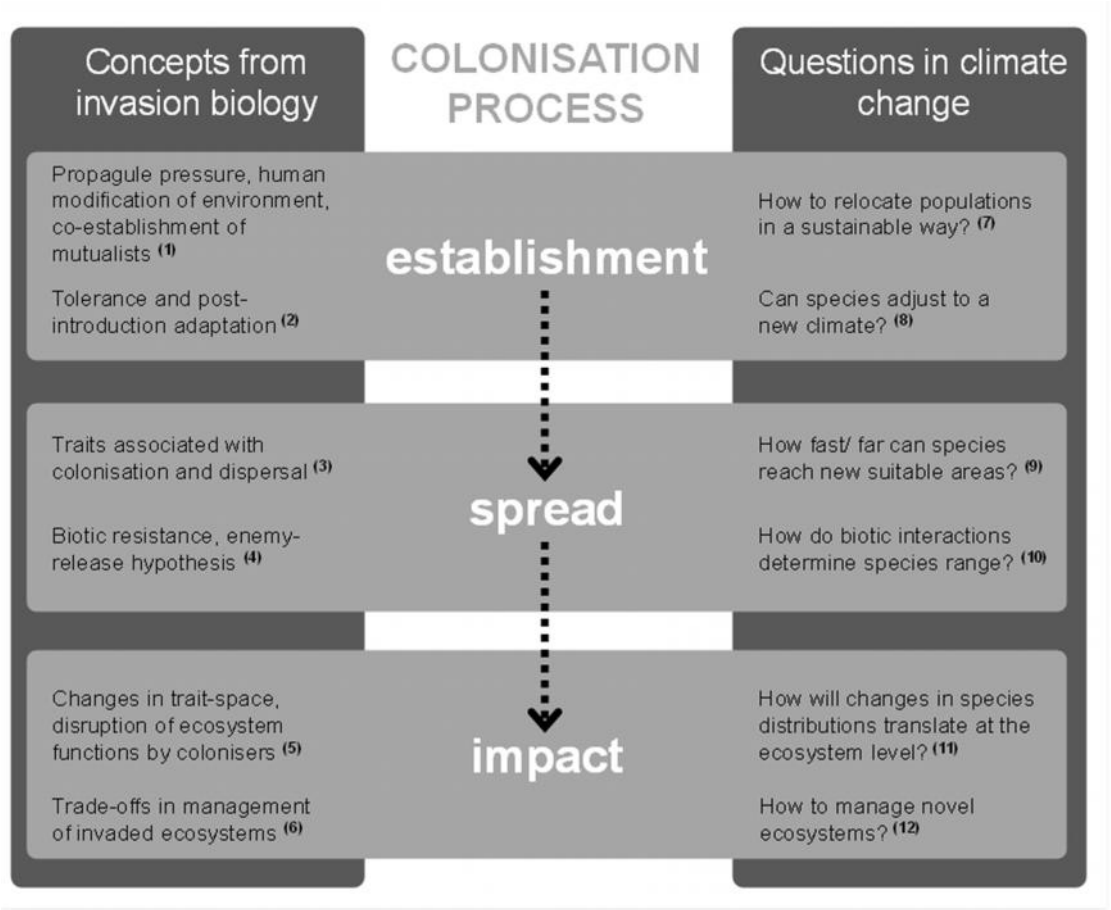

Fig. 13. Concepts from invasion ecology (left hand side) at different stages of the colonisation process and their relevance to climate change questions (right hand side). For invasive species, introduction usually occurs due to human activity (either purposeful or accidental introduction). For native population movements, in a climate change context, purposeful introduction will only be relevant for translocated/assisted migration processes (from Caplat *et al.* 2013).

Colonization strategy in wild radish

Knowledge of the pathways of colonization is critical for risk assessment and management of weeds. A C•I•B team, including post-doctoral researcher Dr Adeline Barnaud and core team members Prof. Melodie McGeoch and Prof. Bettine Jansen van Vuuren, looked at the colonization strategies at different spatial scales in the weedy wild radish, *Raphanus raphanistrum*, considered one of the world's worst agricultural weeds. They adopted a landscape genetics approach where the GPS coordinate of every sampled plant was taken, and used to construct a matrix which was correlated with genetic distance. This was done at the local spatial scale as well as for the Western Cape.

At local spatial scales it was expected that natural pollen and seed dispersal would be restricted. However, the study found no significant relationship between genetic and geographical distance within sites. Instead, the results suggest that *R. raphanistrum* had colonised new habitats via jump dispersal, rather than through natural diffusive dispersal at local scales (Barnaud *et al.* 2013; *Biol. Invasions* 15: 2455-2465.). The importance of road

verges as corridors in dispersal has been reported by various authors including recent work at the C•I•B by core team member Prof. Karen Esler. However, this study found no evidence for road verges acting as dispersal corridors, as evidenced by a lack of isolation-by-distance at local scales. Instead, the absence of spatial genetic structure suggests that *R. raphanistrum* had rapidly spread throughout its current range, possibly facilitated by human-mediated actions (Barnaud *et al.* 2013; *Weed Research* 53: 362-369).

Management plans addressing containment or suppression of this weedy (and possibly other weedy) species should take the high degree of connectivity between distant geographical localities into account. At large spatial scales, the findings confirmed results at local spatial scales, and suggest that *R. raphanistrum* colonized throughout the CFR via both local diffusive spread and long-distance jump dispersal.

The majority of localities included belonged to a single genetic cluster (Fig. 14). The only exception was plants collected at Vredenburg, which the authors attributed to a (possible) second colonization via the port at Saldana Bay. An interesting and important finding was that 47% of analysed plants contained *Raphanus sativus* (cultivated radish) chloroplast genomes, indicating historical and/or contemporary gene flow between wild and cultivated radish populations.

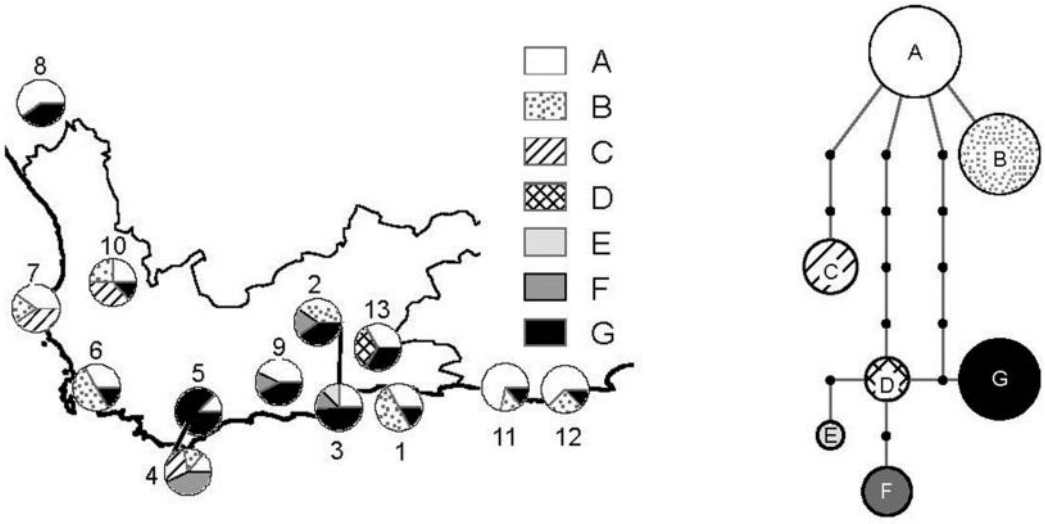

Fig. 14. At left, distribution of the seven *Raphanus raphanistrum* cpDNA haplotypes across the Cape Floristic Region; and at right, parsimony network showing the relationships among the cpDNA haplotypes. Each connecting line indicates one mutational difference and unlabelled nodes are inferred intermediates. Size of circles reveal the frequency of haplotypes; small ≤ 0.10, medium = 0.10 – 0.20, large = 0.20 – 0.30 and ex-large ≥ 0.30. From Barnaud *et al.* 2013.

How far can a fruit fly fly?

The invasive Mediterranean fruit fly or medfly, *Ceratitis capitata*, is one of the world's major agricultural and economic pests. Understanding invasion risk and mitigation of medfly in agricultural landscapes requires knowledge of its population structure and dispersal patterns. A team of C•I•B researchers estimated the dispersal ability of medflies in South Africa at

three spatial scales using molecular approaches (Karsten *et al.* 2013; *PLoSOne* 8: e54281). Their results show that South African medfly populations have high levels of genetic diversity and limited population differentiation at all spatial scales (Fig. 15). This suggests high levels of gene flow among sampling locations. However, natural dispersal in *C. capitata* has been shown to rarely exceed 10 km. Therefore, documented levels of high gene flow in the present study, even between distant populations (~1600 km), are likely the result of human-mediated dispersal or at least some form of long-distance jump dispersal. These findings have broad applicability in fruit production areas and have significant implications for ongoing pest management practices, such as the sterile insect technique.

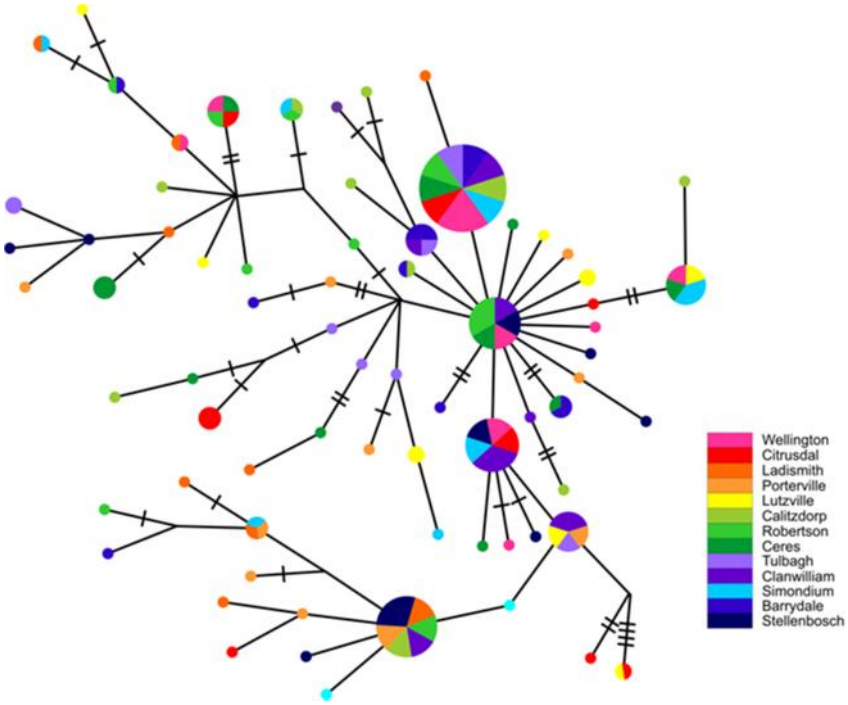

Fig. 15. The parsimony haplotype network for *Ceratitis capitata* in the Western Cape (regional scale). From Karsten *et al.* 2013.

Protected areas as key focal areas for invasive alien plant science

Protected areas are increasingly important for the maintenance of species, ecosystems and the services they provide. At the same time, however, invasions by alien species are accelerating, undermining the conservation value of protected areas and preventing them from achieving their goals. If the invasion of alien species in protected areas is to be prevented, or at least minimised, then a detailed understanding of their drivers is required. While many studies have explored one or a few predictors of invasions, no study has explored the role of a larger number of predictors or included both animals and plants. South Africa's national parks provide a useful model system within which to examine predictors of invasions and to search for generalities: the country's 19 national parks constitute 52% of terrestrial protected areas in the country, span the country geographically and encompass a diverse range of park sizes (from 57 to 19 624 km^2), urban to rural contexts, and a range of climates and biomes. A team of C•I•B researchers explored this system (Spear *et al.* 2013; *Conserv. Biol*. 159: 137–147).

Twelve variables were selected as potential predictors of the number of alien species per national park, including: 1) number of years since the park was proclaimed, 2) number of years since the most recent land acquisition, 3) park size, 4) data availability categorical estimates with three levels), 5) visitor numbers, 6) human population density along the boundary, 7) number of roads entering the park, 8) number of rivers entering the park, 9) indigenous plant species richness, 10) a measure of vegetation productivity, 11) temperature and 12) rainfall. These variables were selected based on current understanding of the determinants of alien species richness, particularly for protected areas.

A total of 813 alien species were listed in SANParks, with a database of 1670 species records across the national parks (Fig. 16). Where there was evidence of a species having a negative impact on biodiversity, (locally or elsewhere) these species were considered invasive, leading to 181 species being considered invasive. The national parks with the most alien and invasive species were Kruger (400 alien and 81 invasive species), Table Mountain (291, 101), Garden Route (200, 74) and Addo Elephant (130, 59) National Parks. The national parks with fewest recorded alien and invasive species were Kalahari Gemsbok (15, 7) and Richtersveld (14 and 12 species) National Parks.

Of the twelve variables tested, human population density surrounding parks was the most consistent and strongest predictor of numbers of alien and invasive species, across both plants and animals. Although there were other significant explanatory variables and some interrelated ones, two contrasting examples illustrate the overriding importance of human population numbers. Kruger National Park, which has the highest number of alien species, is the oldest park with about 110 years of continuous conservation status. However, the human population surrounding Kruger can account for both the numbers of alien plants as well as invasive plants, as at least two million people reside within a 50 km radius of the park, and about 3 600 staff within the park. In a completely contrasting situation, Table Mountain, which is an urban park, falls within the Cape Town metropolitan area, with a large surrounding human population (c. 3 million people). Therefore, even though these two parks are completely different, they still have the highest alien species numbers, as was predicted by the density of people living along their borders.

The conclusion is that human population density is an important predictor of alien species richness in protected areas across taxa, providing a basis for guidelines on where to focus surveillance and eradication efforts.

Protected areas as model systems for invasion science and catalysing management

Interest in biological invasions has increased dramatically since introduced species were mentioned in faunas and floras in the late 1700s, briefly discussed in the works of Charles Darwin, Charles Pickering and others in the 1800s, and then brought to prominence in the mid-1900s through the work of, among others, Charles Elton in his 1958 book ‘The Ecology of Invasions by Animals and Plants’.

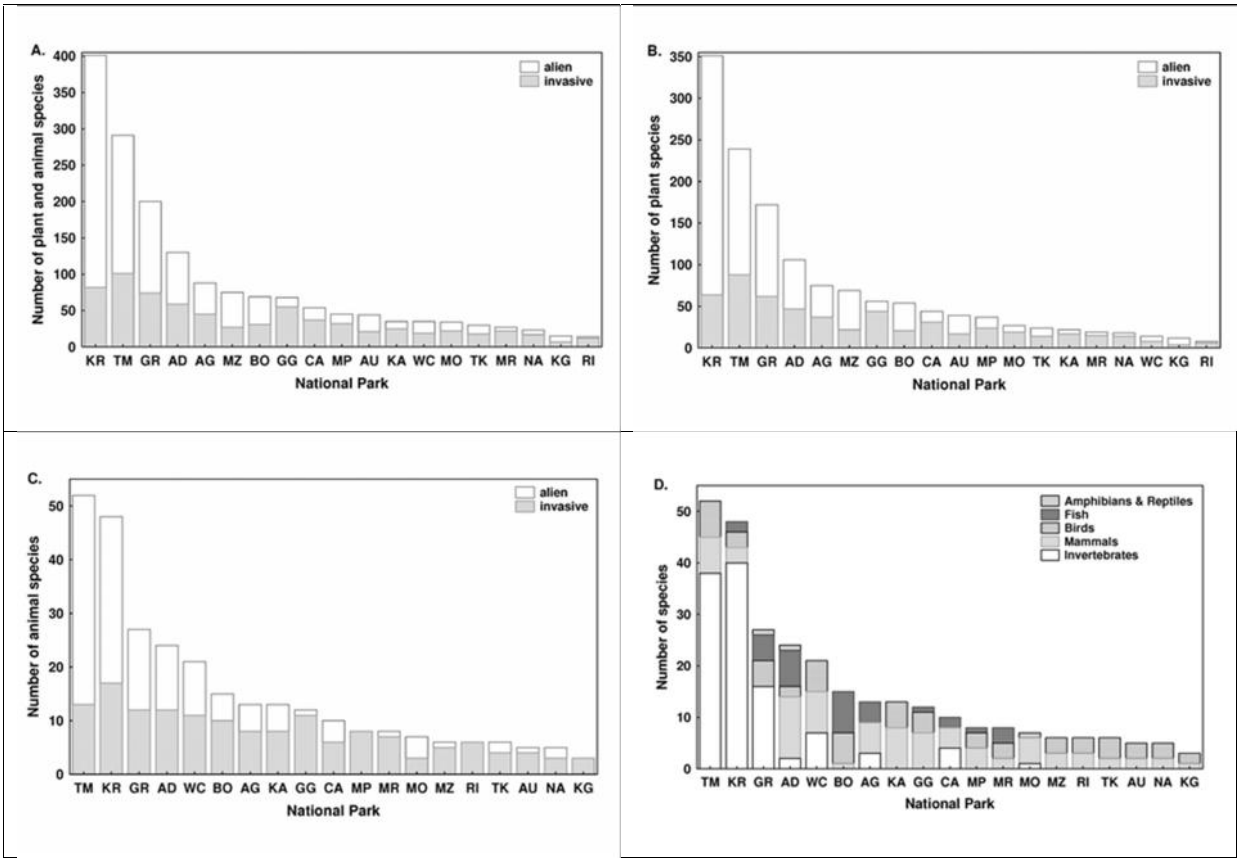

Fig. 16. Number of alien and invasive species per national park for A) all species, B) plants, and C) animals, as well as D) the number of alien animals per park and per taxon. National parks (total number of species): AD: Addo Elephant (130), AG: Agulhas (88), AU: Augrabies Falls (88), BO: Bontebok (69), CA: Camdeboo (54), GR: Garden Route (200), GG: Golden Gate Highlands (68), KG: Kalahari Gemsbok (15), KA: Karoo (35), KR: Kruger (400), MP: Mapungubwe (45), MR: Marakele (27), MO: Mokala (28), MZ: Mountain Zebra (75), NA: Namaqua (23), RI: Richtersveld (14), TM: Table Mountain (291), TK: Tankwa Karoo (30), and WC: West Coast (35). From Spear *et al.* 2013.

The last international research programme to focus specifically on invasive species in protected areas was a working group on invasions in nature reserves, initiated under the SCOPE (Scientific Committee on Problems of the Environment) programme on biological invasions in the 1980s (Wildlife Conservation and the Invasion of Nature Reserves by Introduced Species: a Global Perspective). The central question posed by the working group on nature reserves was whether an undisturbed community could become invaded by alien species. The challenge was to define the communities within which to work. The SCOPE team felt that the best option would be in tracts of land that had been set aside to keep anthropogenic impacts on special features (e.g. wildlife and landscapes) to a minimum. Using nature reserves as the sites most likely to accommodate these requirements, the working group aimed to 1) provide insights into differences between the extent to which natural and disturbed systems could become invaded; 2) provide information on the consequences of invasions for indigenous species; and 3) based on the outcomes, to provide management recommendations. The potential threats posed by biological invasions are widely appreciated, but the state of knowledge and level of management of invasive alien plants in protected

areas differs considerably across the world. The research done on nature reserves as part of the SCOPE programme showed the vulnerability of natural or undisturbed areas to invasions. Subsequent work shows the serious situation regarding plant invasions that prevails in many protected areas.

A team of 80 ecologists and managers from around the world collaborated on a book to extract as much information as possible to support the long-term management of protected areas, and the biodiversity and associated ecosystem services they maintain. The project, led by C•I•B core team member Dr Llewellyn Foxcroft, focused on three core themes: 1) the ecology and science of plant invasions in protected areas, 2) global case studies, and 3) management interventions. The main product of this exercise was an edited book published in 2013 as part of the Springer series *Invading Nature* (Fig. 17).

The first section of the book (Foxcroft *et al.* (eds.), 2013; *Plant Invasions in Protected Areas - Patterns, Problems and Challenges*, Springer) examined research that has been done in protected areas and how it has deepened the general understanding of invasions on, for example, the impacts of invasive alien plants in protected areas. Each of the regions or case studies were examined for their unique experiences that provide insight into the mechanisms and dynamics of plant invasions. The case studies also provide examples of specific problems and responses that can potentially be applied elsewhere. The management section drew on the best available knowledge to provide protected area managers with scientifically sound, locally relevant advice on how to approach management and integrate it into overall operations.

Insights are gained from assessing invasions of protected areas of varying kinds and sizes, from the Azores, Australia, Chile, East and South Africa, Europe, Galapagos, India, Mediterranean Islands, New Zealand, Pacific Islands and Hawaii, Southern Ocean Islands, United States and the Western Indian Ocean Islands. Work in some protected areas has led to well-developed management and policy frameworks. In others, important insights have emerged on invasion mechanisms and the impacts of invasions. Although there is awareness of invasive alien plants in most of the 135 protected areas mentioned in the book, better and more focused actions are urgently needed. This requires, among other things, improved capacity to prevent invasions and to react promptly to new incursions, and increasing efforts to manage well-established invasive species. Research to improve the understanding of invasion dynamics is essential. Updating species lists and distribution data is crucial for successful long-term management, as are collaborative networks, research groups, volunteers, and improved accessibility to resources such as online databases. Efforts to lessen the science-management divide are especially important in protected areas. One reason is that managers are usually required to implement invasive alien plant control programmes as part of general protected area management activities, and in many cases lack the knowledge and support for effective science-based management solutions. Overcoming this barrier is not trivial and will require partnerships between local, municipal, regional and national-level organizations, and international non-profit NGOs and donor organisations.

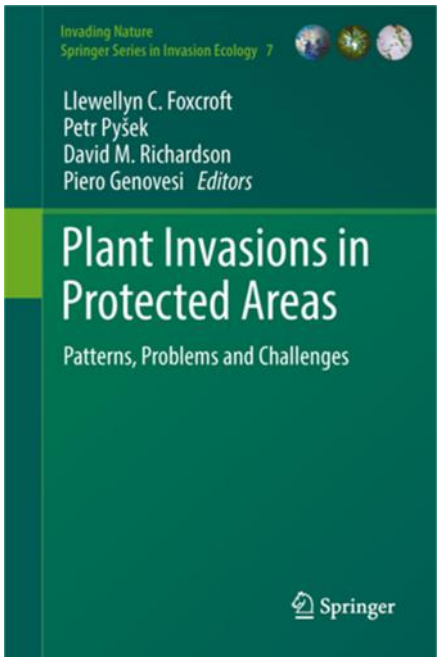

Fig. 17. A major global review of plant invasions in protected areas was published as en edited volume as part of the Springer book series *Invading Nature*.

Ecological footprint and biocapacity: the misconception of unsustainable development

The concept of sustainable development was put forward by the World Commission on Environment and Development in 1987. Among the indicators of sustainable development is the "ecological footprint" methodology. This metric is the total area of productive land and water ecosystems needed to produce adequate resources and absorb wastes for a given enterprise or population. Biocapacity, on the other hand, is the locally available carrying capacity (the availability of resources) of an ecosystem for generating resources and absorbing wastes. The ecological footprint and biocapacity represent humanity's demand for resources and the supply of resources from a regional ecosystem, respectively. As both are measured in the same unit (the global hectare: gha), it is straightforward to calculate regional ecological budget as surplus and deficit. To this end, an ecological surplus has been suggested as a minimum criterion for sustainability.

As conventional ecological footprint methodology ignores management actions and policies, it only gives limited support to decision-making. The use of spatial features, with the help of Geographic Information Systems (GIS), has helped ecological footprint methodology to overcome this shortcoming. However, in doing so, an important issue that is associated with any spatial or area-based information is neglected - the scale dependency of spatial features. Specifically, the area sizes of different types of land cover (e.g. cropland, grazing land, fishing land, forest, built-up area and barren land).

Since area-based information has been widely used for estimating the sizes of different land covers, it is important to assess how the biocapacity estimated will be affected by the resolution of the data and whether this scale dependency will change our view on regional sustainability. C•I•B researchers and colleagues from Lanzhou University investigated the

scale dependency of biocapacity and the potential misconception of unsustainable development (Yue *et al.* 2013; *J. Environm. Manage*. 126: 13-19).

Coarse-scale maps will shift the perception of regional sustainability towards unsustainable development. Using the typical global land cover map derived from MODIS (moderate-resolution imaging spectroradiometer) data and AVHRR (Advanced Very High Resolution Radiometer) data at the resolutions of from 250m to 1km, we could underestimate global sustainability. Although it is reasonable to fuel public awareness, we might not need 1.5 earths in 2007 for sustainable development as predicted from the Living Planet Report. It is only by fully appreciating and utilizing the scale dependencies of land covers and biocapacities that we can have an accurate picture of sustainability.

Upper temperature limits are constrained globally

In most terrestrial systems, temperature is expected to rise by more than 2°C by the end of this century. Organisms will likely face high heat stress in the form of a consistently warmer average temperature and an increased occurrence of temperatures extremes. In order to understand the vulnerability of species to these temperature changes, the extent to which upper temperature tolerance of species can shift, through flexibility in the short term or evolution in the long term, is essential for forecasting potential loss of species diversity. In a synthesis article, C•I•B core team member Dr Susana Clusella-Trullas and collaborators explored the availability and significance of data on flexibility and evolutionary change of upper temperature limits and highlight which taxonomic groups may be particularly vulnerable to climate warming (Hoffmann *et al.* 2013; *Funct. Ecol*. 27: 934-949).

First, lower temperature limits seem to be consistently more plastic than upper temperature limits; second, mid-latitude species will likely experience more heat stress than tropical and polar ones (Fig. 18); third, despite the scarcity of data, selection may take place for tolerance traits but upper limits tend to be constrained across species. Increased information on adaptive responses, phylogenetic constraints and plasticity is required in order to obtain a better picture of diversity loss at large scales. This timely review highlights the extent to which many organisms have reduced scope for adaptation to climate warming and how likely they are to face further extinction risk. Patterns of temperature tolerance and the extent of its plasticity across regions and taxonomic groups are essential for devising management strategies and conserving species diversity, especially as complexity arises when we forecast interactions between the rate of climate change and adaptation to climate change.

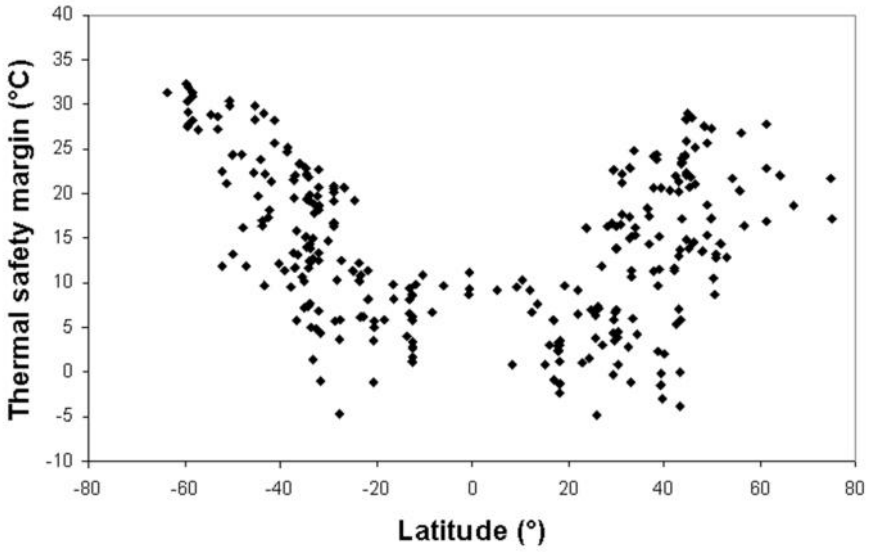

Fig. 18. Some reptile species at mid-latitudes have a smaller margin between the highest temperature they can withstand and the maximum microsite temperature, meaning that their vulnerability to global warming is higher than more poleward or tropical species (From Hoffmann *et al.* 2013).

Coping mechanisms of understudied species

Buffering of environmental change via physiological mechanisms (plasticity, adaptation) is generally aimed at responses to temperature change using insect model species such as Drosophila. However, much less focus is given to cryptic or fossorial fauna such as springtails and onychophorans or to other environmental variables such as humidity rather than temperature. While it is generally recognised that insects inhabiting mesic environments have higher rates of water loss than those in xeric habitats, we know little about the responses of onychophorans (velvet worms) which may be particularly affected by changes in humidity due to their lack of water retention mechanisms. C•I•B post-doctoral fellow Dr Christopher Weldon and collaborators (Weldon *et al.* 2013; *J. Comp. Physiol. B* 183: 323-332) examined the metabolic, total water loss and cuticular water loss of two cryptic species of velvet worms, *Opisthophatus cinctipes* s.l. from locations that had distinct temperature and humidity regimes. Species from drier and warmer sites had lower water loss but similar metabolic rate and cuticular water loss than those from wetter and cooler sites. These results are in keeping with the idea that these species have the capacity to adapt to local conditions and that species differentiation may have been driven by the reduction of rainfall during the Miocene period. More importantly, this information is key for improving our capacity to predict environmental change impacts on cryptic species and develop taxon-specific strategies to enhance local scale ecological forecasting.

HUMAN DIMENSIONS

Humans cause invasions, humans perceive invasions, humans decide why, when and how to manage invasions. The human dimensions of biological invasions is a core part of research at the C•I•B.

Human usage in the native range may determine future genetic structure of an invasion

Quantifying the amount of genetic diversity and how it is distributed within and between populations (genetic structure) has become a major focus in invasion biology. Population genetic structure can be useful as a proxy for the introduction history of a species, e.g. to differentiate between multiple introductions vs. single introductions. Similarly, knowing the ancestral source of invasive populations in their natal ranges has important implications for biological control, i.e. identifying native range areas most likely to have effective host-specific and co-evolved natural enemies. Moreover, genetic studies can be very informative to better understand how contemporary evolution impacts the invasiveness of species.

A study involving C•I•B core team member Dr Jaco Le Roux, C•I•B PhD student Joice Ndlovu and others compared genetic diversity and structure between and within native (Australian) and invasive (South African) populations of the golden wattle, *Acacia pycnantha* (Le Roux *et al.* 2013; *BMC Ecology* 13, 37). This species, like many others wattles that are invasive in South Africa, has been historically introduced for agroforestry and dune reclamation purposes. Forestry trees represent a particularly interesting case to explore genetic diversity and structure since 1) they are typically sampled over large parts of the native range and in large numbers prior to their introduction 2) they often undergo extensive breeding to select for favourable traits and genotypes suited to local environmental conditions. These processes may aid successful invasions by facilitating higher propagule pressure and genetic diversity, or by selecting for traits such as short generation times and high growth rates.

The study showed that, despite having been introduced only on two occasions to South Africa, invasive golden wattle populations have remarkably high genetic diversity, representative of the gene diversity found throughout the species' native range in south eastern Australia (Fig. 19). This could imply that the two introductions into South Africa must have been sampled across a wide range in Australia and that these introduction efforts (propagule pressure) must have been high, leading to high levels of admixture and genetic diversity in the new range. However, the authors also illustrated that golden wattle populations in Australia lack genetic structure and are characterised by extensive levels of hybridisation, similar to those identified in South Africa.

The extensive hybridisation in Australia is most likely due to human-mediated processes, as this species has been extensively moved and planted by humans for many years. Therefore, given only two introduction events, the most parsimonious explanation for the genetic similarities between golden wattle populations from South Africa and Australia is that already-admixed propagules, as a result of extensive plantings during revegetation projects in Australia, reached South Africa. This is one of the first studies to illustrate how human-mediated movement within the native range of a species may impact the genetic structure found within its invasive range.

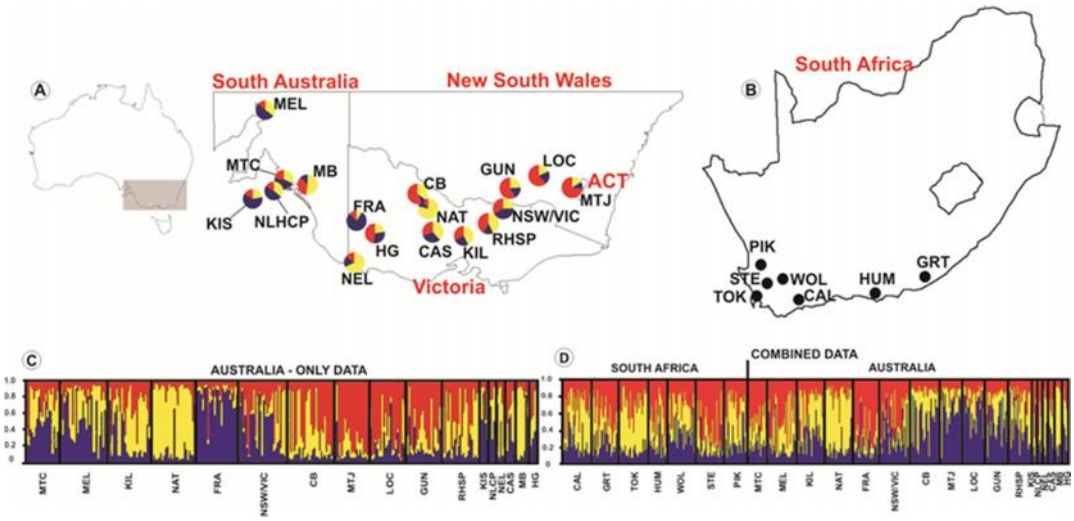

Fig. 19. Population genetic structure based on Bayesian assignment tests performed in STRUCTURE. (A) Localities in south eastern (SE) Australia where native Acacia pycnantha populations were sampled. Pie charts indicate overall genotype assignment for each population to particular genetic clusters identified based on native range data only. (B) Localities in South Africa where invasive Acacia pycnantha populations were sampled. (C) Results of the STRUCTURE analysis showing population genetic structure of A. pycnantha populations in its native range (based on native range data only) and (D) combined native (SE Australia) and invasive (South Africa) ranges (combined data). The vertical axes of all STRUCTURE bar plots illustrate the proportional assignment of individual genomes to the inferred genetic groups (from Le Roux *et al.* 2013).

Beneficiary dependence on the South African Working for Water programme: A multi-site case study of four projects in the Western Cape

Research conducted by former C•I•B-funded student Anton Hough explored beneficiary dependence on four different CapeNature/WfW projects in the Western Cape and led to recommendations to CapeNature and WfW on how to improve the programme to more directly align it with the needs of its beneficiaries. Face-to-face interviews with a sample of those beneficiaries suggest that a number of push and pull factors contribute to their dependency on WfW. Chief among these factors is a fear among previous farmworkers of returning to farm work. It was found that the latter can be linked to a historical power-relations legacy between landowners and farmworkers, mainly created by institutional racism still prevailing on many Western Cape farms (Hough & Prozesky 2013; *S. Afr. J. Sci.* 109 doi: 10.1590/sajs.2013/1119). These findings bear important implications for the implementation of a new draft WfW policy aimed at encouraging private landowners to employ WfW beneficiaries on their land as clearers of invasive alien plants.

If landowners were to contract teams to work on their land, it would mean that beneficiaries might again be working on farms, and therefore assumes the development of a mutually beneficial relationship between landowners and WfW beneficiaries. As the legacy of a long history of farm paternalism and exploitation still prevails in some areas of the Western Cape - and many of these WfW beneficiaries have worked on these farms - this assumption is unrealistic. If WfW currently provides an escape from farm work, and a preferred working environment, it is difficult to understand how beneficiaries would want to or be able to return to work on certain farms where they have very little bargaining power. This is an issue that

needs to be considered more fully in policy development, and requires an analysis of why the legacy of the deeply entrenched historical power relations, created by institutional racism, still exists on Western Cape farms. At the very least, dedicated professionals need to be appointed to assist the contractors and/or their workers in approaching landowners to offer their services to eradicate any IAS which is growing on their land.

The research also identified a number of important issues that should be considered in future research: first, gender identity needs to be taken into account in more detail, as women and men would most probably have had different experiences on the farms, and would also experience the WfW Programme differently; secondly, workers who have left WfW and their reasons for doing so need empirical attention; and finally, as this research has highlighted the importance of race, it is recommended that future research differentiates between the experiences of African and coloured workers, who are presumably positioned in very different ways in local labour markets. This may shape their experience of WfW, and their situation as prospective providers of services to white landowners.

A multi-stakeholder assessment of incentives and barriers to invasive plant management in the Western Cape

Without adequate private landowner involvement in the control of invasive alien plants, those plants tend to persist on the landscape and continuously reinvade cleared areas. To better understand how to effectively incentivise such private-landowner involvement, C•I•B core team members Dr Heidi Prozesky and Prof. Karen Esler, in collaboration with former PhD student Ms Lauren Urgenson, examined the perceptions of three sets of stakeholders – landowners in three study sites (Wilderness, Grabouw and Citrusdal), conservation professionals and WfW managers – regarding a proposed approach to clearing invasive alien plants on private land in the Western Cape Province.

The research found significant consensus among stakeholders concerning their preference for shared landowner and government responsibility and for a policy mix that combines financial incentives with regulations and motivational tools (Urgenson *et al.* 2013; *Ecology Society* 10 doi: 10.5751/ES-05259-180126). The research calls for an acknowledgement of the state's historical role in the introduction and spread of invasive alien plants, and led to the recommendation that invasive plant management should be integrated across public and private lands. As it was found that the perspectives of landowners were strongly associated with ecological and social features of the landscapes in which they are located, it was further recommended that incentives should target potentially greater costs, and ecosystem-services benefits, resulting from management in riparian compared to upland environments; and that a broader suite of ecosystem services important to landowners (i.e. wildlife habitat, wood resources) should be considered.

Furthermore, financial assistance needs to be flexible in order to respond to resource dynamics resulting from stochastic fire events, new and emerging invasive species and/or unanticipated variation in treatment response. For example, WfW's financial assistance could be linked to reduction in invasive alien plant distributions, thereby reducing landowners

concern that they could find their property 'back to square one' without any financial or logistic assistance from the state. This may result in landowners being more willing to manage invasive plants on their properties.

Landowners' willingness to work with WfW, as evinced by the study, opens the door for more effective management. However, there is a need to build trust through effective communication, establishing clear expectations and demonstrating successful outcomes on private land. Specifically, stakeholders identified the need to hire dedicated extension officers to assist WfW managers in this regard.

The challenges of alleviating poverty through ecological restoration

Public works programmes are government job-creation initiatives that use labour to create or restore public infrastructure, for example, roads, hospitals, and in some cases, ecological restoration of degraded land. They have been used for centuries throughout the world, and today are supported by large donors such as the World Bank. A commonly-cited example is South Africa's WfW programme which aims to create employment via the restoration of landscapes invaded with alien plants. The main source of WfW's funding comes from the Expanded Public Works Programme (EPWP), which is the primary provider of direct aid for South Africa's enormous working-age unemployed population (Fig. 20). Established in 2004, the EPWP's ambitious millennium development goal was to halve unemployment by 2015.

Public works programmes such as WfW are often viewed as win–win solutions for reaching goals for ecological restoration and poverty alleviation. However, little systematic research has been conducted to analyse the challenges of implementing such projects. C•I•B post-doctoral associate Dr Matthew McConnachie and co-workers interviewed 23 WfW managers about the challenges they face in meeting the programme's environmental and poverty alleviation objectives (McConnachie *et al.* 2013; *Rest Ecol*. 21: 544–550). They found that most managers mentioned challenges related to the capacity and competence of themselves and their teams, followed by challenges relating to planning and coordination, specifically the difficulties associated with being flexible and adaptive when constrained by operating procedures. Some managers also highlighted the challenges of maximizing short-term employment opportunities as part of EPWP's objectives whilst also trying to make a long-term difference to social and environmental outcomes.

Above all the study highlights the urgent need for evidence-based research on the social and environmental outcomes of public works programmes to provide policy-makers with options for improving the design and implementation of these important poverty-alleviation tools.

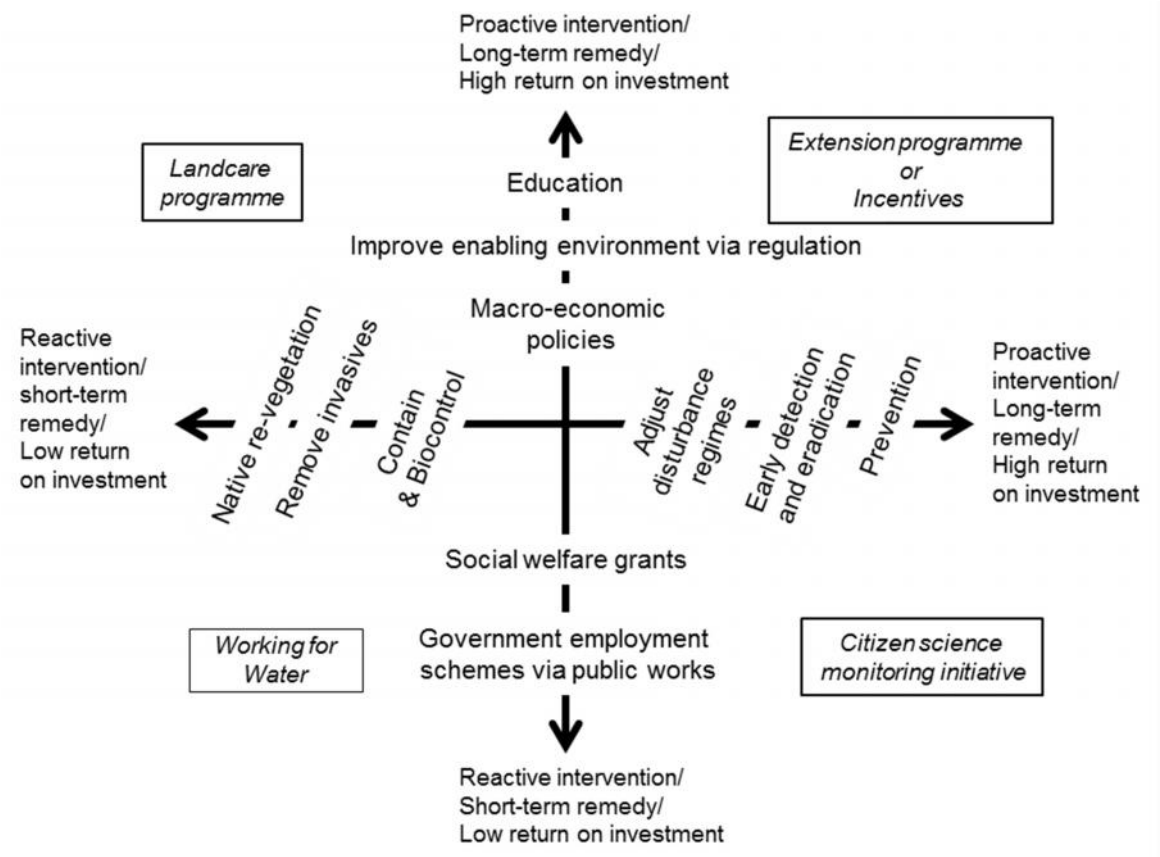

Fig 20. The spectrum of policy intervention options for the South African government to reduce poverty (x-axis) and the impact of invasive alien plants (y-axis). From McConnachie *et al.* 2013.

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 (and increasingly 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

2.2.1 Funding

During 2013 we successfully renewed our research collaboration on the *Integrated management of invasive alien species in South Africa* with the Department of Environmental Affairs' Environmental Programmes directorate (formerly WfW). This agreement provides for a five-year collaboration and the training of more than twenty post-graduate students and post-doctoral associates. The first students were recruited in 2013.

In 2013, the Stellenbosch University Hope Project grant awarded to the Centre in 2008 'Invasion biology in support of environmental sustainability during times of change' came to an end. The project, valued at R4 200 000 over 5 years, explored synergistic interactions between biological invasions and other forms of environmental change, mainly through post-graduate student projects. The C•I•B's Hope project supported five students, of which four graduated (two MScs and two PhDs), and one upgraded to a PhD in 2012 and is currently completing her project (see table below). Elsje Kleynhans and Helene Basson (MSc) both graduated *cum laude*. Together, the students and their advisors and collaborators produced 17 publications, with several more in preparation and under review.

C•I•B Hope projects for the period 2008 to2013

Student	Level	Project
Jessica Allen	PhD, upgraded, continuing	Examining the relative contributions of latitudinal variation and phenotypic plasticity to thermal tolerance in arthropods.
Helene Basson	MSc, completed (*cum laude*)	Thermal adaptation in the lizard *Cordylus oelofseni*: physiological and behavioural responses to temperature variation
Elsje Kleynhans	MSc, completed (*cum laude*)	The effects of climate on tsetse flies (Diptera: Glossinidae): from experimental physiology to biophysical distribution modelling
Candice Lyons	PhD, completed	Mechanistic modelling of two malaria vectors – *Anopheles arabiensis* and *A. funestus*
Natasha Mothapo	PhD, completed	Effects of biotic resistance and resource availability on the invasion success of the Argentine ant, *Linepithema humile*, in the Cape Floristic Region, South Africa.

2.2.2 Graduations

Since our inception in 2004, the C·I·B has graduated 192 students (via the degrees conferred by the students' host universities). Of these, 116 were female and 76 were male; 98 were black and 94 were white; 171 were South African and 21 were foreign. During the reporting year, four Honours, eight Masters and nine PhD students completed their degrees.

All post-doctoral associates students supported by the Centre are shown in Tables 7.2 and 7.3 respectively.

2.2.3 Employment

The whereabouts of some of these graduates are shown in the "Resources in the marketplace" table in Section 7.5.

2.2.4 Awards

The C•I•B student presentation awards for 2013 were presented at the Annual Research Meeting to PhD students Katelyn Faulkner (winner, title: "A simple method to develop watch lists for invasive species") and Terence Bellingan (runner up, title: "The effect of consecutive rotenone treatments on selected invertebrate fauna from the Rondegat River"), and MSc students Becky Shinner (winner, title: "Plasticity of temperature selection in the invasive ladybird *Harmonia axyridis*") and Asiashu Lithole (runner up, title: "Transmission dynamics and mathematical modelling of *Bartonella* in invasive *Rattus* from South Africa"). The presentations were evaluated by science advisor Prof. Anne Magurran (St. Andrews University, Scotland), research associate Prof. Petr Pyšek (Academy of Sciences of the Czech Republic) and keynote speaker Dr Christoph Kueffer (ETH-Zurich).

Winners of the C•I•B students travel awards, 2013

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 a substantial, and often unaffordable, cost.

3.2 Progress

3.2.1 Scientific communication with peers (including partners and students)

In November 2013 the C•I•B held a series of international workshops to increase our and our students and post-doctoral associates' exposure to the international research world. The events were held over a full week, from 25-29 November. A highlight of the workshops was the stature of the international guests they attracted, including Prof. Hugh MacIsaac (University of Windsor, Canada), Dr Tony Ricciardi (McGill University), as well as ten post-graduate students from four Canadian universities.

OBSERVATION AND ECOLOGY

The first two days were devoted to a workshop on Observation and Ecology and Wicked Problems at Lanzerac wine estate in Stellenbosch, the discussions on Observation and Ecology were led by Prof. Rafe Sagarin, marine ecologist at the Biosphere 2 and Institute of the Environment at University of Arizona and Dr Aníbal Pauchard, Professor of Forestry Science at the University of Concepción and Director of the Laboratory of Invasions in Biology (LIB). Fifty South African and international delegates attended the meeting, which allowed researchers and practitioners from around South Africa to discuss the ways in which invasion biology can be enhanced by observational techniques.

WICKED PROBLEMS IN ECOLOGY

This workshop, facilitated by Prof. Jannie Hofmeyr and Dr Rika Preiser from the Centre for Studies in Complexity at Stellenbosch University, considered the management of highly complex, context-dependent invasion problems in ecology and specially invasion biology. Fifty one delegates attending the workshop drew together diverse international expertise under the guidance of Dr Christoph Kueffer from the Institute of Integrative Biology at ETH, Zurich, Switzerland.

INVASION BIOLOGY IN AQUATIC AND TERRESTRIAL ECOSYSTEMS: SYNERGIES AND GAPS IN THEORY AND APPLICATIONS

Following these workshops, the C•I•B and CAISN post-doctoral researchers and students held a series of discussions on Invasion Biology in Aquatic and Terrestrial Ecosystems – Synergies and Gaps in Theory and Applications. This workshop, initiated and run by C•I•B and CAISN students and post-docs, and coordinated by C•I•B Research Associate and post-

doctoral associate, Dr Darragh Woodford, showcased the research of several emerging researchers and will be drawn together into a peer-reviewed publication by a small team of authors from South Africa and Canada.

The visitors brought considerable knowledge and experience to bear on the unique issues of aquatic invasions, and comparing these with what we have learned about terrestrial invasions. Whether marine or freshwater environments, water facilitates greater movement of organisms while often hindering our recognition of the extent of an invasion, requiring special tools yet supplemented and supported by approaches from land-based invasions. Forty six researchers compared and complemented approaches and theory from both types of ecosystems to synthesise new understanding. We anticipate that this event will generate important new international collaborations for our emerging researchers.

ANNUAL RESEARCH MEETING

The C•I•B's Annual Research Meeting was held on the last two days of the week, and brought together the C•I•B team from around South Africa, together with our science advisors Prof. Anne Magurran (St. Andrews University, UK), Prof. Petr Pyšek (Czech Academy of Sciences) and keynote speaker Dr Christoph Kueffer (ETH Zurich, Switzerland). Plenary talks from Dr Christoph Kueffer ('Invasion science: a model for ecological research in the Anthropocene?') and Prof. Mathieu Rouget, recently appointed core team member and SARChI Chair of Land Use Planning and Management (UKZN), provided further food for thought and discussion of the challenges the invasion biologists face in designing, conducting and implementing research that is often transdisciplinary.

The Annual Research Meeting allows us to showcase our research to peers and other interested parties, and the 2013 meeting was attended by 71 delegates, including government and industry leaders, students and post-docs, academics and supervisors. All C•I•B students at the masters and doctoral level presented their work in five-minute speed presentations, requiring the presenters to focus on the most pressing and persuasive aspects of their research. Four winners were selected by the international judges (Profs Magurran, Pyšek and Kueffer), and received substantial travel awards to enable them to travel to an international laboratory, conference or course (see Section 2.2.3).

WEB-BASED SERVICES

Information Retrieval and Submission System

The C·I·B's Information Retrieval and Submission System (IRSS) now contains a total of 1240 items, including 93 long-term project dataset, 892 core team member research outputs, 153 datasets and theses, and 102 post-doc and student outputs.

Web site

The C·I·B web site continues to provide a crucial avenue for the dissemination of research outputs and other interventions. Thirty two nuggets and six highlighted papers were posted on the web site in 2013. The site continues to draw readership, with a total of 77 149 visits (since April 2005). In the second half of the year, the web site had 234 unique visitors (SA: 100,

USA: 70, UK: 22, India: 12, Other: 30), 529 unique page views and an average visit duration of 2m 14s. Our page is accessed through search engines (64%), direct links (30%) and from other sites (6%).

Social media

During 2013, the C·I·B also ventured into the social media with the launch, in July, of our Facebook page. So far, we have 104 "likes", 34 posts have been submitted (7 by core team members) and an average of people 48 view each post. People who visit our page are 54% female; 41% male; most visitors are between the ages of 25 and 34.

3.2.2 Scientific communication with students

See 'Scientific communication with peers' above

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 2013 with key achievements including outreach visits to participating schools, learner workshops and educational and environmental expos. In March and October 2013, the project team paid outreach visits to 18 schools participating in the project. The aim of these schools outreach visits was to give learners a hands-on experience of biodiversity science and to involve them in the collection of environmental data that can be used in long-term monitoring of biodiversity. The project team first introduced the learners to the concept of biodiversity and the importance of ant diversity in the biomes of the Western Cape. The learners were showed how to perform the fieldwork before the group took to the schools grounds for the collection of ant data. At some of the schools, learners were able to join the project team to a nearby nature reserve or national park where they repeated the fieldwork. Learners could see the difference between habitats that have been disturbed by human activity (their school grounds) and areas that have no signs of disturbance (protected areas). This considerably improved their understanding of biodiversity and environmental change.

In addition to school visits, the project also hosted its 4th annual Iimbovane Winter Week from 9-12 July 2013 at Stellenbosch University. Winter Week is aimed at learners from schools belonging to the Iimbovane subscription programme (Sugar Ant schools) and brought together 20 learners from schools including Malibu High School (Blue Downs), Sarepta Secondary School (Kuilsrivier), Vredendal Secondary School (Vredendal), Hermanus High School (Hermanus), Atlantis High School (Atlantis) and Lavender Hill Secondary School (Cape Town). The five-day programme immersed learners in a series of lectures, interactive activities and field excursions. Field excursions exposed learners to a variety of ecosystems found in the Western Cape and introduced them to the biodiversity found in each ecosystem. Learners received also basic training in the use of scientific keys for the identification of insects, with a focus on ant groupings. The session on microscopy proved to be one of the

highlights of the week, as most learners have never had the opportunity to work on microscopes.

> *I really found the [Winter Week] field work informative because I saw what hard work it is to collect many different specimens and to do research. One of my favourite things during the week was the lab work and the microscope work. Our school does not have many microscopes and we do not get to work with them often, which are why it was so interesting to work with them last week. I also want to do forensic science and I love the possibility of just being in a lab and doing experiments all day. I think the week was very, very informative and I have learned new skills because I am not an outdoorsy person but I learned that I can do it and I can survive the elements and work under different types of conditions. I've also learned so many in the lab like learning how to identify different insects and the microscope to do so. I really am thankful for the opportunity.*
>
> Keisha Muller, Grade 10, Malibu High School, Blue Downs

Learners who attended the fourth annual Iimbovane Winter Week were trained in practical fieldwork techniques, laboratory experiments and in the use of microscopes to identify invertebrate species.

Expos and exhibitions

Iimbovane was also involved in a number of other training and science outreach initiatives, where the project team worked with learners and educators from non-participating schools. In April 2013 the Iimbovane Outreach Project hosted, in collaboration with the Table Mountain National Park's Environmental Education Programme, two workshops for a group of home-schooled learners, the Hoerikwaggo Kids Club. Both workshops took place at Cape Point's Visitors Centre and were attended by approximately 50 learners between 4 and 12 years. The team started with a practical session where learners had to memorise and point out the three main parts of an ant's body. Learners were shown a number of different species which they had to tell apart by using descriptive words. Learners were entertained with fascinating facts about ants, the life in an ant nest, ants relationships with other insects and the importance of ants in our ecosystems. In August 2013, the Western Cape Education Department (WCED) invited the Iimbovane Outreach Project to host a workshop at the annual WCED Science Expo for schools from the Overberg District. The workshop was to showcase different careers in science to Grade 10, 11 and 12 learners. The workshop gave attending learners and educators a view of "what it is to be a biodiversity scientist" and what such a career demands. In March 2013, the Iimbovane project team presented a workshop for the Grade 10 Life Science learners of Hermanus High School in Hermanus, as part of the school's annual Life Science camp. The purpose of the workshop was to give the learners practical experience using the scientific method, with a special focus on biodiversity science. Approximately 70 learners attended the workshop.

Another highlight was the donation of scientific equipment and classroom technology to five of the Iimbovane Sugar Ant schools. Funding from external funders, Rand Merchant Bank Fund and AfriSam, enabled the project to supply the Life Science classrooms of Sugar Ant schools with equipment that is essential for teaching Life Sciences. Equipment including stereomicroscopes and data projectors.

Iimbovane team member Olivia Fragale, shows learners how to identify ants using a stereomicroscope during a workshop presented at the Hermanus High School Life Sciences Camp (left), and C•I•B

Outreach Manager Dorette du Plessis, explains to a group of home-scholars the basics of ant morphology at the Cape Point's Visitors Centre (right).

The Iimbovane legacy

In 2013, it was showed that Iimbovane made a lasting impression on some of the learners who participated in Iimbovane during their school career. Three of the "old Iimbovane students" who were first years' in 2013 at the Stellenbosch University, took their involvement in Iimbovane further by acting as mentors at the 2013 Iimbovane Winter Week. The students were sharing their experiences about life as a university student with the learners attending the Winter Week. The students assisting as mentors were Samantha Witbooi (BSc Human Life Sciences), Janine Daniels (BSc Conservation Ecology) and Leonne Adams (BSc Conservation Ecology).

Janine Daniels, a former learner from Malibu High School in Blue Downs, described her decision to follow a degree in life sciences as follows: "Initially I wanted to study medicine. I attended the Iimbovane Winter week in 2010 and loved it so much that I went back in 2011! This is how I eventually knew that I would love to learn more about the environment we live in." Janine is currently studying for a BSc in Conservation Ecology at Stellenbosch University. "I realise that my dream will not be without its challenges, but going after your dreams, believing in yourself, never questioning your capability and looking beyond your circumstances are the things that will definitely move you forward."

Janine Daniels, a former learner from Malibu High School who is now a second year student (first year in 2013) at Stellenbosch University, shows Kayla Bennet, a Grade 10 learner at Malibu High School how to use a microscope during the 4th Iimbovane Winter Week.

3.2.5 Media highlights

The C•I•B's achievements in 2013 were well reported in the media. The full list of media mentions can be viewed in the Section 8.10; however, there are a few highlights that deserve special mention.

In October, a paper by C•I•B post-doctoral researcher Dr Mhairi Alexander and colleagues in the journal, *Neobiota* drew international media attention. The paper looked at the ability of native species to resist alien species. The research, which focussed on the interactions between native and invasive species, was covered in an online article on the *Science Daily* website.

The doctoral study of Ms Natasha Mothapo (advisor: Prof. Theresa Wossler) focused on the potential effects of invasive Argentine ants on fynbos ecosystems. Articles were published in the magazines such as *SA Fruit Journal* and *Landbouweekblad,* and the study further featured in local district and national newspapers such a *Bolander, Saturday Weekend Argus* and *Cape Argus*. In addition to print media, the study also appeared on websites such as *Independent Online Scitech* and the Facebook page of Invasive Species South Africa.

Iimbovane was once again well received by the media for the project's work with Life Science learners and educators. A paper comprising data collected by a joint effort of the Iimbovane scientists and learners has been the topic of articles in newspapers and popular science magazines such as *Public Sector Manager Magazine*, *Oudtshoorn Coerant*, *Suid Kaap Forum*, *Die Burger*, *Eikestadnuus* and *Tygerburger*. In addition to exposure in the print media, the project was also featured in online media on websites including *Eikestad News*, *Worcester Standard* and Facebook pages.

A paper by MSc Student Andrew Rogers, under the leadership of C•I•B Research Associate Prof. Steven Chown, has received media attention. The paper which was published in the journal *Diversity and Distributions*, found that Australian acacias transform the invaded ecosystem to such a degree that it can be classified as a 'novel ecosystem'. The study further examined the effects of novel ecosystems on bird diversity and led to an article in *Die Burger*. The complete list of media interactions appears in Section 8.10.

4 Networking

4.1 Objectives

We achieve 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

NEW NATIONAL NETWORKING AGREEMENTS

No new agreements were signed with new partners, but the C•I•B 's five-year research collaboration with the Department of Environmental Affairs' Working for Water Programme was renewed for the period 2013-2018 (see Section 2.2.1).

Partner and collaborating organisations of the C•I•B. Partnerships initiated or renewed during the reporting year are marked with an asterisk (*)

Partner organisations hosting one or more core team members
Stellenbosch University (the host institution)
University of Pretoria
University of Cape Town
University of Johannesburg
University of KwaZulu-Natal
University of Venda
City of Cape Town
CSIR
South African Institute for Aquatic Biodiversity
South African National Parks
South African National Biodiversity Institute

Collaborating organisations and organisations hosting Research Associates
Department of Environmental Affairs, Environmental Programmes *
ACAP (Agreement on the Conservation of Albatrosses and Petrels)
Austrian Environment Agency, University of Vienna *
Canadian Aquatic Invasive Species Network (II) *
Cape Peninsula University of Technology *
Cape Research Centre, SANParks
CapeNature *
City of Cape Town, Environmental Resource Management *
Institute for Biological Invasions, University of Tennessee
Laboratorio de Invasiones Biológicas (LIB), Universidad de Concepción *
Institute of Botany, Academy of Sciences of the Czech Republic *
Institute of Zoology, Zoological Society of London *
Iziko Museums of Cape Town
Monash University, Australia
Nelson Mandela Metropolitan University
SABONET
UNISA

Major funders and donors
Stellenbosch University and the Hope Project
Department of Science and Technology
National Research Foundation
AfriSam
Rand Merchant Bank Fund
The Drakenstein Trust

NEW INTERNATIONAL NETWORKING AGREEMENTS

CAISN, Canada

The NSERC Canadian Aquatic Invasive Species Network II is a network of researchers working on fresh water invasions in Canada, and has many parallels and shared experience with the C•I•B. During 2013, we signed a Memorandum of Understanding with CAISN. Interaction between researchers from CAISN and the C•I•B, and their students and post-doctoral associates has resulted in the formation of important new research collaborations for emerging researchers.

LIB, Chile

During 2013, the C•I•B signed a Memorandum of Understanding with the Laboratorio de Invasiones Biológicas (LIB) at the Universidad de Concepción, Chile. The mission of LIB is to increase knowledge of biological invasions in Chile, in order to reduce their impacts on natural ecosystems. Resulting from the collaboration agreement, the Director of LIB, Dr Aníbal Pauchard, together with Dr Rafe Sagarin (Institute of the Environment, University of Arizona) co-hosted a C•I•B workshop in Stellenbosch in November 2013.

4.2.2 Academic visitors to core team members

Erasmus University, International Institute of Social Studies (Environment and Sustainable Development). Prof. Bram Büscher (Prozesky)

Gothenburg University, Sweden, Department of Biological and Environmental Sciences. Prof. Staffan Andersson (Downs)

Great Lakes Laboratory for Fisheries and Aquatic, Fisheries and Oceans Canada. Nicholas Mandrak (Weyl)

International Institute for Applied Systems Analysis (IIASA), Austria. Dr Ulf Dieckmann (Hui)

Institut Mediterrani d'Estudis Avançats (CSIC-UIB), CSIC / Spanish Research Council, Terrestial Ecology Group, Spain. Dr Anna Traveset (Richardson)

McGill University, Department of Biology and McGill School of Environment, Montreal, Canada. Dr Brian Leung (Richardson)

McGill University, Department of Biology and McGill School of Environment, Montreal, Canada. Dr Anthony Ricciardi (Richardson)

Nelson Mandela Metropolitan University, School of Natural Resource Management, Sustainability Research Unit. Prof. Christo Fabricius (Foxcroft)

Norwegian University of Science and Technology, Trondheim, Norway, Department of Biology. Mr Craig Jackson (Robertson)

NSERC Canadian Aquatic Invasive Species Network II, Great Lakes Institute for Environmental Research, University of Windsor. Hugh MacIsaac (Weyl)

NSERC Canadian Aquatic Invasive Species Network II, Great Lakes Institute for Environmental Research, University of Windsor. Dan Heath (Weyl)

Queen's University Belfast, School of Biological Sciences. Prof. Jaimie T.A. Dick (Weyl)

Stony Brook University, Department of Ecology and Evolution, USA. Dr Jessica Gurevitch (Richardson)

Truman State University, USA, Department of Biology. Prof. Stephanie Fore (Downs)

Universidade Federal de Goiás, Conservation Biogeography Lab, Department of Ecology, Brazil. Dr Rafael Loyola (Richardson)

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

Université du Québec à Rimouski, Canada, Department of Biology. Ms Esmaella Raymond-Bourret, MSc student (Downs)

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 with Prof. Atte Moilanen, Dr Enrico Di Minin (Rouget)

University of Florida. Michael Allen (Weyl)

University of Illinois, USA, Agricultural and Biological Engineering; Prof. Alan Hansen (Downs)

University of Konstanz, Germany, Department of Biology. Ms Eva Malecore, MSc student (Downs)

University of Liverpool. Mr Tom Bishop (Robertson)

University of Melbourne, School of Land and Environment. Dr Dane Panetta(Wilson)

University of Nebraska, School of Natural Resources. Mark Pegg (Weyl)

University of Potsdam, Germany, Plant Ecology and Nature Conservation, Institute of Biochemistry and Biology. Mr Jörn Pagel (Esler)

University of Tartu, Estonia, Institute of Ecology and Earth Sciences. Dr Jesse Kalwij (Robertson)

University of Tartu, Estonia, Institute of Ecology and Earth Sciences. Dr Jesse Kalwij (van Vuuren)

University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, Canada; and NSERC Canadian Aquatic Invasive Species Network II. Prof. Hugh MacIsaac, Director (Richardson)

4.2.3 Academic visits by core team members to other institutions

Africa Museum, Terveuren, Belgium. Jos Snoeks on African fish and fisheries (Weyl)

Ecole Thématique sure les Invasions Biologiques (2013) 3-5 June, La Réunion (Presenter at a summer school on biological invasions) (Wilson)

Estación Biológica de Doñana (EBD-CSIC), Department of Integrative Ecology, Spain. Dr Pablo González Moreno (Richardson)

Helmholtz Centre for Environmental Research, Macroecology Group, Dept. Community Ecology, Germany. Dr Ingolf Kühn (Richardson)

Institut de Recherche pour le Développement (IRD), Montpellier, France. Sabbatical (Le Roux)

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

Laboratoire de Biogéographie et Ecologie des Vertébrés CEFE, Montpellier, France (van Vuuren)

Open University, The, Milton Keynes, UK, Department of Life Sciences. Prof. Jonathan Silvertown (Esler)

Purdue University, Entomology Department. Dr Grzegorz Buczkowski (Wossler)

South African Institute for Aquatic Biodiversity, Grahamstown, 2013. Drs Francesca Porri, Nikki James and Olaf Weyl (Clusella-Trullas)

University of Coimbra, Department of Life Sciences, Platform for Enhancing Ecological Research and Sustainability (PEERS), Centre for Functional Ecology, Portugal. Prof. Helena Freitas (Richardson)

University of Finland, Conservation Biology Informatics Group. Prof. Atte Moilanen, Dr Enrico Di Minin (Rouget)

University of Venda, Department of Biological Sciences. Dr Rod Baxter (Chimimba)

University of Venda, School of Mathematical and Natural Sciences. Dr Peter Taylor, SARChI Chair on Biodiversity Value and Change in the Vhembe Biosphere Reserve (Richardson)

Wageningen University, The Netherlands, Aquaculture and Fisheries Group. Leo Nagelkerke (Weyl)

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

Basson, Helene (MSc student), Travel award from the Society for Experimental Biology, July 2013, Valencia (Clusella-Trullas)

Esler, Prof. K.J., Wildlife Conservation Society (WCS) travel award to participate as a speaker in the meeting entitled “How will synthetic biology and conservation shape the future of nature”

Janse van Rensburg, M. (MSc student), C•I•B travel award for ‘Mathematics behind Biological Invasions’, held at the University of Alberta, Canada 27 May - 14 June (Hui)

Le Roux, Dr J.J., NRF-KIC travel award 2013 (Le Roux)

Le Roux, Dr J.J., Stellenbosch University Dean of Science travel award 2013 (Le Roux)

Munyai, T.C. visiting scientist – CSIRO, Tropical Ecosystem Research, Northern Territory, Darwin, Australia (August 2013 – September 2013). Collaboration with Prof. A.N. Andersen on ant functional groups (Foord)

Thabethe, V. to attend and present at ZSSA, July 2013 (Downs; Thabethe, V., Thompson, L., Hart, L., Brown, M., & Downs, C.T. 2013. Seasonal effects in the thermoregulation of invasive Rose-ringed parakeets (*Psittacula krameri*). Zoological Society of Southern Africa Conference, Limpopo)

4.2.5 Research collaborations

Adaptive dynamics. Collaboration: Dr Ulf Dieckmann, International Institute for Applied Systems Analysis (Hui)

Advancing impact prediction and hypothesis testing in invasion ecology using a comparative functional response approach. Collaboration: Prof. Jamie Dick, School of Biological Sciences, Queen's University Belfast (Richardson, Robinson)

Agricultural pest diversity and dynamics. Collaboration: Dr Zihua Zhao, Institute of Zoology, Chinese Academy of Science (Hui)

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

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

Bioclimatic modelling of invasive plant species. Dr Pablo Gonzalez-Morena, Estación Biológica de Doñana, Sevilla. Spain (Richardson)

Biodiversity and human evolution. Collaboration: Prof. Richard Cowling. Department of Botany, Nelson Mandela Metropolitan University, South Africa (Esler)

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

Biodiversity patterns. Collaboration: Prof. Melodie McGeoch, Monash University (Hui)

Carnivore Reintroduction Biology and effects on biodiversity, 2004-2013 – Collaborations: Micaela Szykman, Humboldt State University; Dave Wildt & Steve Monfort, Smithsonian Institute; Elisa Cameron, University of Tasmania, Kelly Marnewick, Endangered Wildlife Trust; Matt Hayward, Australian Wildlife Conservancy (Somers) *Chromolaena odorata* and biodiversity in Hluhluwe-iMfolozi Park, 2011 – Collaborations, Dr Kate Parr, Oxford University (Somers)

Conservation monitoring of otters in Europe and South Africa, 2011-2013: 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, Endandered Wildlife Trust (Somers)

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

Cumulative biodiversity debts: the cascading nature of change. Dr Franz Essl, Institute for Ecology, University of Vienna, Austria (Richardson, Wilson)

Defining impacts of invasive species. Dr Johnathan Jeschke, Technical University of Munich, Germany (Gaertner, Richardson)

Detection methods for rare fishes. Collaborations: Prof. Hugh MacIsaac and Dan Heath, NSERC Canadian Aquatic Invasive Species Network, Great Lakes Institute for Environmental Research, University of Windsor; and 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. Collaborations: Prof. Petr Pyšek, Department of Ecology, Charles University in Prague, Czech Republic, and Institute of Botany, Academy of Sciences of the Czech Republic (Foxcroft, Hui, Richardson)

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

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

Drought response in Fynbos. Collaboration: Dr Anna Jacobsen, Department of Biology, California State University Bakersfield, Bakersfield, CA, USA (Esler)

Ecological footprint and bio-capacity. Collaboration: Prof. Dongxia Yue, MOE Key Laboratory of Western China's Environmental Systems, Lanzhou University (Hui)

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

Ecology, genetics and physiology of Stegodyphus spiders, the: towards obtaining an understanding of the origins and consequences of sociality. Collaboration: Dr Michelle Greve, Dept. of Plant Science, Pretoria University, South Africa (Clusella-Trullas)

Ecosystem services. Collaboration: Dr Belinda Reyers, CSIR, Stellenbosch (Esler)

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

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

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

Global associations between plant breeding systems and ecology. Collaboration: Mark van Kleunen Institute of Plant Sciences, University of Bern, Altenbergrain 21, CH-3013 Bern Switzerland (Johnson)

Global environmental change - Invasive alien species in South African National Parks. Collaborations: Prof. Melodie McGeoch, Dr Di Spear and Dr Nicola van Wilgen, Cape Research Centre, SANParks, and Centre for Invasion Biology, Stellenbosch University (Foxcroft)

Historical, hybrid and novel ecosystems. Collaboration with Prof. Richard Hobbs, University of Western Australia (Richardson)

Impacts and benefits of alien fish introductions. Collaboration: Dr Leo Nagelkerke, Wageningen University, Aquaculture & Fisheries Group, Netherlands (Weyl)

Landscape genetic patterns in small mammal species. Collaboration: Dr Claudine Montgelard, Laboratoire de Biogéographie et Ecologie des Vertébrés CEFE, France (van Vuuren)

Locally invasive (= ‘domestic exotic’) amphibians of South Africa. Collaboration: Dr G. John Measey, Department of Zoology, Nelson Mandela Metropolitan University (Davies)

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

Overall research on *Rattus* in South Africa – Collaborations: 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)

Parasites of alien crab *Carcinus maenas*. Collaborations: Claudia Zetlmeisl and Trevor Petney, Universität Karlsruhe, Germany (Griffiths)

Pasture plants as invasive species - global trends. Dr Don Driscoll, Australian National University, Canberra (Richardson)

Physiological niches of invasive plants. Dr Steven Higgins, University of Otago, New Zealand (Richardson)

Post-fire regeneration in Fynbos. Collaboration: Dr Brandon Pratt, Department of Biology, California State University Bakersfield, Bakersfield, CA, USA (Esler)

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

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

Restoration of natural capital. Collaboration: Prof. James Blignaut. ASSET, Jabenzi, Beatus & Department of Economics, University of Pretoria (Esler, Gaertner)

Restoration of natural capital. Collaboration: Prof. Sue Milton. RENU KAROO, Prince Albert (Esler)

Restoration of natural capital. Collaboration: Dr David Le Maitre. CSIR, Environmentek, Stellenbosch (Esler)

Rose chafer beetle invasion in Europe. Collaboration: Dr Jakub Horak, Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague (Hui)

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

Small carnivores in space and time, 2012-2013: Emmanual do Linh San, University of fort Hare; Jerry Balant, Mississippi State University, USA; Dr Jun Sato, Fukuyama University, Japan (Somers)

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

Social parasitism within the Cape honeybees: Collaborations: Profs. Ben Oldroyd and Madeleine Beekman, School of Biological Sciences, University of Sydney, Australia and Mike Allsopp, Bee Research Unit, Plant Protection Research Institute, Agricultural Research Council (Wossler)

Soil ecosystem research grouping; research into South African soils. Collaboration: Prof. Schalk Louw, University of Free State (Davies, Wilson)

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

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

Temperature effects on ascidian tolerance and development. Collaboration: Dr Marc Rius, National Oceanography Centre, University of Southampton, UK (Clusella-Trullas)

Unified scheme for classifying alien species based on the magnitude of their environmental impacts, a. Prof. Tim Blackburn, Institute of Zoology, London, UK (Gaertner, Richardson)

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

5 Service provision

5.1 International panels and committees

6th Frugivore & Seed Dispersal International Symposium-St. Lucia, SA 2015: Chair (Downs, Richardson)

Adjunct Professor, Research School of Arid Environment & Climate Change, Lanzhou University (Hui)

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

GBIF Africa Science committee: Member (Rouget)

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

International Association for Biological Oceanography (IABO) South African National Representative (Griffiths)

IUCN Conifers Specialist Group Member (Richardson)

IUCN Invasive Species Specialist Group Member (Foxcroft, Richardson, van Wilgen, Wilson)

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

IUCN Red List assessment of the genus Anguillidae (Eels); (reviewer) (Weyl)

IUCN-SSC Otter Specialist Group: Member and Southern African Coordinator (Somers)

IUCN-SSC Pig, Peccary and Hippo Specialist Group: Member (Somers)

IUCN-SSC Re-introduction specialist Group: Member (Somers)

Mediterranean Research Managers International Cooperative: Member (Esler)

MPE Expert (in network science in ecology, environment, society, and finance), Mathematics of Planet Earth (MPE 2013), mpe2013.org (Hui)

Pan African Ornithological Congress Committee: Member (Downs)

5.2 National panels and committees

AfriOceans Conservation Alliance: board member (Griffiths)

Berg River Clearing and Rehabilitation Advisory Committee: Member/Technical Advisor (Esler)

Biodiversity Scientific Working Group, Dept. Environmental Affairs and Tourism: Member (Griffiths)

Cactus National Working Group Member; Alien Grasses National Working Group Member (Wilson)

CAPE Invasive Alien Animals Working Group. Member (Davies, Wilson)

Centre of Excellence at the Percy FitzPatrick Institute of Ornithology, University of Cape Town: Advisory board member (Chimimba)

Department of Agriculture Forestry and Fisheries review committee for the release of a biological control agent on invasive alien plant species in South Africa (reviewer) (Weyl)

Earth for Elephants working group: member, scientific advisors board (Somers)

Endangered Wildlife Trust - Healthy Rivers Programme: Panel of Experts (member) (Weyl)

Fynbos Forum Committee: Member (Esler)

Green Trust. Member, Board of Trustees (Chimimba)

Helderberg Nature Reserve Advisory Board committee member (Wossler)

HERS Advisory Board: Chair (Esler)

IUCN Wild Dog Advisory Group of South Africa: Member (Somers)

KZN Rhodes Scholarship Selection: Committee member (Downs)

National Invasive Alien Animal Forum (Alternate Member) (Wilson)

Research advisory panel for CSIR, Natural Resources and the Environment: Member (Rouget)

Research Advisory Panel, DEA Natural Resource Programmes (member) (Richardson, van Wilgen, Wilson)

SAEON Fynbos Node Liaison committee: Member (Esler)

Scientific Committee on Antarctic Research, Vice-chair of the South African National Committee (van Vuuren)

South African Data Centre for Oceanography (SADCO) 2004: board member (Griffiths)

South African Department of Agriculture, Forestry and Fisheries, Directorate Plant Health. Biological Control Agent Release Application: Reviewer (Foxcroft)

South African Department of Environmental Affairs, Environmental Programmes Branch; Ex-officio member of the Research Advisory Panel (Wilson)

South African Institute for Aquatic Biodiversity (SAIAB) 2012: advisory board member (Griffiths)

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

South African National Biodiversity Institute; Panel member for Permitting representing zoological diversity (van Vuuren)

Southern African Plant Invaders Atlas: Advisory board member (Robertson)

Table Mountain Fund Conservation Strategy advice committee: Member (Esler)

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

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

Working for Water National Invasive Alien Plant Survey Project Reference Group Member (Wilson)

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

Zoological Society of Southern Africa; Incoming President (van Vuuren)

5.3 Editorial and refereeing activities

5.3.1 Editor

BioInvasions Records (Wilson)
Diversity and Distributions (Editor-in-Chief) (Richardson)
Koedoe (Foxcroft)
Small Carnivore Conservation, Co-editor on Special African Edition (Somers)

5.3.2 Associate/Assistant Editor

African Entomology (Wossler)
African Journal of Aquatic Science (Weyl)
African Zoology (Weyl)
BioInvasions Records (Weyl)
Biological Invasions (Hui, Le Roux, Richardson)
Climate Change Responses (Terblanche)
Diversity and Distributions (Robertson) (Wilson)
Fire Ecology (van Wilgen)
Frontiers in Physiology (Terblanche)
Ibis (Downs)
International Journal of Wildland Fire (van Wilgen)
Koedoe. Associate Editor (Somers)
Mammalian Biology. Associate Editor (Somers)
Neobiota (Foxcroft, Richardson)
Ostrich (Downs)
PeerJ. Academic Editor (from June 2013) (Somers)
PloS ONE (Somers; resigned in June 2013)
South African Journal of Science (van Wilgen)
South African Journal of Wildlife Research (Somers)

5.3.3 Editorial Boards

African Natural History (Griffiths)
African Entomology (Terblanche)
African Zoology (Jansen van Vuuren)
Animals (Griffiths)
AoPlants (Richardson)
Applied Mathematics and Computational Sciences (Hui)
Arthropod-plant interactions (Johnson)
Austral Ecology (Clusella-Trullas)
Austral Entomology (Terblanche)
Diversity and Distributions (Roberston, Rouget, Wilson)
Environmental Development (Richardson)
Forest Ecosystems (Richardson)
Frontiers in Ecology and Evolution. Review Editor (Hui)
Frontiers in Invertebrate Physiology. Review editor (Clusella-Trullas)
International Journal of Wildland Fire (van Wilgen)

Journal of Fish Biology (Weyl)
Journal of Thermal Biology (Clusella-Trullas, Terblanche)
Koedoe (Griffiths)
Oecologia (Johnson)
Smithiana (Griffiths)
The Open Zoology Journal (Hui)
The Scientific World Journal (Hui)
Zookeys (Foord)

5.3.4 Reviewing

NATIONAL

African Entomology; *African Journal for 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 Geomatics*; *South African Journal of Science*; *South African Journal of Wildlife Research*; *Transactions of the Royal Society of South Africa*

Review of an application for a permit to release the seed-feeding weevil *Coelocephalapion gandolfoi* for biological control of invasive mesquite species (Prosopis species) in South Africa (van Wilgen).

INTERNATIONAL

Acta Herpetologica; *Acta Zoologica Cracoviensia*; *African Invertebrates*; *African Journal of Ecology*; *African Zoology*; *American Naturalist*; *Animal Biology*; *Annals of Botany*; *Aquatic Invasions*; *Auk*; *Austral Ecology*; *Biocontrol Science and Technology*; *Biodiversity and Conservation*; *Biofuels, Bioproducts and Biorefining*; *Biological Conservation*; *Biological Control*; *Biological Invasions*; *Biological Reviews*; *Bull. BOC*; *Canadian Journal of Zoology*; *Chinese Birds*; *Conservation Letters*; *Current Zoology*; *Diversity and Distributions*; *Ecological Entomology*; *Ecological Modelling*; *Ecological Monographs*; *Ecological Processes*; *Ecological Research*; *Ecology*; *Ecology Letters*; *Ecology & Society*; *Emu*; *Entomologia Experimentalis et Applicata*; *European Journal of Forest Research*; *Forest Ecology and Management*; *Forestry*; *Frontiers in Ecology and the Environment*; *Global Change Biology*; *Global Ecology and Biogeography*; *International Journal of Pest Management*; *International Journal for the Study of Social Arthropods*; *International Journal of Science Education*; *International Journal of Wildland Fire*; *Jordan Journal of Biological Sciences*; *Journal of Applied Ecology*; *Journal of Applied Geography*; *Journal of Biogeography*; *Journal of Ecology*; *Journal of Environmental Management*; *Journal of Evolutionary Biology*; *Journal of Experimental Biology*; *Journal of Experimental Marine Biodiversity Records Marine Biology Research*; *Journal of Herpetology*; *Journal of Horticulture and Forestry*; *Journal of Thermal Biology*; *Journal of Zoology (London), Pest Management Science*; *Management of Biological Invasions*; *Marine Biology and Ecology*; *Molecular Ecology*; *Naturwissenschaften*; *NeoBiota*; *New Phytologist*; *Oecologia*; *Parasites and Vectors*; *Physiological and Biochemistry Zoology*; *PloS ONE*; *Primate Conservation*; *Proceedings of the Royal Society B.*; *Raffles Bulletin of Zoology*; *Revista de Biología Marina*

y Oceanografía; *Tree Genetics and Genomes*; *Trends in Ecology and Evolution*; *Waterbirds*; *Zoomorphology*; *Zoological Studies*

5.3.5 Grant reviews for external bodies

Claude Leon Postdoctoral Applications (Jansen van Vuuren)

Economic and Social Research Council, United Kingdom, The. Peer Review of Grant Proposal (Esler)

European Co-operation in the Field of Science and Technology, COST – Switzerland. 4 proposals submitted for one research call (Wilson)

Fondation Pour La Recherche sur la Biodiversite (Switzerland). Review of proposal for modelling scenarios of biodiversity in Sub-Saharan Africa (van Wilgen)

National Geographic (Downs)

National Science Foundation (Downs)

University of Pretoria Promotions Committee (Jansen van Vuuren)

5.3.6 Appointment reviews and committees

Stellenbosch University: Lecturer appointment (Esler)

Stellenbosch University: Lecturer/Senior Lecturer appointment (Terblanche)

University of Ghana: Professorial Appointment (Chimimba)

University of Madagascar: External examiner for Professorship (Rouget)

University of Swaziland: External examiner for biological courses (Rouget)

5.3.7 Consulting and other services rendered

CONSULTANCY PRODUCTS

Blignaut, J., de Wit, M., Milton, S., Esler, K., Le Maitre, D., Mitchell, S., Crookes D. (eds). Determining the economic risk/return parameters for developing a market for ecosystem goods and services following the restoration of natural capital: a system dynamics approach. Volume 1: Main Report. WRC Report No. 1803/1/13 (Esler)

Risk assessment advice for the Department of Environmental Affairs

In 2013 the Centre completed its work on risk assessment of invasive species introductions for the Department of Environmental Affairs. The C•I•B was contracted in 2012 to compile guidelines for the assessment and evaluation of risk assessment for alien and invasive species. The final deliverable, submitted in February 2013, provided guidelines for pre-border risk assessments of alien species in South Africa, based on international experience. Different types of species-based risk assessments have been developed as part of global, multi-facetted programme to reduce problems associated with invasive species. Developments relating to species-based RAs for pre-border screening of alien species were discussed, and recommendations were made for practical risk assessments for implementation in South Africa. Our advice also included discussion of overarching considerations, such as the precautionary principle, and criteria for successful risk assessments from international best practice.

The researchers found that several issues require further attention or research before a practical risk assessment system can be implemented in South Africa. For example, climate matching or the level of similarity between the native and target ranges is a fundamental determinant of invasion risk. A range of climate-matching procedures are available for risk assessment, but each has its own advantages and disadvantages, and a key consideration is the ease of use and the reliability of outputs. In order to accurately assess risks, and particularly to assess relative risks of different species introductions, a standard system for the quantification of impacts is required. No such system currently exists for assessing the impacts of introduced species, and in any case it would have to be tailored for South African conditions. Risk communication is an important part of implementing a risk assessment system, and broad consultation would be needed within the stakeholder group in South Africa's complex legal and socio-political environment.

National Invasive Species Strategy and Action Plan (Department of Environmental Affairs)

During 2013 the C•I•B signed a sub-consultancy agreement with the (South African) Centre for Scientific and Industrial Research (CSIR) to assist with the production of a National Invasive Species Strategy and Action Plan for the Department of Environmental Affairs. The strategy is designed to help to achieve the goals of South Africa's National Development Plan as well as assist with the implementation of South Africa's legislation and policy relating to invasive species and their impacts on productivity and quality of life, especially the National Environmental Management: Biodiversity Act (Act No. 10 of 2004, NEM: BA). The strategy considers the management of alien species at four stages of invasion: initial introduction, establishment, expansion and dominance. In addition, it considers each of these stages in terms of managing species, or areas, or pathways of introduction and movement. The strategy aims to facilitate the achievement of four complimentary sub-objectives: to prevent the introduction of new species that could pose a risk of becoming invasive; to eradicate introduced species where possible and desirable; to reduce the rate of spread of invasions; and to reduce the impacts of existing invasions.

6 Gender impact of research

Gender equity forms a major theme underlying the C•I•B's activities, all of which are underpinned by the need to remain a leading research organisation in our field. One hundred percent of the C•I•B's administrative personnel, 100% of the outreach team, 56% of the student body, and 33% of the both our core team members, and Research Associates are female. Sixty percent of the Centre's graduates are women.

Much of our research for WfW has an underlying theme relating to gender and racial equity. For example, core team member Dr Heidi Prozesky's evaluation of the impacts of WfW has identified a number of important issues that should be considered in future research and in WfW's operations. Ongoing interaction with Working for Water through our research collaboration will encourage the uptake of research results in operations and priority-setting.

7 Human resources

7.1 Core team members

Core team members who worked with the Centre during 2013, including those who joined or resigned during the year

Name	Citizenship	Institution	Race	Gender	Time 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	20
Dr Susana Clusella-Trullas	Spain	SU	W	F	25
Prof. Colleen Downs	SA	UKZN	W	F	5
Prof. Karen Esler	SA	SU	W	F	30
Prof. Stefan Foord	SA	UniVen	W	M	50
Dr Llewellyn Foxcroft	SA	SANParks	W	M	20
Prof. Charles Griffiths	SA	UCT	W	M	10
Dr Cang Hui	China	SU	B	M	100
Prof. Bettine Jansen van Vuuren	SA	UJ	W	F	10
Prof. Steven Johnson	SA	UKZN	W	M	10
Dr Jaco le Roux	SA	SU	W	M	50
Dr Heidi Prozesky	SA	SU	W	F	10
Prof. Mark Robertson	SA	UP	W	M	20
Dr Tammy Robinson	SA	SU	W	F	15
Prof. Mathieu Rouget	France	UKZN	W	M	10
Prof. Michael Somers	SA	UP	W	M	10
Prof. Peter Taylor	SA	UniVen	W	M	5
Prof. John Terblanche	SA	SU	W	M	10
Prof. Brian van Wilgen	SA	CSIR	W	M	20
Dr Olaf Weyl	SA	SAIAB	W	M	20
Dr John Wilson	SA	SANBI	W	M	50
Prof. Theresa Wossler	SA	SU	W	F	15

7.2 Post-doctoral associates

Post-doctoral associates who worked in the Centre during 2013, 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 Brigitte Braschler	Switzerland	SU	W	F	Resigned
Dr Michelle Jackson	UK	UP	W	F	Continuing
Charlene Janion-Scheepers	SA	SU	W	F	Resigned
Dr Sabrina Kumschick	Switzerland	SU	W	F	Continuing
Dr Natasha Mavengere	Zimbabwe	SU	B	F	Resigned
Dr Matthew McConnachie	SA	CSIR	W	M	Continuing
Dr Ana Novoa Perez	Spain	SU	W	F	Continuing
Dr Vernon Visser	SA	SU	W	M	Continuing
Dr Feng Zhang	China	SU	B	M	Continuing
Dr Darragh Woodford	SA	SAIAB	W	M	Resigned

7.3 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

Name	Citizenship	Institution	Race	Gender	Status*	Funding level
Honours/4th Year						
Mr David Phair	SA	SU	W	M	Completed	Full
Ms Audrey Raidani	SA	UniVen	B	F	Pending	Full
Ms Thembelihle Mlokoti	SA	WSU	B	F	Resigned	Full
Ms Khensani Rakgalakane	SA	SU	B	F	Resigned	Full
Ms Khantse Serobe	SA	UFS	B	F	Resigned	Full
Mr Brent Abrahams	SA	SU	B	M	Completed	Full
Mr Vhuhwavho Gelebe	SA	UniVen	B	M	Completed	Full
Ms Michelle Jooste	SA	SU	W	F	Completed	Full
Masters						
Mr Stuart Barrow	SA	SAIAB	W	M	Continuing	Partial
Ms Helene Basson	SA	SU	W	F	Completed	Full
Ms Patricia Begwa	SA	NWU	B	F	Continuing	Full
Ms Laura Caetano	SA	SU	B	F	Continuing	Full
Ms Samantha De la Fontaine	SA	SU	B	F	Completed	Full
Mr Jason Donaldson	SA	SU	W	M	Completed	Full
Mr Brendon Dredge	SA	SAIAB	W	M	Continuing	Partial
Mr Muhamed Gardee	SA	SU	B	M	Pending	Full
Ms Enelge Gildenguys	SA	SU	W	F	Completed	Partial
Mr Stuart Hall	SA	SU	W	M	Continuing	Full

Name	Citizenship	Institution	Race	Gender	Status*	Funding level
Mr Brendan Havenga	SA	SU	W	M	Continuing	Full
Mr Llewellyn Jacobs	SA	SU	B	M	Continuing	Indep.
Ms Marinel Janse van Rensburg	SA	SU	W	F	Completed	Indep.
Ms Wilna Jansen	SA	UP	W	F	Pending	Full
Mr Jacques Jansen van Rensburg	SA	SU	W	M	Continuing	Indep.
Ms Rolanda Julius	SA	UP	B	F	Completed	Full
Ms Asiashu Lithole	SA	UP	B	F	Pending	Full
Ms Amy Liu	SA	SU	B	F	Pending	Full
Mr Rendani Mulaudzi	SA	SU	B	M	Resigned	Full
Mr Mashudu Mashau	SA	SU	B	M	Pending	Indep.
Ms Vanessa Matukana	SA	UniVen	B	F	Pending	Full
Mr Matthew Miles	SA	UKZN	W	M	Resigned	Full
Mr Vuledzani Mukwevho	SA	SU	B	M	Continuing	Full
Ms Haley Pope	USA	SU	W	F	Continuing	Indep.
Mr Luke Potgieter	SA	SU	W	M	Completed	Full
Mr Dylan Prentice	SA	UP	W	M	Resigned	Full
Ms Saachshaini Sadchatheeswaran	Canada	UCT	B	F	Continuing	Indep.
Ms Elsje Schreuder	SA	SU	W	F	Continuing	Full
Ms Azwinndini Sebola	SA	UniVen	B	F	Completed	Full
Mr George Sekonya	SA	SU	B	M	Resigned	Indep.
Mr Ross Shackleton	SA	SU	W	M	Continuing	Full
Ms Rebecca Shinner	UK	SU	W	F	Continuing	Indep.
Ms Daisy Thononda	SA	UniVen	B	F	Pending	Full
Mr Mark Turnbull	SA	UJ	W	M	Continuing	Full
Ms Kerry Ann Van der Walt	SA	SAIAB	W	F	Continuing	Partial
PhD-Upgrade						
Ms Jessica Allen	SA	SU	W	F	Continuing	Partial
PhD						
Mr Antoine Bahizi	Rwanda	SU	B	M	Continuing	Full
Mr Terence Bellingan	SA	RU	W	M	Continuing	Full
Mr Ryan Blanchard	SA	SU	B	M	Pending	Indep.
Ms Marguerite Blignaut	SA	SU	W	F	Resigned	Partial
Mr Emile Bredenhand	SA	SU	W	M	Completed	Full
Mr Chad Cheney	SA	SU	W	M	Continuing	Indep.
Mr Andrew Davies	SA	UP	W	M	Completed	Full
Ms Sarah Davies	SA	SU	W	F	Continuing	Full
Ms Katelyn Faulkner	SA	UP	W	F	Continuing	Indep.
Ms Tanya Haupt	SA	SU	B	F	Completed	Indep.
Ms Rolanda Julius	SA	UP	B	F	Continuing	Full
Ms Sandra MacFadyen	SA	SU	W	F	Continuing	Indep.
Mr Gregory McClelland	Canada	SU	W	M	Completed	Partial
Ms Mandisa Mgobozi	SA	UKZN	B	F	Pending	Partial
Ms Ingrid Minnaar	SA	SU	W	F	Continuing	Full
Ms Henintsoa Onivola Minoarivelo	Madagascar	SU	B	F	Continuing	Indep.

Name	Citizenship	Institution	Race	Gender	Status*	Funding level
Ms Desika Moodley	SA	UKZN	B	F	Continuing	Indep.
Dr Natasha Mothapo	SA	SU	B	F	Completed	Full
Mr Caswell Munyai	SA	UniVen	B	M	Pending	Full
Ms Joice Ndlovu	Zimbabwe	SU	B	F	Completed	Full
Ms Savannah Nuwagaba	Uganda	SU	B	F	Continuing	Indep.
Ms Unjinee Poonan	SA	Wits	B	F	Pending	Partial
Ms Andriamihaja Ramanantoanina	Madagascar	SU	B	F	Completed	Full
Mr Jeremy Shelton	SA	UCT	W	M	Completed	Full
Mr Matthys Strydom	SA	SU	W	M	Continuing	Full
Mr Matthew Zylstra	Australia	SU	W	M	Completed	Full

*Pending = student is working beyond the stipulated degree funding period but has not yet completed the degree.

7.4 Administrative staff

Staff who worked in the Centre in 2013, including those who resigned or completed their work 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 Ferreira	UP	Technical and Admin. Assistant	W	F
Ms Olivia Fragale	SU	Iimbovane Assistant	W	F
Ms Anel Garthwaite	SU	PA to the Director	W	F
Dr Mirijam Gaertner	SU	Eucalyptus Researcher	W	F
Ms Keafon Jumbam	SU	Iimbovane Technical Officer	B	F
Ms Megan Koordom	SU	Molecular Lab. Technical Assistant	B	F
Ms Thembile Khoza*	SU	Long Term Projects Technical Officer	B	F
Ms Suzaan Kritzinger-Klopper	SU	Senior Technical Officer	W	F
Mrs 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 Nortje	SU	Laboratory Manager	W	F
Ms Ria Olivier*	SU	Social Science Database Assistant	W	F
Ms Dora Scott*	SU	Antarctic Legacy Project Tech. Officer	W	F
Ms Mathilda van der Vyver	SU	Administrative Officer	W	F

Name	Institution	Position	Race	Gender
Staff employed by other organisations and hosted by the C•I•B:				
Dr Mirijam Gaertner	CoCT	Restoration Ecologist	W	F
Dr John Wilson	SANBI	Invasive Species Scientist	W	M

*These staff left the service of the Centre during the reporting year

7.5 Resources in the market place

C·I·B graduates and post-doctoral associates employed or engaged in subsequent activities

Graduate name	Level	Supervisor/host	Position/Organisation
Ms Helene Basson	MSc	Clusella-Trullas	NRF internship, UCT
Dr Brigitte Braschler	Post-Doc	Chown	Academic research assistant, Section for Conservation Biology, University of Basel, Switzerland
Dr Emile Bredenhand	PhD	Samways	Lecturer
Dr Tanya Haupt	PhD	Chown	Post-doctoral associate, Dept. Animal Science, SU
Dr Charlene Janion-Scheepers	PhD	Chown	Post-doctoral associate, School of Biological Sciences, Monash University, Australia
Ms Marinel Janse van Rensburg	MSc	Hui	Research Assistant, Oceanographic Research Institute / South African Association for Marine Biology Research
Dr Natasha Mothapo	PhD	Wossler	Post-doctoral associate, Dept. Botany and Zoology, SU
Dr Joice Ndlovu	PhD	Richardson	Lecturer, Chinhoyi University of Technology, Zimbabwe
Dr Jeremy Shelton	PhD	Samways/ Day	Freelance consultant

8 Outputs

8.1 Books

Dippenaar-Schoeman, A.S., Foord, S.H. and Haddad, C.H. (2013). *Spiders of the savanna biome*. Agricultural Research Council, Pretoria. 134 pp, ISBN: 978-1-86849-421-7

Foxcroft, L.C., Pyšek, P., Richardson, D.M. and Genovesi, P. (eds)(2013). *Plant invasions in protected areas: patterns, problems and challenges*. Springer, Berlin. 656 pp, ISBN: 978-94-007-7749-1

8.2 Book chapters

Andrew, N. and Terblanche, J.S. (2013). The responses of insects to climate change. In: *Living in a warmer world.* Salinger, J. (ed.) David Bateman and Co. Ltd, Auckland, New Zealand. pp. 38-50

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8.4 Published conference proceedings and abstracts

Beckett, S.E. and Prozesky, H.E. (2013). Hegemonic definitions from the "North": environmental concern as a western construct and its applicability to the South African and Antarctic context. In: *Exploring Linkages between Environmental Management and Value Systems: The Case of Antarctica.* University of Canterbury, Christchurch, New Zealand (eds. Liggett, D. and Hemmings, A.D.). *Exploring Antarctic values.* pp. 107-123.

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Geerts, S. and Pauw, A. (2013). Pollination structures plant and nectar-feeding bird communities in Cape Fynbos, South Africa. *South African Journal of Botany* **86**, 161-161.

Heystek, A., Geerts, S., Barnard, P. and Pauw, A. (2013). Flower colour preference of sunbird pollinators. *South African Journal of Botany* **86**, 160-160.

Mokotjomela, T.M., Musil, C.F. and Esler, K.J. (2013). Seed dispersal distances by frugivorous birds in the Cape Floristic Region: predicted distances and movement distributions from ring-recapture records. *South African Journal of Botany* **86**, 177-178.

8.5 Published conference abstracts

See Published conference proceedings above.

8.6 Products / artifacts / patents

None

8.7 Conferences / meetings attended

8.7.1 International plenary/keynote addresses

Esler, K.J. The practice of conservation and how it might be affected by synthetic biology: South African perspective. Synthetic Biology and Conservation, Clare College, Cambridge 9 – 11 April 2013. [Invited presentation on international panel.] (Esler)

Gildenhuys, E., Le Roux, J.J., Ellis, A.G. & Carroll, S.P. Home sweet home: resolving biogeographic uncertainties of invasive balloon vines in the genus *Cardiospermum*. 12th International Conference on the Ecology and Management of Alien Plant Invasions (EMAPi12), Pirenopolis, Brazil, September 2013. (Le Roux)

Le Roux, J.J. From molecules to landscapes: What can genes tell us about biological invasions? Insights from Australian acacias. Plenary address at the 12th International Conference on the Ecology and Management of Alien Plant Invasions (EMAPi12), Pirenopolis, Brazil, September 2013. (Le Roux)

Mavengere, N., Ellis, A.G. & Le Roux, J.J. Changes in mutualistic networks – the influence of invasive acacias on nitrogen-fixing symbiont diversity and its impact on native ecosystems. 12th International Conference on the Ecology and Management of Alien Plant Invasions (EMAPi12), Pirenopolis, Brazil, September 2013. (Le Roux)

Richardson, D.M. Aliens everywhere! Invasive species, novel ecosystems & ecosystem functioning in a changing world. Keynote address at launch the German Centre for Integrative Biodiversity Research (iDiv) – Symposium on Integrative Biodiversity Research, Leipzig, Germany, April 2013 (Richardson)

Richardson, D.M. Biological invasions - Invasive species in a changing world. Keynote address on Insights from the South Annual Research Conference, at Canadian Aquatic Invasive Species Network (CAISN) Kananaskis, Alberta, Canada, May 2013 (Richardson)

Richardson, D.M. Making science useful: invasive woody species as a case study. Presenter and Co-convenor of symposium on Biological invasions: how to reconcile science, management and policy at Intecol 2013, London, UK August 2013 (Richardson)

Terblanche, J.S. Physiological diversity in insects. President's Medal address at Society for Experimental Biology Annual Main Meeting, Valencia, Spain, July 2013. (Terblanche)

van Wilgen, B.W. (2013). Approaches to the management of pine invasions in South African fynbos shrublands. Southern Connections Conference, New Zealand, January 2013. (van Wilgen)

van Wilgen, B.W. (2013). Working for Water: Wonderful or Wicked? Wicked problems: A challenge for invasion science, Stellenbosch, November 2013. (van Wilgen)

Weyl, O.L.F. (2013). Managing alien fishes in South Africa. Plenary presentation at the Freshwater Invasives: Networking for Strategy conference, Galway, Ireland. 9-10 April, 2013. (Weyl)

8.7.2 National plenary/keynote addresses

Griffiths C.L. Marine biodiversity in South Africa – past present and future (Keynote address). Biodiversity Southern Africa. Cape Town November 2013

Downs, C.T. The importance of ecology and physiology in a changing world: Wahlberg´s epauletted Fruit Bat (Epomophorus wahlbergi) as an example. Plenary address at Zoological Society of Southern Africa Conference, Limpopo

Esler, K.J. Where collaboration counts: ecological restoration is best tackled by multi-disciplinary teams. Plenary address at Biodiversity SA 2013, University of Cape Town, December 2013

8.7.3 International oral contributions

Clusella-Trullas, S. Are there coherent patterns in thermal acclimation responses of ectotherms? Society for Experimental Biology conference, Valencia, Spain, 3-6 July 2013. (Clusella-Trullas)

Dippenaar-Schoeman, A.S., Lyle, R., Haddad, C.R., Foord, S.H., Lotz, L. The South African Survey of Arachnida (SANSA) – the way forward. 19th International Congress of Arachnology. Kenting National Park, Taiwan, Jun 23-28, 2013 (Foord)

Do Linh San, E., Sato, J.J., Belant J. & Somers, M.J. 2013. Small carnivores in space and time: an introduction and overview. 11th International Mammalogical Congress, Belfast, Ireland August 2013 (Somers)

Do Linh San, E., Fattebert, J. & Somers, M.J. 2013. Activity patterns of Cape grey mongooses: do sex, photoperiod and weather play a role? 11th International Mammalogical Congress, Belfast, Ireland August 3013 (Somers)

Downs, C.T., Awuah, A., Paine, C., Magagula, L., Mkhize, T., Raymond-Bourret, E. 2013. Effects of extreme hot days on the sleep behaviour and surface body temperature of Wahlberg's epauletted fruit bat. International Mammal Conference, Belfast, UK (Downs)

Egoh, B.E., Reyers, B., Rouget, M., O'Farrell, P.J., Le Maitre, D., Blignaut, J., Cowling, R. Identifying priority areas for ecosystem services management in South Africa. International Grassland Congress, Sydney, Australia, September 2013. (Rouget)

Faulkner K.T., Robertson M.P., Rouget M., Wilson J.R.U. A simple method to develop 'watch lists' for invasive species. 12th Meeting on the Ecology and Management of Alien Plant Invasions, Pirenópolis, Goiás, Brazil, 22-26 Sep 2013. (Wilson)

Foord, S.H., and Dippenaar-Schoeman, A.S. Drivers of spider diversity along an altitudinal transect in a floristic kingdom sensitive to climate change. 19th International Congress of Arachnology. Kenting National Park, Taiwan, Jun 23-28, 2013 (Foord)

Foxcroft, L.C., Pyšek, P. Richardson, D.M., Pergl, J. & Hulme, P.E. The bottom line: impacts of alien plant invasions in protected areas. 12th Ecology and Management of Alien Plant Invasions (EMAPI) conference, Pirenópolis, Brazil, September 2013. (Foxcroft)

Haddad, C.R., Dippenaar-Schoeman, A.S., Foord, S.H., Lotz, L., Lyle, R. The faunistic diversity of spiders (Arachnida: Araneae) of the Grassland Biome in South Africa. 19th International Congress of Arachnology. Kenting National Park, Taiwan, Jun 23-28, 2013 (Foord)

Hill, J.M., Jones, R.W., Weyl, O.L.F. & Hill, M.P. (2013). Community Dynamics of an Invaded Ecosystem: Preliminary Investigation of a *Pterygoplichthys disjunctivus* Invasion. The 18th International Conference on Aquatic Invasive Species (ICAIS), Niagara Falls, Ontario, Canada. (April 21-25th 2013). (Weyl)

Impson, D., Weyl, O.L.F. & Woodford, D. (2013). Rehabilitation of a Freshwater Ecosystem Priority River in South Africa using a piscicide to kill alien smallmouth bass. Pan African Fish and Fisheries Assosciation (PAFFA 5) Bujumbura, Burundi 16-20 September 2013. (Weyl)

Isaacs, L., Swanepoel, L. & Somers, M.J. African civet density in a mosaic of land uses in South Africa. 11th International Mammalogical Congress. Belfast, UK, August 2013 (Somers)

Le Roux, J.J. What makes some species invasive and others not? Université de La Réunion – Summer School on Biological Invasions. Le Tampon, La Réunion, June 2013. (Le Roux)

Mannetti, L., Esler, K., Zeller, U. (2013) Evaluating social-ecological aspects of edge effects and land-use conflict at the borders of Etosha National Park, Namibia. WILD10: 10th World Wilderness Congress. Salamanca, Spain, 4-10 October 2013. (Esler)

Mavengere, N.R, Ellis, A.G and Le Roux, J.J. Changes in mutualistic networks – the influence of invasive acacias on nitrogen-fixing symbiont diversity and its impact on native ecosystems. Sixth International Legume Conference, Johannesburg, January 2013. (Le Roux)

Nanni I., Wilson J.R.U., Ivey P., Manyama P. A new national unit for invasive species detection, post-border risk assessment, and eradication planning in South Africa. 12th Meeting on the Ecology and Management of Alien Plant Invasions, Pirenópolis, Goiás, Brazil, 22-26 Sep 2013 (Wilson)

Nottebrock, H., Schmid, B., Esler, K.J., Böhning-Gaese, K., Schleuning, M., Pagel, J., Schurr, F. Predicting plant fecundity from spatiotemporal variation in sugar landscapes. 34rd Annual Meeting of the Ecological Society of Germany, Austria and Switzerland. Potsdam, Germany, 9-13 September 2013. (Esler)

Ntshotsho, P., Esler, K.J.E., Prozesky, H.E. & Reyers, B. (2013). What drives the use of scientific evidence in invasive alien plant management? A case of the South African Working for Water program. Society for Ecological Restoration's 5th World Conference on Ecological Restoration: Reflections on the past, directions for the future. Wisconsin, October 2013. (Prozesky)

Prozesky, H.E. (2013). In the eye of the beholder: Researching the social aspects of invasive alien species as wicked problems. Wicked problems: A challenge for invasion science, Stellenbosch, November 2013. (Prozesky)

Ramesh, T. & Downs, C.T. 2013. Effect of farmland use on population density and activity patterns serval. International Mammal Conference, Belfast, UK (Downs)

Richardson, D.M. (Re)defining the impact of alien species. Ecology and Management of Alien Plant Invasions (EMAPi) 12th International Conference, September 2013, Pirenopolis, Brazil. (Richardson)

Robertson, M.P. Proactive approaches for identifying and managing invasive species in a changing world. Third international workshop of the Global Challenges University Alliance, Swedish University of Agricultural Sciences, 4-6 September 2013. Uppsala, Sweden (Robertson)

Rouget, M. Novel ecosystems in South Africa: geographic extent, value and conservation implications. Interdisciplinary German - South African Symposium on Socio-ecological novelty, Berlin, Germany, March 2013. (Rouget)

Rouget, M., Roberts, D., Cockburn, J., *et al.* Developing a partnership bridging the science-policy divide to plan and manage for a threatened ecosystem: the case of eThekwini Municipality, Durban, South Africa. Ecosystem Services Partnership Conference, Bali, Indonesia, September 2013 (Rouget)

Ruis, M., Clusella-Trullas, S., McQuaid C.D., Navarro, R.A., Griffiths, C.L., Matthee, C.A., von der Heyden, S., Turon, X. Range expansions of tunicate fauna across ecoregions: interactions of climate change, physiology and genetic diversity. 7th Tunicate Meeting, Naples Italy, July 2013 (Griffiths)

Rius M., Clusella-Trullas, S., McQuaid C.D., Navarro R.A., Griffiths C.L., Matthee C.A., von der Heyden S. & Turon X. Range expansions of tunicate fauna across ecoregions: interactions of climate change, physiology and genetic diversity. 7th International Tunicate Meeting, 22-26 July, Naples, Italy. (Clusella-Trullas)

Singels E., Esler K.J. & Cowling R.M. Geophytes on the Agulhas plain: a foraging model. 10th Conference on Hunter Gatherer Communities, Liverpool, United Kingdom, 24-27 July 2013. (Esler)

Schurr, F., Nottebrock, H., Schmid, B., Esler, K.J., Böhning-Gaese, K., Schleuning, M., Pagel, J. Towards a trait-based understanding of interactions in species-rich plant communities. 34rd Annual Meeting of the Ecological Society of Germany, Austria and Switzerland. Potsdam, Germany, 9-13 September 2013. (Esler)

Treurnicht, M., Pagel, J., Esler, K.J., Schurr, F. (2013) Climatic drivers of range-wide variation in the demography of serotinous South African (Fynbos) Proteaceae. Predicting plant fecundity from spatiotemporal variation in sugar landscapes. 34rd Annual Meeting of the Ecological Society of Germany, Austria and Switzerland. Potsdam, Germany, 9-13 September 2013. (Esler)

Weyl, O.L.F., Nagelkerke, L.A.J., Ellender, B., Kinghorn, J., Snowball, J., Britz, P., Evans, C., Gambiza, J., McHugh, K., & Smit, N. (2013). Assessing ecological impacts and socio-economic benefits of alien fish introductions: a case study of the Amatola trout. Pan African Fish and Fisheries Association (PAFFA 5) Bujumbura, Burundi 16-20 September 2013. (Weyl)

Widdows, C. & Downs, C.T. 2013. Ecology of large spotted genets (Genetta tigrina) in an urban environment. International Mammal Conference, Belfast, UK (Downs)

Wilson J.R., Caplat P., Dickie I.A., Hui, C., Maxwell B.D., Nuñez M.A., Pauchard A., Rejmánek M., Richardson D.M., Robertson M.P., Spear D., Webber B.L., Van Wilgen B.W., Zenni R.D. A standardized set of metrics to assess and monitor tree invasions. 12th Meeting on the Ecology and Management of Alien Plant Invasions, Pirenópolis, Goiás, Brazil, 22-26 Sep 2013 (Wilson)

Wilson, J. R. Managing invasive plants—how much information do we need? An International Workshop on Observation and Ecology, Lanzerac Hotel, Stellenbosch, 25-26 Nov 2013 (Wilson)

8.7.4 National oral contributions

Bellingan, T., Villet, M., Weyl, O.L.F. (2013). Can we detect impacts of trout in small mountain streams by examining invertebrate communities using a multivariate approach? Southern African Society of Aquatic Scientists Conference, Arniston, South Africa, 30 June - 4 July. (Weyl)

Coetzer, R., Perrin, M.R., Downs, C.T., Willows-Munro, S. 2013. The use of microsatellites to address taxonomic and illegal trade in Cape Parrots (*Poicephalus robustus*) (Downs)

Coetzer, R., Perrin, M.R., Downs, C.T., Willows-Munro, S. 2013. Cape Parrot genetics. Zoological Society of Southern Africa Conference, Limpopo (Downs)

Do Linh San, E., Ferguson, A.W., Belant, J.L., Schipper, J., Hoffman, M., Gaubert, P., Angelici, F.M., & Somers, M.J. 2013. Conservation status of small carnivores in Africa. Zoological Society of South Africa Symposium, Tshipise, South Africa, July 2013 (Somers)

Esler, K.J. (2013) Where collaboration counts: assessing the impact of ecological restoration though payment for environmental services. Frontiers in Social-Ecological Research Symposium, Kirstenbosch, Cape Town, April 2013. (Esler)

Faulkner, K., Robertson, M., Rouget, M., Wilson, J. A simple method to develop 'watch lists' for invasive species. 41st Annual Symposium on Management of Invasive Alien Plants, Cape St Francis Resort, May 2013 (Wilson)

Foord, S.H., Dippenaar-Schoeman, A.S. Drivers of epigeal spider diversity along an altitudinal transect in a floristic kingdom sensitive to climate change. The Zoological Society of Southern Africa, 2013 Biennial Symposium. Tshipise, Forever Resort, South Africa, 14-17 July, 2013 (Foord)

Foxcroft, L.C., Pyšek, P. Richardson, D.M., Pergl, J. & Hulme, P.E. (2013) The bottom line: impacts of alien plant invasions in protected areas. 41st Annual Symposium on Management of Invasive Alien Plants, Cape St. Francis, May 2013. (Foxcroft)

Geerts, S., Botha, P.W., Visser, V., Richardson, D.M., Le Roux, J.J., Mavengere, N., and Wilson, J.R.U. Why do French (*Genista monspessulana*) and Spanish brooms (*Spartium junceum*) not sweep across South Africa? South African Association of Botanists - Annual meeting 2013, Bergville. January 2013. (Le Roux)

Griffiths, C.L. Alien and invasive animals in South Africa – patterns and impacts. ZSSA Conference: Biodiversity Value and Change, Thsipise July 2013 (Griffiths)

Hall, S, Holmes, P.M., Gaertner, M., Esler, K.J. (2013) Restoration potential of alien-invaded Cape Flats Sand Fynbos at Blaauberg Nature Reserve. Fynbos Forum, Kirstenbosch, October 2013. (Esler)

Jacobs, L., Richardson, D., Wilson, J. Invasive potential of Melaleuca parvistaminea in South Africa and the need to assess invasive potential of dry-seeded Myrtaceae. 41st Annual Symposium on Management of Invasive Alien Plants, Cape St Francis Resort, May 2013 (Wilson)

Jacobs, S., Naude, M., Slabbert, E., Kambaj, O., Fourie, M., Esler, K.J., Jacobs, K., Mantlana, B., Rozanov, A, Cowan, D. (2013) Fynbos riparian function and invasive alien Acacias: does removal restore function? Fynbos Forum, Kirstenbosch, October 2013. (Esler)

McPherson, S., Brown, M., & Downs, C.T. 2013. The Ecology of Urban Crowned Eagles of KwaZulu-Natal. Zoological Society of Southern Africa Conference, Limpopo (Downs)

Munyai, T.C and Foord, S.H. Ant thermal tolerance and behavioural dominance along an altitudinal transect in the Savanna biome: towards a functional classification. 11th Annual Savannah Network Meeting, 03-08 March 2013, Kruger National Park Skukuza (Foord)

Munyai, T.C., Foord, S.H. Ant thermal tolerance and behavioural dominance along an altitudinal transect in the Savanna Biome: towards a functional classification. The Zoological Society of Southern Africa, 2013 Biennial Symposium. Tshipise, Forever Resort, South Africa, 14-17 July, 2013 (Foord)

Munyai, T.C. and S.H. Foord (2013) Ant thermal tolerance and behavioural dominance along an altitudinal transect in the savanna biome: towards a functional classification. Biodiversity Southern Africa, 02 – 07 December 2013 University of Cape Town, Cape Town (Foord)

Mzumara, T., Perrin, M.R., & Downs, C.T. 2013. Distribution of Lilian's lovebirds in Malawi: The role of water availability and vegetation type. Zoological Society of Southern Africa Conference, Limpopo (Downs)

Pfeiffer, M., Venter, J., & Downs, C.T. 2013. Investigations of the complex human-wildlife interactions of the Cape Vulture in the former Transkei, South Africa. Zoological Society of Southern Africa Conference, Limpopo (Downs)

Pfeiffer, M., Venter, J., and Downs, C.T. 2013. Community perceptions of the Cape Vulture in the Mkambati Nature Reserve, Eastern Cape Province. Endangered Wildlife Trust Symposium, Limpopo (Downs)

Ramesh, T. & Downs, C.T. 2013. Effect of farmland use on population density and activity patterns serval. Zoological Society of Southern Africa Conference, Limpopo (Downs)

Robertson, M.P., Bishop, T.R., van Rensburg, B.J., Parr, C. 2013. Ant diversity across an altitudinal gradient in the Drakensberg. 18th Congress of the Entomological Society of Southern Africa. 30 June - 3 July 2013, Potchefstroom (Robertson)

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

Rouget, M., Roberts, D., Cockburn, J., *et al.* Managing threatened ecosystems in urban environments: Implementation of a science-action partnership. Symposium of Contemporary Conservation Practice, Howick, South Africa, November 2013. (Rouget)

Schoeman, C.S. & Foord, S.H. Deciding on an appropriate scale for conservation activities: partitioning alpha and beta ant diversity in North-West Province, South Africa (Formicidae: Hymenoptera). The Zoological Society of Southern Africa, 2013 Biennial Symposium. Tshipise, Forever Resort, South Africa, 14-17 July, 2013 (Foord)

Simba, L.D., Foord, S.H., Seymour, C. The role of natural vegetation as a source of pollinators, pests and pest control in mango (*Mangifera indica*, Anacardiaceae) orchards, in North-Eastern South Africa. The Zoological Society of Southern Africa,

2013 Biennial Symposium. Tshipise, Forever Resort, South Africa, 14-17 July, 2013 (Foord)

Singh, P. & Downs, C.T. 2013. Hadedas in the hood: Hadeda Ibis (*Bostrychia hagedash*) activity in suburban neighbourhoods of Pietermaritzburg, KwaZulu-Natal, South Africa. Zoological Society of Southern Africa Conference, Limpopo (Downs)

Sandberg, R., Allsopp, N., Bond, W.J., Esler, K.J. (2013) Community response of plants and birds to habitat fragmentation: looking to fynbos islands for direction. Fynbos Forum, Kirstenbosch, October 2013. (Esler)

Taylor, G., Weyl, O.L.F. & Cowley, P.D. (2013). Post-capture dispersal and mortality of tournament captured largemouth bass *Micropterus salmoides* in a South African impoundment. Southern African Society of Aquatic Scientists Conference, Arniston, South Africa, 30 June - 4 July. (Weyl)

Terblanche, R. & Prozesky, H.E. (2013). Propagating environmental knowledge: A case study of learners as catalysts. South African Sociological Association – Annual congress 2013, Pretoria, July 2013 (Prozesky)

Thabethe, V., Thompson, L., Hart, L., Brown, M., & Downs, C.T. 2013. Seasonal effects in the thermoregulation of invasive Rose-ringed parakeets (*Psittacula krameri*). Zoological Society of Southern Africa Conference, Limpopo (Downs).

Thompson, L., Brown, M., & Downs, C.T. 2013. Seasonal variation in metabolic rate of Cape White-eyes, *Zosterops pallidus*. Zoological Society of Southern Africa Conference, Limpopo (Downs)

Widdows, C. & Downs, C.T. 2013. Ecology of large spotted genets (*Genetta tigrina*) in an urban environment. Zoological Society of Southern Africa Conference, Limpopo (Downs)

Zungu, M.M. & Downs, C.T. 2013. The role of ethanol in fruit selection by frugivores. Zoological Society of Southern Africa Conference, Limpopo (Downs)

Zylstra, M., Esler, K.J., Knight, A.T., Le Grange, LL. (2013) Connectedness as a core conservation concern. Fynbos Forum, Kirstenbosch, October 2013. (Esler)

Vardien, W., Richardson, W.D., Foxcroft, L.C., Wilson, J.R.U. & Le Roux, J.J. (2013) Management history determines gene flow in a prominent invader: *Lantana camara* L. (sensu lato) in the Kruger National Park, South Africa. 11th Savanna Science Network Meeting (March 2013). (Foxcroft)

Visser, V., Wilson, J. Alien grasses: The current local perspective and forming a National Working Group on Alien Grasses. 41st Annual Symposium on Management of Invasive Alien Plants, Cape St Francis Resort, May 2013 (Wilson)

Weyl, O.L.F. (2013) Managing alien fishes in South Africa. Southern African Society of Aquatic Scientists Conference, Arniston, Western Cape, South Africa, 30 June - 4 July. (Weyl)

Wilson, J. R. A standardized set of metrics to assess and monitor tree invasions. 41st Annual Symposium on Management of Invasive Alien Plants, Cape St Francis Resort, May 2013 (Wilson)

Woodford, D.J., Hui, C., Weyl, O.L.F. & Richardson, D.M. (2013). Inter-basin water transfer schemes and the threat of fish invasions: a water management conundrum. Southern

African Society of Aquatic Scientists Conference, Arniston, South Africa, 30 June - 4 July (Weyl)

8.7.5 International posters

Basson, H.C. & Clusella-Trullas, S. Physiological and behavioural compensation in lizards depend on thermal history. Society for Experimental Biology conference, Valencia, Spain, 3-6 July 2013. (Clusella-Trullas)

Boardman, L., Sørensen, J.G., Grout, T.G., Terblanche, J.S. Cross tolerance between modified atmospheres and low temperature in insects. Society for Integrative and Comparative Biology Annual Meeting, San Francisco, USA, January 2013. (Terblanche)

Le Bourgeois, T., Foxcroft, L.C., Thompson, D.I., Guezou, A., Grard, P., Taylor, R.W, Marshall, T. & Carrara, A. PL@NTINVASIVE-KRUGER: computer-based identification and information tools to manage alien invasive plants the Kruger National Park, South Africa. 12th Ecology and Management of Alien Plant Invasions (EMAPI) conference, Pirenópolis, Brazil, September 2013. (Foxcroft)

Melin, A., Rouget, M., Difford M., Midgley J. & Donaldson, J. Understanding the landscape requirements for pollination services derived from managed honeybees. European Congress of the International Association for Landscape Ecology, Manchester, United Kingdom, September 2013. (Rouget)

Woodford, D.J., Hui, C., Weyl, O.L.F. & Richardson, D.M. (2013) The danger of inter-basin water transfer schemes in driving alien fish establishment. Freshwater Invasives: Networking for Strategy conference, Galway, Ireland. 9-10 April, 2013. (Weyl)

8.7.6 National posters

Peters, K, Griffiths C.L. & Robinson, T.B. Patterns and drivers of marine alien species in Western Cape harbours. Biodiversity Southern Africa. Cape Town, November 2013 (Griffiths)

Peters, K., Griffiths, C.L. & Robinson, T.B. Patterns and drivers of marine bioinvasions in eight Western Cape harbours. Biodiversity Southern Africa, Cape Town, South Africa, December 2013. (Robinson)

Pope, H.R, Robinson, T.B. The spread of the alien barnacle, *Balanus glandula*, along the west coast of South Africa. Biodiversity Southern Africa, Cape Town, South Africa, December 2013. (Robinson)

Sadchatheeswaran, S., Branch, G.M., Robinson, T.B. From Bungalows to Skyscrapers: sequential invasions change rocky shore community. Biodiversity South Africa, Cape Town, South Africa, December 2013. (Robinson)

8.8 Other relevant outputs

8.8.1 Popular articles and talks

ARTICLES

Anonymous. 2013. Battle of the ants affecting fynbos, study finds. *SA Fruit Journal*, August 2013, pp. 49

Anonymous. 2013. More work needed to curb spread of invasive species – expert. *The Water Wheel*, January 2013, pp. 6.

Do Linh San, E. & Somers, M.J. 2013. Editorial: African small carnivores: the "forgotten Eden." *Small Carnivore Conservation* 48, 1–3

Downs, C.T. & Hart, L. 2013. Joining the dots for Cape Parrots. Why conservation of networks of forests is important for the Cape Parrot. *Birdlife IBA Programme Newsletter*, Autumn 2013

Karsten, M., Jansen van Vuuren, B., Barnaud, A. & Terblanche, J.S. 2013. Genetic markers suggest invasive medfly is highly mobile in South Africa. *Fruit Fly News*. February 2013, pp. 2

Kriel, G. 2013. Argentynse miere bedreig fynbos, veroorsaak plantsiektes. *Landbouweekblad*, Julie 2013, pp. 8

Murugan, S. 2013. Young scientist is growing an army of ant researchers. *Public Sector Manager Magazine*, October 2013, pp. 32.

Somers, M.J. 2013. Mentorship for young scientists. A book review on 'Wilson, E.O. 2013. Letters to a Young Scientist, Liveright.' *South African Journal of Science* 109, pp. 1.

TALKS

Downs, C.T. Cape parrot conservation. KZN Bird Forum, Wildlife and Environment Society of Southern Africa, Howick, February 2013

Downs, C.T. Cape parrot conservation. SANParks Honorary Officers, Pietermaritzburg, April 2013

Downs, C.T. Highlights from Tanzania. St Alpheges Church, Pietermaritzburg, July 2013

Downs, C.T. Overview of research. Girl Guides Association, Hilton, November 2013

Downs, C.T. The importance of ecology and physiology in a changing world: Wahlberg´s epauletted Fruit Bat (Epomophorus wahlbergi) as an example. Royal Society of Southern Africa, Pietermaritzburg, October 2013

Esler, K.J. Where collaboration counts: assessing the impact of ecological restoration though payment for environmental services. Invited Talk at Open University, Milton-Keynes, United Kingdom, April 2013

Esler, K.J. Where collaboration counts: assessing the impact of ecological restoration though payment for environmental services. Invited Talk at Biological Sciences, University of Zimbabwe, Zimbabwe, June 2013

Foxcroft, L.C. Invasive alien species: research and management in Kruger National Park. Organisation for Tropical Studies, Skukuza, Kruger National Park, February 2013

Foxcroft, L.C. Invasive alien species: research and management in Kruger National Park. Organisation for Tropical Studies, Skukuza, Kruger National Park, September 2013

Mothapo, N.P. Clever invasive ants. Voices in Science, Maties Diversity week, October 2014

Weyl, O.L.F. Alien fishes as conflict species. Public lecture presented at KU Leuven, Belgium, October 2013

Weyl, O.L.F. Aquaculture in Sub-Saharan aquaculture: the good and the bad. Public lectures presented KAHO-Roeselare, Belgium, October 2013

Weyl, O.L.F. Aquaculture in Sub-Saharan aquaculture: the good and the bad. Public lectures presented KAHO Sint-Niklaas, Belgium, October 2013

Weyl, O.L.F. Bass research and management. Cape Town, Western Cape Bass Angling Association, March 2013

Weyl, O.L.F. Evaluating fish and macro-invertebrate recovery rates in the Rondegat River. Western Cape CAPE IAA Working Group meeting, CAPE Research Center, Tokai, May 2013

Weyl, O.L.F. Impacts of alien fish in the Cape Floristic Region and the need for integrated management. CapeNature, Head Office, May 2013

Weyl, O.L.F. Invasive alien smallmouth bass in the Rondegat stream: impacts, efficiency of removal and future prospects. Western Cape Bass Angling Association, March 2013

Weyl, O.L.F. Managing alien fishes in South Africa. University of Fort Hare, Alice, June 2013

Weyl, O.L.F. Managing Alien Invasive fishes in the Cape Floristic Region. Public lecture presented at KU Leuven, Belgium, October 2013

Weyl, O.L.F. Setting a precedent for river rehabilitation by alien fish removal: fish and macro-invertebrate responses. South African Institute for Aquatic Biodiversity, June 2013

Weyl, O.L.F. Setting a precedent for river rehabilitation by alien fish removal: fish and macro-invertebrate responses. Nelson Mandela Metropolitan University, June 2013

Weyl, O.L.F. Using multiple information sources to make sense of fish invasions. Observation and ecology workshop, Lanzerac Hotel, Stellenbosch. November 2013.

Wilson, J. Alien vegetation and alien eradication. Friends of the Tygerberg Hills, Cape Town, Sep 2013

8.9 NRF Service Provision

8.9.1 Rating and project proposal reviews

Focus Area - Conservation and Management of Ecosystems and Biodiversity (Downs)

Focus Area – Environmental and Earth Sciences: PhD proposal reviews (Terblanche)

Integrated Biodiversity Information Programme (van Vuuren)

Rating: conduct assessment of rating application (1) (Le Roux)

Rating application review (1) (Griffiths)

Rating applications (1) (van Vuuren)

Rating applications (2) (van Wilgen)

Rating reviews (3) Richardson

Rating review (1) (Robertson)

Rating review (1) (Somers)

Review of the application for renewing the SARChI chair in Marine ecology and Fisheries (Robinson)

Thuthuka Social Sciences Panel: grant application/annual progress report reviews (10) (Prozesky)

8.9.2 Panel and committee service

Integrated Biodiversity Information Programme (van Vuuren)

Plant sciences rating panel (Johnson)

SEAChange Panel Member (Griffiths)

8.10 Media interactions

8.10.1 Newspaper articles

Anonymous . 2013. Fezikile-leerders help met navorsing. *Oudtshoorn Coerant*, 7 Julie 2013

Anonymous . 2013. Leerders dra by tot wetenskaplike publikasie oor miere. *Suid Kaap Forum*, 31 Mei 2013

Anonymous . 2013. Miere nou onder die projekmikroskoop. *Tygerburger* (Eersterivier/Blue Downs), 29 Mei 2013

Anonymous . 2013. Vredendal leerders ontvang mikroskope vir skool. *Ons Kontrei*, 17 Mei 2013

Anonymous. 2013. Battle of Argentine ants. Bolander, 9 May 2013.

Anonymous. 2013. Worcester pupils trap ants for a science project. *Worcester Standard*, 6 June 2013

Esler, K.J. 2013. Creating ecological consciousness. *Bolander*, 27 November 2013

Esler, K.J. 2013. We can be champions of our natural environment: a mindset change will put us on the right eco-path. *Cape Argus*, 30 July 2013

Griffiths, C. 2013. Changing marine life. *Envirokids* 34(3), August 2013

Griffiths C 2013. Ocean change and people. *Envirokids* 34(3), August 2013

Van Den Berg, S. 2013. Stellenbosch youth inspires nationally. *Eikestadnuus*, 4 Julie 2013

Venter, M. 2013. US maak verskil in Afrika. *Die Burger*, 7 Junie 2013

Foerie-Basson, W. 2013. Bykans 22m. voëls op Kaapse Vlakte. *Die Burger* (Oos Kaap, Buite), 5 November 2013

Witness reporter. 2013. Graduate makes it against all odds. *The Witness*. April 2013

Witness reporter. 2013. Help varsity count those noisy mynas. *The Witness*. October 2013

Yeld, J. 2013. Xenophobia justified in the ant kingdom. *Cape Argus*, May 2013

Yeld, J. 2013. Xenophobia justified in the ant kingdom. *Saturday Weekend Argus*, 4 May 2013

8.10.2 Newsletters

8.10.3 Articles published by Stellenbosch University

ELECTRONIC RESOURCES

Anonymous, 2013. Predators vs. alien: european shrimps win predatory battles with an american invader. Science Daily, [online] 11 October 2013. Available at: <http://www.sciencedaily.com/releases/2013/10/131011135336.htm> [Accessed on 23 October 2013]

Anoniem, 2013. Leerders dra by tot wetenskaplike publikasie oor miere. Suid Kaap Forum, [online] 30 Mei 2013. Beskikbaar by: <http://www.suidkaapforum.com/news.aspx?id=54291&h=Leerders-dra-by-tot-wetenskaplike-publikasie-oor-miere> [Toegang verkry 4 Junie 2013]

Anoniem, 2013. Vredendal leerders ontvang mikroskope vir skool. Ons Kontrei Streekskoerant Facebook, [online] 16 Mei 2013. Beskikbaar by: <www.facebook.com/pages/Ons-Kontrei-Streekskoerant/173748722722056> [Toegang verkry 27 Mei 2013]

Anoniem, 2013. Vredendal leerders ontvang mikroskope vir skool. Ons Kontrei Streekskoerant, [online] 16 Mei 2013. Beskikbaar by: < http: //www.onskontrei.co.za/2013/05/16/vredendal-leerders-ontvang-mikroskope-vir-skool/> [Toegang verkry 22 Mei 2013]

Anonymous, 2013. Argentine ants a threat to fynbos plant species. Invasive Species South Africa Facebook, [online] 14 May 2013. Available at: < https: //www.facebook.com/#!/media/set/?set=a.455946757823598.1073741836.222820744469535&type=1> [Accessed on 12 February 2014]

Anonymous, 2013. The 41st Annual Symposium on Management of Invasive Alien Plants. Invasive Species South Africa Facebook, [online] 10 July 2013. Available at: < https: //www.facebook.com/#!/media/set/?set=a.481841495234124.1073741856.222820744469535&type=1> [Accessed on 12 February 2014]

Anonymous, 2013. National Invasive Species Strategy and Action Plan Workshop. Invasive Species South Africa Facebook, [online] 22 January 2013. Available at: < http: //www.invasives.org.za/item/423-national-strategy-for-invasive-species.html> [Accessed on 12 February 2014]

Anonymous. 2013. Worcester pupils trap ants for a science project. Worcester Standard [online] 6 June 2013. Available at: < http: //www.worcesterstandard.com/articles/articledetails.aspx?id=67160> [Accessed on 30 May 2013]

Anonymous, 2013. National strategy for invasive species. Invasive Species South Africa website, [online]. Available at: < https: //www.facebook.com/#!/media/set/?set=a.405424949542446.97773.222820744469535&type=1> [Accessed on 12 February 2014]

Anonymous, 2013. The 41st Annual Symposium on management of invasive alien plants. Invasive Species South Africa website, [online]. Available at: < http: //www.invasives.org.za/item/465-the-41st-annual-symposium-on-management-of-invasive-alien-plants.html> [Accessed on 12 February 2014]

Anonymous, 2013. National strategy for invasive cactus. Invasive Species South Africa website, [online]. Available at: < http: //www.invasives.org.za/item/455-national-strategy-for-invasive-cactus.html> [Accessed on 12 February 2014]

Anonymous, 2013. Alien and invasive animals. Invasive Species South Africa Facebook, [online] 27 April 2013. Available at: < https: //www.facebook.com/#!/invasivespeciessouthafrica?fref=ts> [Accessed on 12 February 2014]

Basson-Foerie, W. 2013. Western Cape learners contribute to scientific publication about ants. SU News, [online] 05 May 2013. Available at: <http: //www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=127> [Accessed on 15 May 2013]

Basson-Foerie, W. & Viljoen, M. 2013. SU staff members feature in Mail & Guardian 200 Young South Africans list. SU News, [online] 14 June 2013. Available at: <http: //www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=745>[Accessed on 10 September 2013]

Basson-Foerie, W. 2013. Major investment in SA's research capacity to combat invasive species. SU News, [online] 28 November 2013. Available at: <http: //www.sun.ac.za/english/Lists/news/DispForm.aspx?ID=1129/>[Accessed on 5 December 2013]

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RADIO AND TELEVISION

Le Roux, J.J. Interview on Radio Sonder Grense (Ekoforum) concerning novel ecosystems, October 2013

Pepler, D. Interview on Radio Sonder Grense (Tjailatyd), Dink Groen, August 2013

Pepler, D. Interview on Radio Sonder Grense (Tjailatyd), Dink Groen, November 2013

9 Stage progress

Progress according to Service Level Agreement No. 5 of 5 (2012-2014).
2013 was the second year of Stage 5

TIMEFRAMES

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

Two CoE Advisory Board (virtual or real) meetings should take place per annum during this Stage, typically during March and November of each year

2012: Board meetings were held on 15 March and 1 November
2013: Board meetings were held on 28 March and 17 October

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

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

FINANCIAL RESPONSIBILITIES

The CoE shall present an audited set of financial statements annually at the March Advisory Board meeting reflecting the financial situation of the CoE during the previous financial year

2012: Audited statements were presented to and approved by the C•I•B Board on 28 March 2013
2013: Draft financial statements for 2013 will be presented to the Board on 26 March 2014

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

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 Advisory Board

2012: The annual progress report for 2012 was presented to and approved by the C•I•B Board on 28 March 2013

2013: Draft annual progress report for 2013 will be presented to the Board on 26 March 2014

The CoE shall submit a Statement of Compliance by no later than March 2015 referring to Stage 5

To be submitted in 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

Woman students ⩾ 50% of all students on average per annum

2012: 55% (50 women)

2013: 58% (51 women)

Black students ⩾ 50% of all students on average per annum

2012: 56% (51 students)

2013: 47% (41students)

Number of social science students ⩾ 2 on average per annum

2012: 2

2013: 2

Average duration of submitted Masters degrees (post Honours) ⩽ 2.5 years at end of stage

2012: 3.5 years

2013: 2.5 years

Average duration of submitted PhD degrees (post Masters) ⩽ 3.5 years at end of stage

2012: 4.2 years

2013: 4.7years

Average duration of submitted PhD degrees (upgraded from Masters) ⩽ 5 years at end of stage

2012: 4.6 years

2013: No upgrades completed

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

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

Number of patents ⩾ 1
2012: None
2013: None

Number of peer reviewed publications ⩾ 60 on average per annum
2012: 103
2013: 135

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

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

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)

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

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

Number of local conferences organized ⩾ 1 at end of stage
2012: 1 (Workshop on ‘Rapid Response, Early Detection, and Risk Assessment of Invasive Alien Species’, Wallenberg Centre, Stellenbosch, South Africa, August 2012)
2013: None

Number of international conferences organized ⩾ 1 at end of stage
2012: 1 (Tree Invasion Workshop, Bariloche, Argentina, September 2012)
2013: 2 (Observation and Ecology, including Wicked Problems, 25-26 November, 2013; and Invasion Biology in Aquatic and Terrestrial Ecosystems: Synergies and Gaps in Theory and Applications, 27 November 2013)

SPECIAL OUTPUT TARGETS FOR THE CURRENT STAGE
At least one full CoE team activity per annum
2012: Annual Research Meeting held on 15-16 November (one CTM did not attend)
2013: Mid-year Core Team Member Meeting held 6-7 August, 2013(4 CTMs unable to attend); Annual Research Meeting held on 28-29 November (5 CTMs did not attend)

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)

10 Conclusion
The C·I·B showed exceptional performance in all its Key Performance Areas during 2013, It is widely recognized internationally as one of the top research organizations in the field of invasion ecology.

11 Finances
Audited financial statements provided by PriceWaterhouse Coopers (attached).

DST / NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

ANNUAL FINANCIAL STATEMENTS - 31 DECEMBER 2013

DST / NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

ANNUAL FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 DECEMBER 2013

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

.....

.....2014
DATE

DST / NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF FINANCIAL POSITION AT 31 DECEMBER 2013

	Notes	2013 R	2012 Restated R	2011 Restated R
ASSETS				
NON-CURRENT ASSETS		797 022.45	753 377.45	1 048 787.48
Equipment and vehicles	2	797 022.45	753 377.45	1 048 787.48
CURRENT ASSETS		6 583 091.20	5 178 167.32	2 675 214.12
Trade and other receivables	3	2 299.65	256 569.65	37 602.62
Stellenbosch University	4	6 580 791.55	4 921 597.67	2 637 611.50
TOTAL ASSETS		**7 380 113.65**	**5 931 544.77**	**3 724 001.60**
EQUITY AND LIABILITIES				
CAPITAL AND RESERVES		6 958 353.69	5 740 427.03	3 323 139.21
Accumulated funds		6 958 353.69	5 740 427.03	3 323 139.21
CURRENT LIABILITIES		421 759.96	191 117.74	400 862.39
Trade and other payables	5	421 759.96	191 117.74	400 862.39
TOTAL FUNDS AND LIABILITIES		**7 380 113.65**	**5 931 544.77**	**3 724 001.60**

DST / NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF COMPREHENSIVE INCOME FOR THE YEAR ENDED 31 DECEMBER 2013

	Notes	2013	2012 Restated	2011 Restated
		R	R	R
Revenue		8 501 834.00	8 096 985.00	7 767 276.00
Other income		1 982 097.50	4 661 232.77	5 160 496.48
Operating expenses	7	(9 593 334.80)	(10 573 502.33)	(12 476 915.12)
Operating loss		890 596.70	2 184 715.44	450 857.36
Finance income		327 543.94	236 126.29	214 060.90
Finance cost		(213.98)	(3 553.91)	(351.82)
Surplus for the year		1 217 926.66	2 417 287.82	664 566.44
Other comprehensive income		-	-	-
Total comprehensive income for the year		1 217 926.66	2 417 287.82	664 566.44

DST / NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF CHANGES IN EQUITY FOR THE YEAR ENDED 31 DECEMBER 2013

	2013 R	2012 Restated R	2011 Restated R
ACCUMULATED FUNDS			
At the beginning of the year	5 740 427.03	3 323 139.21	2 658 572.77
Total comprehensive income for the year	1 217 926.66	2 417 287.82	664 566.44
At the end of the year	**6 958 353.69**	**5 740 427.03**	**3 323 139.21**

DST / NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

STATEMENT OF CASH FLOWS FOR THE YEAR ENDED 31 DECEMBER 2013

	2013 R	2012 Restated R	2011 Restated R
CASH FLOWS FROM OPERATING ACTIVITIES			
Net surplus for the year	1 217 926.66	2 417 287.82	664 566.44
Adjustment for:			
Interest received	(327 543.94)	(236 126.29)	(214 060.90)
Interest paid	213.98	3 553.91	351.82
Exchange rate loss	-	-	-
Depreciation	334 058.60	367 871.31	428 463.97
(Profit)/Loss on sale of equipment and vehicles	(53 508.73)	74 060.26	(62 955.73)
Operating profit before working capital adjustments	1 171 146.57	2 626 647.01	816 365.60
Working capital adjustments	484 912.22	(428 711.68)	112 257.73
Decrease/(Increase) in trade and other receivables	254 270.00	(218 967.03)	69 933.23
Increase/(Decrease) in trade and other payables	230 642.22	(209 744.65)	42 324.50
Cash generated from operations	1 656 058.79	2 197 935.33	928 623.33
Interest received	327 543.94	236 126.29	214 060.90
Interest paid	(213.98)	(3 553.91)	(351.82)
NET CASH FLOWS FROM OPERATING ACTIVITIES	1 983 388.75	2 430 507.71	1 142 332.41
CASH FLOWS FROM INVESTMENT ACTIVITIES			
Equipment and vehicles purchased	(488 317.87)	(146 521.54)	(543 713.87)
Proceeds on the sale of fixed assets	164 123.00	-	63 155.00
Increase in amount owed by Stellenbosch University	(1 659 193.88)	(2 283 986.17)	(661 773.54)
NET CASH FLOWS FROM INVESTMENT ACTIVITIES	(1 983 388.75)	(2 430 507.71)	(1 142 332.41)
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 2013

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 2014 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 2015)
IFRS 9 – Financial Instruments (2010) (1 January 2015)
Amendments to IFRS 9 – Financial Instruments (2011) (1 January 2015)
Amendments to IAS 32 – Financial Instruments: Presentation (1 January 2014)
Amendment to IAS 39 on novation of derivatives (1 January 2014)
Amendments to IAS 36, 'Impairment of assets' (1 January 2014)
Amendments to IFRS 10, consolidated financial statements', IFRS 12 and IAS 27 for investment entities (1 January 2014)

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 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)
31 December 2012			
Carrying amount at the beginning of the year	711 057.03	337 730.45	1 048 787.48
Cost	2 672 959.92	432 535.56	3 105 495.48
Accumulated depreciation	(1 961 902.89)	(94 805.11)	(2 056 708.00)
Additions during the year	146 521.54	-	146 521.54
Transfers	-	-	-
Cost	276 593.24	-	276 593.24
Accumulated depreciation	(276 593.24)	-	(276 593.24)
Disposals	(74 060.26)	-	(74 060.26)
Cost	(156 280.91)	-	(156 280.91)
Accumulated depreciation	82 220.65	-	82 220.65
Depreciation for the year	(257 629.26)	(110 242.05)	(367 871.31)
Carrying amount at the end 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)

3. TRADE AND OTHER RECEIVABLES

	2013 R	2012 R
Trade receivables	-	254 270.00
Other	2 299.65	2 299.65
	2 299.65	256 569.65
The ageing of these receivables are as follows:		
Up to 2 months	2 299.65	254 270.00
2 to 6 months	-	-
	2 299.65	254 270.00

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 2013 was 5.10% (2012: 7.00%). The loan has no fixed terms of repayment.

	2013 R	2012 R
5. TRADE AND OTHER PAYABLES		
Leave pay provision	127 709.46	106 331.74
Other creditors	40 838.00	32 072.40
Income received in advance	201 485.00	-
Provision for audit fees	51 727.50	52 713.60
	421 759.96	191 117.74

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	51 727.50	52 713.60
Depreciation	334 058.60	367 871.31
Salaries	4 332 830.02	5 374 618.97
Team member research cost	3 877 242.14	3 659 748.92
Other	997 690.52	1 122 103.44
	9 593 548.78	10 577 056.24

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 2013 and 2012, if the interest rate had been 100 basis points higher/lower and all other variables held con-stant, the centre's profit/(loss) would have increased/decreased as a result of interest received on loans by R65 807.92 (2012: R46 783.99). The other financial instruments are not exposed to interest rate risk.

8. FINANCIAL INSTRUMENTS (continued)

Fair values

At 31 December 2013 and 2012 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 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	-	-
31 December 2012					
Trade and other payables	191 117.74	191 117.74	191 117.74	-	-
Net financial liabilities	191 117.74	191 117.74	191 117.74	-	-

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.

9. RESTATEMENT OF COMPARITIVE FIGURES

Comparative financial statements have been restated to account for the Vehicle Fleet cost centre (VP72). This cost centre was created in 2011. Monthly payments are made to this Vehicle Fleet cost centre (and these were previously recognised as expenses in the annual financial statements). These accummulated funds in VP72 is used to pay expenses related to the vehicles owned by the centre. Unused funds is managed by the centre, it can either be used to fund future vehicle purchases, or it can be realised and utilised elswhere for the centre activities. The effect of the restatement is summarised below.

	Previously reported	Currently reported	Difference
	R	R	R
Income statement			
31 December 2012			
Other income	4 661 232.77	4 661 232.77	-
Expenditure	(10 648 967.61)	(10 573 502.33)	(75 465.28)
Interest received	226 450.36	236 126.29	(9 675.93)
31 December 2011			
Other income	5 260 496.48	5 160 496.48	100 000.00
Expenditure	(12 728 912.09)	(12 476 915.12)	(251 996.97)
Interest received	208 000.12	214 060.90	(6 060.78)
Statement of financial position			
31 December 2012			
Current Assets	4 934 968.36	5 178 167.32	(243 198.96)
Capital and Reserves	5 497 228.07	5 740 427.03	(243 198.96)
31 December 2011			
Current Assets	2 517 156.37	2 675 214.12	(158 057.75)
Capital and Reserves	3 165 081.46	3 323 139.21	(158 057.75)

DST / NRF CENTRE OF EXCELLENCE FOR INVASION BIOLOGY

DETAIL INCOME STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2013

	2013 R	2012 R	2011 R
INCOME	10 811 475.44	12 994 344.06	13 141 833.38
National Research Foundation grant	8 501 834.00	8 096 985.00	7 767 276.00
Other income	1 928 588.77	4 734 502.26	5 096 662.36
Interest received	327 543.94	236 126.29	214 060.90
Foreign exchange profit	-	790.77	878.39
Profit/(Loss) on sale of equipment	53 508.73	(74 060.26)	62 955.73
EXPENDITURE	9 593 548.78	10 577 056.24	12 477 266.94
Operational expenses	5 260 718.76	5 202 437.27	6 768 701.74
Advertisements	104 798.57	61 745.89	22 214.38
Audit fees - current year	51 727.50	52 713.60	53 985.00
- previous year over provision	-	(4 719.90)	-
Consumables	35 549.87	57 751.69	91 661.58
Copying and stationery	57 377.94	56 012.54	28 650.73
Depreciation	334 058.60	367 871.31	428 463.97
Entertainment	55 524.32	6 738.90	6 172.41
Interest paid	213.98	3 553.91	351.82
Insurance	3 600.00	2 266.11	3 389.48
Indirect cost recovery	28 618.98	111 121.59	150 940.58
Membership and affiliation fees	14 921.80	57 898.65	25 943.30
Non-capitalised books	242.44	295.00	3 961.31
Small capital works: not capitalised	14 325.96	38 107.52	20 497.92
Postage, telephone and fax	85 530.06	76 463.98	87 896.54
Safety clothing	2 121.00	4 456.11	3 885.44
Rent paid for facilities	24 640.00	1 700.00	-
Repairs	32 642.37	140 260.36	79 386.13
Software and internet	19 378.82	50 597.67	31 344.26
Sundry expenses	18 207.76	5 202.86	82 774.09
Team member research costs	3 877 242.14	3 659 748.92	5 204 623.46
Transport and accommodation	292 468.25	342 725.45	276 837.00
Workshops	207 528.40	109 925.11	165 722.34
Personnel expenses	4 332 830.02	5 374 618.97	5 708 565.20
Salaries	4 332 830.02	5 374 618.97	5 708 565.20
SURPLUS FOR THE YEAR	1 217 926.66	2 417 287.82	664 566.44