

DST-NRF Centre of Excellence for Invasion Biology









Self-Evaluation Report

1 July 2008 - 31 December 2012

JANUARY 2013





Cover images (from top):

A word cloud constructed in Wordle® from the titles of C·I·B peerreviewed journal articles published between July 2008 and December 2012. Type size indicates the frequency of occurrence of different words in the publication titles.

The C-I-B family - staff, Core team members, research associates, students, post-docs, and guests at the C-I-B's annual research meeting (Stellenbosch University, November 2012).

Soapberry bugs, Jadera haematoloma, on balloon vine, Cardiospermum grandiflorum, in Hawaii. These insects are specialist seed feeders on plants in the Sapindaceae family.

Map showing the locations of invasive plant samples collected for molecular analysis in the WfW- C·I·B project on the provenance, genetic structure, and genetic identity of selected invasive alien plant populations in South Africa. Collections outside South Africa are from the native ranges or other invasive ranges of key invasive plants in South Africa.

Director's statement



This report provides a self-evaluation of the performance of the C·I·B for the period 1 July 2008 to 31 December 2012. Details, metrics and elucidation are given in respect of all key performance areas. This section discusses some overarching issues that relate to the C·I·B's performance and are of direct relevance to the scope and terms of reference of the 2013 review but which do not fit easily into any of the key performance area feedback sections.

This report shows that the Centre has fulfilled the objectives in all its KPAs, excelling in most areas as set out in the C·I·B's strategic plan. The Centre is clearly established internationally as a major academic centre for scientific research on the phenomenon of biological invasions.

Confirmation has come from many quarters – in the form of awards and accolades to individual researchers, direct and unsolicited statements of appreciation and, increasingly in the form of requests for collaboration and other inputs to international initiatives. Besides our performance as measured by internationally recognized metrics of research outputs (numbers of publications, journal impact factors, citation details, etc.), the C·I·B has fulfilled its objectives in producing research outputs that are highly relevant to the South African situation.

I am particularly proud of the C·I·B's achievements in all the boxes in the framework that has guided the allocation of resources to research and other KPAs (Fig. 1).



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Important findings have emerged regarding the 'nuts and bolts' of biological invasions – in all components under the heading Invasion Patterns and Processes, of the guiding framework. This is where the C-I-B has gained most recognition internationally. We produce around 100 papers in ISI-listed journals every year and make important contributions to key international meetings. Importantly though, efforts directed at providing practical results on Invasion Management and Remediation have also been very successful. Achieving a balance between these two columns in the C-I-B's guiding framework has enjoyed considerable attention during the review period.

The C·I·B functions as a distributed network (hub-andspoke model) and much effort goes into ensuring that the network structure functions as smoothly and effectively as possible. Changes during the review period strengthened the C·I·B's secondary hub at the University of Pretoria (the 'northern hub'), enhanced the range of researchers involved in the Centre as core team members and research associates, and established formal relationships with several important partner organisations. The Centre's core team member and research associate network now includes almost every active university-based researcher in the field of biological invasions in South Africa as well as several noted researchers working in science councils or scientific divisions of conservation authorities. A new model for drawing in research associates was developed in 2012. As a result of this strategy the research associate network has been expanded to include key players in under-represented themes and those associated with existing and potential partner organizations nationally and internationally. New links are being created to address emerging dimensions of invasions. Because biological control of invasive species in South Africa is funded separately through the Working for Water programme, experts in this area are underrepresented in formal However, associations with the C·I·B. good collaborations with researchers working on biological control exist, and these are being strengthened.

Formal memoranda of understanding have been signed with national, provincial and municipal agencies involved in the management of invasive species. This is a crucial mechanism for ensuring effective identification of research priorities, for improving the implementation of research results and ensuring better access to sustained funding in the future. Long-term research collaborations have been established with the Working for Water programme, the South African National Biodiversity Institute and South African National Parks.

A major partnership was negotiated with the Working for Water programme during 2012 to continue the successful collaborative project 'Research for Integrated Management of Invasive Alien Species' through to March 2013. The continuation will ensure ongoing strong engagement with the primary user of C·I·B research outputs and a major employer of C·I·B graduates until 2017.

Special attention was given during the review period to **nurturing outstanding researchers within the C-I-B's core team**. Here we have provided incentive funding (to be increased from 2013) and priority access to funding for student support. Core team members and their students and post-doctoral associates also enjoy the benefit of exposure to international research and funding opportunities afforded by the C-I-B's international networks. These include invitations to thematic workshops and symposia hosted by the Centre (at least one per year) and invited participation in international programmes. We are careful to keep reporting requirements of core team members to a minimum necessary for compliance with funders' and the host institution's requirements.

A highlight of 2012 was the awarding of a joint research chair (South African Research Chairs Initiative) to the University of Venda and the C-I-B at Stellenbosch University. This initiative will strengthen the C-I-B's activities in the northern regions of South Africa, integrate and support research initiatives that are aligned with the mission of the Centre and provide meaningful support to a historically disadvantaged institution. Through this partnership we are optimizing resources and effort by sharing expertise, personnel, equipment, data and ideas.

The C·I·B supports long-term ecological research in the form of three landscape-scale transects in biologically important parts of South Africa (the Cederberg, Drakensberg and Soutpansberg mountain ranges). The transects are regionally, nationally and internationally important resources for monitoring global change (including climate change and biological invasions) in three very different biogeographic zones. Challenges related to the scientific leadership of all three transects received much attention during 2012, following the departure of Prof. Berndt van Rensburg from University of Pretoria and founding C·I·B Director, Steven Chown from Stellenbosch University. Longterm partnerships with the Universities of Pretoria and Venda have secured the ongoing data collection and leadership for the Drakensberg and Soutpansberg transects respectively, and negotiations are continuing regarding the Cederberg transect. Plans are in place to establish an additional long-term project as part of a multi-facetted agreement with the City of Cape Town to develop long-term monitoring of invasive species within the borders of the City.

In conclusion, it has been a privilege to have been involved with the C·I·B throughout the review period and to be its Director since May 2012. The C·I·B is well-placed to continue serving the needs of South African society by producing world-class research and skilled human resources capable of reducing the rate and impacts of biological invasions.

I thank the C·I·B Board, staff, core team members, research associates, students, representatives of our partner organizations, personnel at the Department of Science and Technology, the National Research Foundation and Stellenbosch University for their enthusiastic support.

Special thanks are due to Steven Chown who was C-I-B Director for most of the review period (until April 2012). He led the Centre with enthusiasm and passion.

David M. Richardson Stellenbosch 27 January 2013



C-I-B student Fani Given Nyembezi (B.Sc. Hons., 2010, Walter Sisulu University) collects data on the impacts of Lantana camara on rural livelihoods along the Mthatha River, Eastern Cape Province

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Glossary and abbreviations

ARM	The annual research meeting of the C·I·B
CBD	Convention on Biological Diversity
CSIR NRE	Council for Scientific and Industrial Research, Natural Resources and Environment programme
DEA	Department of Environmental Affairs
DST	Department of Science and Technology
DWAF	Former Department of Water Affairs and Forestry
EDRR	Early detection, rapid response
KNP	Kruger National Park
КРА	Key performance area specified in the collaborative agreement between the National Research Foundation and the host institution (Stellenbosch University)
NEM:BA	National Environmental Management: Biodiversity Act (Act 10 of 2004)
NRF	National Research Foundation
SAIAB	South African Institute for Aquatic Biodiversity
SANAP	The South African National Antarctic Programme
SANBI	South African National Biodiversity Institute
SANPARKS	South African National Parks
SARCHI	South African Research Chairs Initiative of the Department of Science and Technology, managed by the National Research Foundation
SLA	Service level agreement
WFW	Working for Water programme of the Department of Environmental Affairs. (WfW was previously part of the Dept. Water Affairs and Forestry, but is now incorporated into the new Natural Resources Management Programme of DEA.)
WCED	Western Cape Education Department



INTRODUCTION

The DST-NRF Centre of Excellence for Invasion Biology (also known as the Centre for Invasion Biology, or C·I·B) is an interdisciplinary, inter-institutional Centre of Excellence established *de novo* in June 2004 to provide the scientific understanding required to reduce the rate and impacts of biological invasions in a manner that will improve the quality of life of all South Africans¹.

During the review period 1 July 2008 to 31 December 2012 the C·I·B has generated substantial knowledge, with 459 primary research outputs, including papers in the world's top general science journals (*Nature* [1 contribution], *Proceedings of the National Academy of Science of the USA* [5], *Science* [4]), as well as ten books and 57 chapters in edited books.

The key performance areas (KPAs), mandated by the service level agreement (SLA) with the National Research Foundation (NRF), guide not only strategic planning but also the management and operation of the Centre. The five standard KPAs – research, education and training, networking, information brokerage and service provision - are augmented by management for this self-evaluation report. In accordance with the Department of Science and Technology's (DST's) 10-Year Global Change Research Plan for South Africa, our approach to meeting our goals has been explicitly:

- strongly interdisciplinary, actively seeking out expert partners;
- grounded in a social-ecological paradigm;
- directed at making a contribution to the international knowledge base while remaining locally relevant;

- aimed at advancing a better understanding of the functioning of South Africa's ecosystems to inform efforts to respond effectively to changes;
- policy-relevant;
- directed to consider biological invasions as a key facet, along with climate change, of overall global change, and taking into consideration contemporary debates and discussions.

In striving to achieve all its KPAs, the C-I-B has sought to distribute its responses to address both fundamental questions in invasion ecology (and biodiversity science in general) as well as seeking practical solutions to inform strategies and policies (Fig. 2). To operationalize our adherence to the above considerations in realizing strong impacts, good progress has been made by following the ten strategic responses for addressing the problem of invasive alien species as set out in the Global Strategy on Invasive Alien Species of the Global Invasive Species Programme (GISP):

- Build management capacity;
- Build research capacity;
- Promote sharing of information;
- Develop economic policies and tools;
- Strengthen national, regional and international legal and institutional frameworks;
- Institute a system of environmental risk analysis;
- Build public awareness and engagement;
- Prepare national strategies and plans;
- Build invasive alien species issues into global change initiatives;
- Promote international cooperation.



¹ Please see the C·I·B home page at <u>http://academic.sun.ac.za/cib/</u>.

This approach is firmly in line with the stated aim in Chapter 7 of the South African National Development Plan to 'showcase South Africa and promote its presence and leadership on strategic issues'². South Africa is definitely a world leader in the field of invasion science.

RESEARCH

The C·I·B's research output has covered all aspects of invasion ecology and many associated fields relating to environmental management in South Africa. Most of the C·I·B's research has, following its brief, dealt with issues relating to invasions in South Africa. Our research has, however, made major contributions to the international literature on biological invasions. This is in keeping with the requirement for CoEs to be seen as a major international player in their fields. Summaries of key publications, achievements and interventions are provided as nuggets on the C·I·B's web site. Rather than summarizing research outputs across the full spectrum of the C·I·B's work, we summarize research outputs in five areas where notable impact has been achieved in terms of national or international benefits (see Fig. 1).

Highlights

Research to improve on-the-ground invasive species management

The C·I·B has been a key research partner of the primary agency tasked with managing invasive species in South Africa, the Working for Water programme (WfW), since the establishment of the Centre in 2004. Since 2008, a substantial part of the C·I·B's research efforts have been guided by a formal collaboration with WfW on research and capacity building entitled 'Integrated management of invasive alien species in South Africa'. The partnership has produced numerous research products, many of which have been taken up in strategies and management plans of WfW and their partner organizations (see Appendix). A research partnership with the South African National **Biodiversity** Institute (SANBI) quided the implementation of an Early Detection, Rapid Response initiative for dealing with emerging invasive species (now SANBI's Invasive Species Programme). Research at the C·I·B has also contributed in various ways to raising awareness of problems associated with invasive species and thus helped to justify expenditure of public funds on natural resource management initiatives like WfW. This latter partnership has also trained postgraduate students (37 degrees have been completed) in a range of disciplines related to conservation biology, environmental management and invasion ecology, and socio-anthropology and provided regular training to WfW staff.



² National Planning Commission (undated) *Our future - make it work - National Development Plan 2030*. Available at: <u>http://www.npconline.co.za</u>.

WfW emerged as a national, community-based public works programme that initially focussed on the clearing of invasive plant species that have been shown to reduce water quality and quantity in catchments. The scope of WfW has expanded and it is now tasked with invasive species management in all ecosystems of South Africa, with management consolidated under the Natural Resources Management Programme of the national Department of Environmental Affairs (DEA). The C·I·B has been a pivotal partner in these initiatives, and others such as SANBI's Invasive Species Programme, through the provision of research results, networking, expert advice, institutional resources and the provision of trained personnel for employment in various capacities within WfW and partner agencies.

Areas where research co-funded by the C·I·B has provided crucial inputs to WfW operations include the following:

Research relevant to on-the-ground management:

- Seed bank ecology of selected invasive species; much work has addressed aspects of the seed banks of Australian acacia species. The longlived seeds of these species are stored in the soil and greatly complicate management;
- Elucidation of the effects of alien plants on ecosystem structure and functioning and implications for restoration as a fundamental part of invasive plant management;
- Provision of basic ecological data for eradication plans for several species of *Acacia* (wattles), *Anigozanthos* (kangaroo paw) and *Melaleuca* (tea tree) among others.

Strategic management and planning:

- Elucidation of the role of fire in spread and management of invasive species in Fynbos and savanna ecosystems;
- Development of methods for prioritizing species and areas for management using spatiallyexplicit modelling and methods for incorporating key complexities in objective decision making;
- Development of methods for incorporating the next major invasive threats in regional prioritization schemes;
- Economic assessment of the contribution of biological control to management of invasive alien plants and protection of ecosystem services;

- Development of an objective framework for the management of invaded riparian ecosystems in South Africa;
- Development of a strategy of best practice for management of Australian Acacia species based on a major international review of ecology and management options (one third of the budget of WfW has been allocated to managing these species);
- Development of guidelines as input to a strategy for dealing with invasive plants on private land;
- Development of strategies, approaches and protocols for evaluating the potential for eradicating emerging invasive species as input to SANBI's Invasive Species Programme.

Research on the seed ecology of Australian Acacia species (the focus of about a third of WfW projects) emphasized the huge role of accumulated seed banks in the persistence of populations of these species. Richardson & Kluge (2008) concluded that 'preventing the accumulation of seed banks by limiting seed production through biological control is by far the most effective means, and in almost all cases the only practical means, of reducing seed numbers' and that 'this must be an integral part of management strategies'. This information, together with the research on the economics of the returns on investment of biological control compared to other forms of control (de Lange & van Wilgen 2010) provided key support for the implementation and expansion of biological control as an integral part of the WfW programme as shown in their biocontrol implementation plan and policies.

Research at the C-I-B on species identified as important emerging invaders has informed management plans. For example, the eradication plans for *Acacia paradoxa* and *A. stricta* of the Invasive Species Programme of SANBI flowed directly from C-I-B research (e.g. Zenni *et al.* 2009 for *A. paradoxa* and Haylee Kaplan's unpublished M.Sc. thesis on *A. stricta*³).

Research by C·I·B core team member Brian van Wilgen and co-workers provided the first full quantification of the current and future potential impacts of invasive alien plants on three major ecosystem services. This work showed that reductions in surface water run-off

³ Kaplan, H. (2012) Assessing the invasiveness of *Acacia stricta* and *Acacia implexa*: Is eradication an option? M.Sc. thesis, Stellenbosch University.

due to current invasions exceeded 3000 million m³ (about 7% of the national total), mostly in the Fynbos and grassland biomes. The study showed that the potential reductions would be more than eight times greater if invasive alien plants were allowed to spread to occupy their full potential range. Current levels of invasion could reduce grazing capacity to just over 1% of the potential number of livestock that could otherwise be supported. However, future impacts could increase to 71% reduction in grazing capacity. A 'biodiversity intactness index' ranged from 89% to 71% for the five major biomes. With the exception of the Fynbos biome, current invasions have had little impact on biodiversity intactness. Under future levels of invasion, however, these intactness values could decrease to well below 30% for the savanna, Fynbos and grassland biomes.

Thus, while the current impacts of invasive alien plants are quite low (with the exception of those on surface water run-off, which are huge), projections point to rapidly-escalating impacts, giving serious cause for concern. This work provided an objective basis for estimating the impacts, and the value of control programmes in preventing growth of these impacts in economic terms. De Lange & van Wilgen (2010) estimated the area freed of invasion pressure by all historic control efforts in South Africa. The estimated value of potential ecosystem services (water, grazing and biodiversity) amounted to R152 billion annually (2008 Rand values). Although an estimated R6.5 billion was lost every year due to invading alien plants, this would have been an estimated additional R41.7 billion had no control been carried out. This indicates a saving of R35.2 billion every year (approximately 4.8% of South Africa's GDP), about one third of which was due to biological control. In short, annual losses would increase substantially if invasive alien plants were to be allowed to occupy all available habitat. This information has been pivotal in justifying and expanding the budget for WfW.

The C·I·B coordinated a major initiative to provide guidelines for the improved management of riparian ecosystems which are among the most severely invaded habitats in South Africa. This work resulted in a special issue of the *South African Journal of Botany* (e.g. Vosse *et al.* 2008). The National Environmental Management: Biodiversity Act (NEM:BA) regulations (see Service Provision, below) call for the development of strategic plans for key groups of invasive species. The C-I-B produced the first strategic plan for Australian acacias, as a blue-print for the plans that will be required for all major invasive species (van Wilgen *et al.* 2011). This plan defined (1) categories of species based on invaded area (a surrogate for impact) and the value of benefits generated; and (2) management regions based on habitat suitability and degree of invasion. Strategic goals and combinations of management practices were defined for each category and region.

Invasive species management in South Africa's National Parks

Until very recently, little science-based evidence was available to conservation and land managers in South Africa for making decisions about the threat of invasive alien species to biodiversity in protected areas. Information was available for some protected areas, but the understanding of patterns and processes of invasions needed to formulate effective management strategies was lacking. Research at the C·I·B has greatly improved our knowledge of the extent, impacts and ecology of key invasive species in protected areas. Results have already been incorporated directly into various management plans and policies. This work has also informed the development of various protocols that are now in practice in Kruger National Park (KNP), and insights are now being transferred to other national parks in South Africa.

The Kruger National Park (KNP) is one of South Africa's flagship protected areas. Despite its large size (over 2 million ha) the park is long and narrow and has an extensive boundary with human-modified landscapes from which the spread of invasive alien plants is inevitable. Seven large rivers flow into KNP from adjoining residential, agricultural and pastoral areas. Almost 400 alien plant species have been recorded in the park. Some species spread into the KNP along rivers from adjoining catchment areas, and some were intentionally introduced as ornamental plants in staff villages and rest camps and spread into the park from these foci.



Cover of the May 2009 issue of Diversity and Distributions, highlighting C-I-B research which assessed the usefulness of invasive plant distribution data collected at different scales in the Kruger National Park

Preventing alien plants from invading along river corridors and across the long boundary is a major challenge for the park's conservation managers. Research by the C·I·B has provided fundamental information on the invasion ecology of the most important invasive alien plants in KNP, particularly prickly pear (Opuntia stricta) and lantana (Lantana camara). Detailed studies on the drivers of invasion of prickly pear and insights from studying invasion patterns of this species at different scales have helped formulate improved management plans (Foxcroft et al. 2009, 2010, 2011; Hui et al. 2011; Jarošík et al. 2011). The spread of lantana into the park was studied using molecular techniques to identify the relative importance of spread along rivers, versus diffusion from rest camps⁴. Flooding events are hugely important for dispersing seeds along rivers, and population genetics methods allowed researchers to quantify spread rates,

identify primary propagule source areas, and assess the influence of different management efforts in structuring the invasive populations. We explored the permeability of the western boundary of KNP to invasive alien plants and its implications for management, showing that the number of invasive alien plants inside the park was a function of the amount of water run-off and the density of major roads. This information has great value for predicting trajectories of further incursions and for guiding management actions (Foxcroft *et al.* 2011; Jarošík *et al.* 2011). Thus, there is an urgent need to develop predictive methods that allow land managers to prevent, manage and respond to the introduction and spread of plants.

Key insights on the dynamics of plant invasions were gained from developing and implementing thresholds of potential concern for invasive species and integrating these into frameworks for adaptive management, which in turn provided a database and insights on the distribution and invasion processes well ahead of those available for any other large national park. Such insights are being incorporated into policy briefs and action plans (see below), and will lead to improved management of protected areas throughout South Africa. For example, work on ornamental plants and their spread through staff activities and movements (Foxcroft et al. 2008) supported the development of a policy that specified the conditions of use of specific plant species in developed areas of the park. This led to the phased removal of all invasive species from staff villages and rest camps.

South African National Parks (SANParks) uses adaptive management and thresholds of potential concern as a formal and functional strategy. Thresholds are identified for invasive species and integrated, together with formal feedback loops, into park management plans. A range of C·I·B research is used for adaptive management and planning, which is being expanded to other national parks in South Africa. The collective work on strategic adaptive management, thresholds of potential concern, monitoring approaches and risk assessment has provided a pool of information from which to draw (1) a high-level corporate framework to guide the organisation's approach to dealing with alien and invasive species; (2) monitoring of ecosystem responses through a dedicated invasive alien species monitoring programme which is being expanded to other national parks; and (3) fine-scale mapping of alien plants across the parks to provide baseline data from which future changes in species composition, distribution and spread, and changes in abundance may be determined.

⁴ Vardien, W. (2012) Molecular ecology and invasive species management: Unravelling the dynamics of *Lantana camara* invasions in the Kruger National Park, South Africa using a molecular approach. M.Sc. thesis, Stellenbosch University.

SANParks has developed a programme to investigate each of the major drivers of global environmental change and the impacts for the organisation, determining the relative risks posed. Specifically, the assessment aims to collate existing information and knowledge of alien and invasive species in and around parks, in an attempt to synthesise this knowledge, and provide the information in a form that is useful for management and policy development. This programme has drawn on all the publications mentioned above.

The impact of C·I·B-funded research is corroborated by the KNP's *alien ornamental plant policy* wherein C·I·B work (in particular Foxcroft *et al.* 2008) was directly translated into KNP policy on use and management of alien ornamental plants, as detailed in various KNP reports.

Several publications by C-I-B core team member L.C. Foxcroft formed the basis for the 2008 KNP policy brief on 'Kruger National Park Biodiversity Management Programme: Strategic adaptive management'.

A system of ten biodiversity monitoring programmes has been developed, one of which addresses invasive alien species. The aim of the programme is to provide the information necessary for reducing the rate of introduction, spread and impact of biological invasions in national parks. This monitoring will provide information on trends in invasive species for a number of selected indicators. C·I·B-funded work has been directly integrated into monitoring policy for SANParks. SANParks has developed an Alien and Invasive Species module for their Global Environmental Change Programme to investigate each of the major drivers of global environmental change and the impacts for the organisation, determining the relative risks posed. Specifically, the assessment aims to collate existing information and knowledge of alien and invasive species in and around parks, and provide the information in a form that is usable for management and policy development. This programme has drawn on all the C·I·B research discussed above.

Global indicators of biological invasions

Invasive alien species are a major threat to global biodiversity. The Convention on Biological Diversity selected 22 Headline Indicators to measure progress towards the Millennium Development Goals and the Convention on Biological Diversity's target of reducing the rate of loss of biodiversity by 2010. The 'trends in invasive alien species' indicator was selected as one of the 22 Headline Indicators. However, no fullydeveloped indicator for invasive alien species was available that combined trends, used a standard set of methods, and addressed a range of species groups, ecosystems and regions. This prevented the objective assessment of this key trend worldwide. The C-I-B was contracted to develop and populate indicators of 'trends in invasive alien species'.

Sub-indicators were developed which addressed (1) the number of documented invasive alien species per country, (2) trends in invasive alien species relevant to international agreements and (3) national policy responses to invasive alien species. A fourth indicator, impact of invasive alien species on species conservation status, was developed by IUCN personnel, with substantial inputs from the C-I-B.

C-I-B research to amplify this 'trends in invasive alien species' indicator demonstrated that the global threat from invasive alien species is not being reduced substantially. Although there has been some response, countries have not responded adequately to the threat to biodiversity and livelihoods posed by invasive alien species.

The indicators were populated for 57 countries (~30% of all countries) representative of different country sizes, climatic regions, continents and development status. Six groups of species were included: mammals, birds, amphibians, freshwater fish, vascular plants and marine organisms (including algae, corals, invertebrates and fish). The outcomes of the 2010 Biodiversity Target assessment were reported in McGeoch et al. (2010) and Butchart et al. (2010). This work was incorporated into a report on the experiences and lessons learnt from the indicator development. Fact sheets on the indicators were developed, which in turn informed the development of indicators at a national scale. The paper that developed and populated the indicators (McGeoch et al. 2010) was widely cited in the peer-reviewed literature (45times by January 2013) and also received substantial media attention.

To address policy responses (the third indicator) the C-I-B used international conventions, organisational agreements, guidelines and national legislation and policy to quantify trends in the adoption of invasive alien species-relevant international policy, e.g. through promoting the regulation of introduction pathways of invasive alien species and controlling invasive alien species in situ. All 191 parties to the Convention on Biological Diversity were included in the indicator.

The 2010 Biodiversity Indicators Partnership brought together over 40 organizations working on a suite of indicators to assess progress in different environmental sectors. The GISP and the IUCN were the key partners in this project, and established an expert working group to guide the development of the indicators for invasive alien species. After development of the indicators, the C-I-B was contracted to produce a proof of concept and strategy for delivery of the indicators. In 2010, the final report to GISP completed the project while on-going work maintains the Invasive Aliens Species Indicator (IASI) website and database as a free resource to the user community.

The C-I-B's work was incorporated into a substantial report on the experiences and lessons learnt from the indicator development. Factsheets on the indicators have also been developed and are available online⁵.

The C-I-B maintains a website dedicated to the indicators, as well as a database of alien species in the target countries (www.sun.ac.za/iasi) that was used to assess trends in invasive alien species. Two hundred and thirty two users from 56 countries have registered to use the database. These users have made 457 enquiries on the database, viewing or downloading information on 58 countries. The invasive alien species target (No. 9) of the Aichi Biodiversity Targets now paves the way for both further development and testing of the invasive alien species indicator.

Following the development of the indicators, the C·I·B research team contributed to an assessment (using 30 indicators of biodiversity change) of the global effort to achieve the 2010 Biodiversity target. The outcomes of this assessment showed that the rate of biodiversity loss has not been significantly reduced and the results of this study were published in Science. The Science paper titled Global Biodiversity: Indicators of Recent Declines caused great excitement in the international media scene with numerous articles on some of the foremost international news sites. Articles appeared on the websites of Nature, Daily Mail, World Science, Science Now, BBC News, The Telegraph, Time and several European news sites. Articles about this paper also appeared in seven national publications. By January 2013 the paper had been cited 266 times.

Improving international conservation schemes – Antarctica and islands

Extensive research over the past eight years has led to the C-I-B becoming a centre for knowledge generation on the Antarctic and sub-Antarctic islands. South

⁵ www.bipindicators.net/invasivealienspecies

Africa's involvement in the Antarctic Treaty and presence on that continent, as well as its ownership of the Prince Edward Island group, make the country a key player in Antarctic matters both nationally and internationally.

The C-I-B has conducted research for the South African National Antarctic Programme (SANAP) of the National Research Foundation (NRF) and DEA: Directorate: Antarctica and Islands, as well as for international bodies. This research has addressed all levels of Antarctic conservation, from fundamental research to management planning and the production of handbooks for tourists. C-I-B outputs have been taken up into protected area management plans and Antarctic Treaty System policy and position papers.

RISK ASSESSMENT FOR ALIENS AND TOURISM

The combined influence of growing tourism and research activities and climate change makes alien species a significant threat to the Antarctic continent and the islands of the Southern Ocean. C·I·B-led projects have undertaken comprehensive, continent-wide evaluations to gain a better understanding of alien species dispersal and establishment mechanisms in order to manage the risks they pose (Hughes *et al.* 2010, 2011; Lee *et al.* 2011). A recent study, which was a consortium effort as part of the International Polar Year Aliens in Antarctica project, aimed to calculate the chances of different parts of the continent being invaded by flowering plants that are foreign to its soils (Chown *et al.* 2012a).

Tourists and scientific team members who visited Antarctica during the first summer season of the 2007-2008 International Polar Year answered questions about their previous travel. Results indicated that tourists and ships' crews are less likely to transport propagules (seeds) to the region than are scientists, science support personnel and tourist support personnel; and that the average number of seeds per visitor is 9.5 seeds. About 20% of tourists had unintentionally carried seeds to Antarctica while more than 50% of field researchers did so. Overall, it was estimated that all visitors to the region that season brought about 71 000 seeds, of which approximately 31 732 seeds entered Antarctica on tourists and 38 897 seeds on scientists (Chown *et al.* 2012a).

Analyses of the types of seeds gathered, together with information from the survey questionnaires about the visitors' travel habits, suggest that between 49-61% of the seeds reaching Antarctica are from areas with similarly cold climates, and therefore pose a threat by being able to survive the cold conditions. Many of the

seeds collected are also from plant families that are known to already have invaded cold-climate regions in the Arctic and sub-Antarctic. A risk index based on propagule pressure and origins, and climatic suitability of the ice-free areas of the continent indicated that alien species establishment is currently most likely for the Antarctic Peninsula coast and the islands off the coast of the Peninsula.

The participation of the International Association of Antarctica Tour Operators (IAATO) together with several tour operators and visitors ensured that the outcomes of the study are supported by these stakeholders and this is confirmed by the IAATO web site:

'One of the strengths of IAATO is its flexibility and commitment in adopting new guidelines and filling gaps in procedures. During the past several years, for instance, IAATO has been able to effectively incorporate findings and recommendations presented at annual ATCM meetings into its own standard operating practices. A good example of this in recent years has been the use by IAATO operators of Don't Pack a Pest pamphlets with their passengers. The pamphlets are available in English, French, Spanish, German and Chinese.'

The implications of the risk assessment were discussed at the Antarctic Treaty Consultative Meeting in June 2012 and the Committee for Environmental Protection committed to developing a surveillance strategy for areas at high risk of non-native species establishment.

The Antarctic Treaty System, which cooperatively regulates the Antarctic continent, is subject to increasing pressure from resource-use proposals, visits by tourists and scientists and by global environmental change. Horizon scanning is a technique of identifying and describing the severity of current and future threats to an area in the light of emerging pressures and trends. A workshop hosted by the C·I·B in May/June 2011 assisted decision-makers in addressing future challenges through policy by identifying these major emerging threats and resulted in the high-impact publication in *Science* (Chown *et al.* 2012c).

The most immediate conservation threats to species, ecosystems, and resources around the Antarctic margin are regional warming, ocean acidification, and changes in sea-ice distribution, along with marine resource extraction that may act to heighten these threats. Climate change is elevating the risk of introducing alien species that might become invasive, and these risks are increased by tourist and research activity. Increasing human activity in the region also means higher risks of pollution from vessel emergencies and point-source discharges, while diversification of both science (e.g., intensified sub-glacial drilling activity) and tourism (e.g., polar crossings) challenge policymakers' responses. As climate continues to change and technology advances, Antarctic resource extraction, driven by escalating global demand, will become more economically feasible. Activities that do not reduce CO₂ emissions will add to problems associated with ocean acidification, predicted to be most acute in the Southern Ocean (Chown *et al.* 2012c).

The horizon-scanning study identified several practicable policy responses for Antarctic managers. Better marine ecosystem protection may help ensure that resource extraction is conducted in a more sustainable fashion. The alien species threat is better recognized than any other in the region and has been addressed most comprehensively by policy-makers to date. However, risks of transfer of organisms among biogeographically distinct regions of the Antarctic remain under-researched and poorly regulated. Wildlife disturbance is likely to increase with growing numbers of visitors, especially to popular sites. Identification of long-term consequences of such disturbance is hindered by the lack of appropriate surveys. Data to evaluate hydrocarbon and mineral deposits could be gathered, with attendant environmental risks, as part of legitimate scientific programmes.

PRINCE EDWARD ISLANDS MANAGEMENT PLAN

South Africa's Prince Edward Islands were proclaimed a Special Nature Reserve in 1995. The National Environmental Management: Protected Areas Act (No. 57 of 2003) requires the production and implementation of protected area management plans for such reserves. The C·I·B was contracted by the Directorate: Antarctica and Islands in 2005 to prepare such a plan for the Prince Edward Islands. This management plan brought the administration, conservation management, historical conservation and waste management on the islands in line with international standards using the ISO 14000 Environmental Management Systems Standards series. The ISO standards require organisations to implement plans to minimise harmful effects on the environment caused by its activities, and to achieve continual improvement in environmental performance. In practice, this means creating and using the feedback loops necessary to ensure on-going learning and adaptive management.

The new management plan for the Prince Edward Islands includes systematic treatment of all activities that were likely to affect the environment and states explicit objectives, management actions, targets, monitoring actions, responsibilities and remedial actions for each activity. The advantage of this approach, besides being in line with international standards is that a comprehensive 'handbook' is created that can be used by all suppliers and visitors to determine the appropriate way to carry out their activities and to respond to emergency situations.

South Africa's management of the Prince Edward Islands Special Nature Reserve is of international interest. The possibility of a second World Heritage Site Nomination brings this issue to the forefront of South Africa's environmental management concerns. The Prince Edward Islands Management Plan, once implemented, will ensure that environmental management of the islands is integrated, reviewed regularly and in line with international standards.

ANTARCTIC LEGACY PROJECT

Funded by SANAP, a C·I·B-led consortium is developing a platform for social science research in South Africa's

Antarctic region. The Antarctic Legacy Project is compiling a repository of social science information including oral histories, photographs, interview transcripts and art work created on the islands. We are gathering historical images of the people, infrastructure and environments to illustrate the islands social and environmental changes since their annexation by South Africa in 1948 to encourage research on social issues, history, global change and invasions by providing a reliable and comprehensive knowledge-base.

Team structure and expertise

The C·I·B's research team reflects the broad range of aspects of biological invasions being investigated in South Africa. In addition to the core team members, we have enlisted the expertise of a diverse range of research associates to ensure that the C·I·B is able to address all possible biological invasion vectors and issues, whether terrestrial or marine, theoretical or applied, vertebrate or invertebrate, empirical or sociological, historical or emerging.



Delegates, including 12 affiliated with the C·I·B, at the 11th EMAPI conference in Szombathely, Hungary, in September, 2011. Conferences in the series are held every two to three years, and the C·I·B hosted the 10th Conference on the Ecology and Management of Alien Plant Invasions in Stellenbosch (EMAPI-10, August 2009)

The C·I·B core team							
Prof. David Richardson	Director and Professor	Centre for Invasion Biology and Department of Botany and Zoology, Stellenbosch University	Leading international Researcher	Prof. Richardson's expertise is in invasion ecology; ecology; biogeography of Acacia, Eucalyptus, Pinus and other major tree genera; Fynbos ecology; scientific and popular writing; collation & editing of scientific texts. Other research interests include conservation biology, conservation planning, biogeography, vegetation science, environmental modelling, and fire ecology.			
Ms Sarah Davies	Deputy Director: Operations	Centre for Invasion Biology, Stellenbosch University	Not rated	Ms Davies' recent focus has been on the ecology of the painted reed frog (Hyperolius marmoratus), specifically its biogeography, thermal tolerance and metabolic rates. She has also been mapping the extent of its novel range; and manages both the C-I-B's research programme and projects.			
Prof. Chris Chimimba	Professor and Head of Department	Department of Zoology and Entomology, University of Pretoria	Established Researcher	Prof. Chimimba's expertise is in interactions between indigenous and alien species, specifically in the areas of disease pathogen transfer and competition for habitat resources			
Dr Susana Clusella- Trullas	Senior Lecturer	Centre for Invasion Biology and Department of Botany and Zoology, Stellenbosch University	Promising Young Researcher	Dr Clusella-Trullas is a physiological ecologist examining responses of organisms to changing environmental conditions, with a strong focus on thermal biology. Her interests include climate change impacts on indigenous and invasive species; the interactive effects of climate and invasion; patterns of physiological traits at large spatial scales; bottom-up modelling.			
Prof. Karen Esler	Professor	Department of Conservation Ecology and Entomology, Stellenbosch University	Established Researcher	Prof. Esler studies drivers of change (over-exploitation, habitat fragmentation & alien invasion) influence population, community structure and processes in Fynbos, karoo and riparian vegetation via research into seed bank and germination ecology, seedling establishment and phenology.			
Prof. Stefan Foord	Senior Lecturer	Department of Zoology, University of Venda	Promising Young Researcher	Dr Foord's research focuses mainly on arachnid systematics, ecology and conservation. He is author and co-author of eleven publications.			
Dr Llewellyn Foxcroft	Scientist/ecologist, Invasion Ecology research and monitoring programme	Skukuza Research Centre, Conservation Services Division, South African National Parks	Promising Young Researcher	Dr Foxcroft's main research interests are in alien plant invasions, investigating the processes and patterns of invasion, and the links to management interventions. He also has wide ranging interests in conservation biology, as well as strategic adaptive management frameworks.			
Prof. Charles Griffiths	Professor and Director	Marine Biology Research Institute, University of Cape Town	Internationally Acclaimed Researcher	Prof. Griffiths' research focuses primarily marine invasive species and marine biodiversity/ taxonomy but also general rocky shore ecology.			
Dr Cang Hui	Researcher	Centre for Invasion Biology, Stellenbosch University	NRF Prestigious Award	Dr Hui studies the interface between mathematics and ecology; he proposes models and theories for explaining emerging patterns in community ecology, macroecology and evolution.			
Prof. Bettine Jansen van Vuuren	Professor	Department of Zoology, University of Johannesburg	Established Researcher	Prof. Jansen van Vuuren's research is of a molecular ecology nature, examining the spatial distribution of genetic variation at different spatial scales and the processes that shape these patterns. Ongoing projects are based in Southern Africa as well as the Antarctic and sub-Antarctic Regions.			
Prof. Steven Johnson	Professor	School of Biological and Conservation Sciences, University of KwaZulu-Natal, Scottsville Campus	Leading international Researcher	Prof. Johnson's research focuses on the ecology and evolution of plant-pollinator interactions, including pollinator-driven speciation in plants; plant breeding systems and ecological determinants of fruit and seed set; coevolution of flowers and insects; and the breakdown of plant-insect mutualisms in degraded landscapes.			
Dr Jaco le Roux	Lecturer; Molecular Ecology Lab Manager	Centre for Invasion Biology and Department of Botany and Zoology, Stellenbosch University	Not rated	Dr le Roux uses molecular ecology and population genetic and phylogenetic approaches to better understand the evolutionary processes that underpin biological invasions particularly in small plant populations.			

The C·I·B core t	eam			
Dr Heidi Prozesky	Senior Lecturer	Department of Sociology and Social Anthropology, Stellenbosch University	Not rated	Dr Prozesky's interests include gender inequities in science, engineering and technology (SET); social impacts of invasive alien plants in different socio-economic communities; and the sociology and ethics of science.
Prof. Mark Robertson	Associate Professor	Department of Zoology and Entomology, University of Pretoria	Promising young Researcher	Prof. Robertson attempts to predict the potential distributions of invasive alien species via ecological niche models which use distribution records and environmental predictor variables to illuminate species-environment relationships.
Dr Tammy Robinson	Lecturer	Department of Botany and Zoology, Stellenbosch University	Not rated	Dr Robinson is a marine biologist and community ecologist whose research interests centre on marine biodiversity with a particular focus on the impacts of marine invasive species on the South African coast.
Prof. Mathieu Rouget	Professor	School of Agricultural, Environmental and Earth Sciences, University of KwaZulu-Natal	Internationally acclaimed Researcher	Prof. Rouget researches the interface between biodiversity conservation and human activities on issues such as alien plant invasions, climate change, effective conservation planning and implementation, and ecosystem services.
Dr Michael Somers	Lecturer	Centre for Wildlife Management, University of Pretoria	Established Researcher	Dr Somers broad interests include carnivore ecology and behaviour, and invasion and reintroduction biology, in an aim to produce applied research that has practical conservation application and value.
Prof. Peter Taylor	Associate Professor	School of Environmental Sciences, University of Venda	Internationally acclaimed Researcher	Prof. Taylor's research interests include invasion biology as it is concerned specifically with zoonotic diseases, patterns of colonisation and integrated pest management of introduced, invasive rat and mouse species.
Prof. John Terblanche	Associate Professor	Department of Conservation Ecology and Entomology, Stellenbosch University	NRF Prestigious Award	Prof. Terblanche studies factors affecting climatic stress resistance in insects and their potential implications for climate change, as a model for vectors of disease in Africa; and agricultural pests.
Prof. Brian van Wilgen	Fellow, Terrestrial Ecologist	Natural Resources and the Environment, Council for Scientific and Industrial Research; Extraordinary Professor, Department of Botany and Zoology, Stellenbosch University	Internationally acclaimed Researcher	Prof. van Wilgen's primary fields of research include fire ecology and the use of fire in managing ecosystems, as well as the ecology and management of invasive alien plants in terrestrial and freshwater ecosystems.
Dr Olaf Weyl	Principal Scientist	South African Institute for Aquatic Biodiversity	Established Researcher	Dr Weyl's research interests include fish biology and ecology, particularly on the impact of alien fishes and the influence of anthropogenic factors such as fishing on aquatic ecosystems.
Dr John Wilson	Researcher and Invasive Species Programme Research Co-ordinator	South African National Biodiversity Institute, housed at the Centre for Invasion Biology, Stellenbosch University	Internationally acclaimed Researcher	Dr Wilson is interested in the ecology and evolution of biological invasions, how humans have influenced these processes, and how we can improve the science-base for management and legislative decisions.
Prof. Theresa Wossler	Associate Professor	Department of Botany and Zoology, Stellenbosch University	Established Researcher	Prof. Wossler's research focuses on social insects and the threats posed by introduced social insects to their host communities due to the flexibility that sociality offers; as well as social insects signalling systems used to maintaining colony co-ordination and function.

The research associates					
Prof. Armanda Bastos	Department of Zoology & Entomology, University of Pretoria	Prof. Bastos focuses on molecular epidemiology of infectious diseases and on the systematics of diverse native & invasive African taxa.			
Prof. Jane Carruthers	Department of History, University of South Africa	Prof. Carruthers studies history of biology and national parks, colonial art, and heritage & cartography in southern Africa and Australia.			
Prof. Steven Chown	Professor; Head of School, School of Biological Sciences, Monash University, Australia	Prof. Chown is interested in biogeographic and macroecological studies, evolutionary physiology, spatial ecology, invasion biology; Antarctic & sub-Antarctic biology & conservation.			
Mr John Cooper	Freelance researcher	Mr Cooper is an expert in seabird biology & conservation, especially on Southern Ocean islands. He is both an Honorary Conservation Officer, Tristan da Cunha & member, Tristan Biodiversity Advisory Group (T- BAG).			
Prof. Jan Giliomee	Emeritus Professor of Entomology	Prof. Giliomee studies ecology & management of insects of economic importance to agriculture; newly- introduced alien insects; biodiversity conservation.			
Prof. Brian Huntley	Former CEO of SANBI (retired)	Prof. Huntley advises and consults to many international agencies such as UNDP, UNEP, GEF & UNESCO; and has special interest in developing and implementing protected areas expansion strategies.			
Dr Rainer Krug	Freelance researcher	Dr Krug studies the spread of invasive alien plants under different management scenarios, via spatial as well as non-spatial simulation models.			
Dr Jennifer Lee	Environment Officer, Government of South Georgia and the South Sandwich Islands	Dr Lee is an ecologist interested in species distribution modelling at micro and macro scales, invasion biology, invertebrate physiology & molecular ecology, climate change & biosecurity policy.			
Prof. Melodie McGeoch	Associate Professor, School of Biological Sciences, Monash University, Australia	Prof. McGeoch is a spatial ecologist & biodiversity scientist studying climate change, the quantification and prediction of spatial pattern in biodiversity and the development of bioindicators.			
Dr John Measey	Senior Lecturer, Department of Zoology, Nelson Mandela Metropolitan University	Dr Measey's research centres on ecological investigations in evolution, conservation and population biology or reptiles and amphibians.			
Mr Dave Pepler	С-І-В	Mr Pepler's interests are biodiversity conservation & rehabilitation; zoology and the environment. His media relations publicise both these issues and the C·I·B.			
Dr Aleks Terauds	Australian Antarctic Division	Dr Terauds is interested in vertebrate and invertebrate ecology in both sub- and Antarctic marine and terrestrial ecosystems.			
Dr Antoinette Veldtman	Regional Ecologist, CapeNature	Dr Veldtman is Regional Ecologist with CapeNature, responsible for the Boland region. She has a strong background in biodiversity research and monitoring, especially of invertebrates.			

EDUCATION AND TRAINING

Overall performance

During the review period, we supported a total of 466 student registrations. Of these, 53% were registrations of black students and 56% were women. In total 84% of the registrations supported were South African, and 16% from Southern Africa (Zimbabwe, Lesotho), Central and West Africa (Malawi and Gabon), USA, UK and Canada (Figs. 3-4).

Forty three Honours/4th Year B.Sc. students, 37 Masters and 23 Ph.D. students graduated during the review period. We supported a total of 60 post-doctoral associates (Fig. 5). Forty-three land managers have attended various C·I·B-run training and information workshops designed to increase the interaction between scientists and managers and to transfer research results for implementation. Overall, we have an industry-retention rate of greater than 95% of our graduates.



Figure 3: Student demographic information for the review period, including 2008 in full and excluding post-doctoral associates



Figure 4: Student graduations and post-doctoral associates supported in each year of the review period (2008-2012)



Figure 5: Nationalities of post-doctoral associates supported during the review period (2008-2012)

Biodiversity and Conservation Academy

Thirty nine students, most of them undergraduates, were trained through the Biodiversity Academy short course held jointly with the Birds as Keys to Biodiversity CoE. Six interns from SANBI and one from SANParks/ Custodians of Rare and Endangered Wildflowers (CREW) also attended (Table 1).

 Table 1. Students and staff who attended the 2009-2011 Biodiversity and Conservation Academies held jointly with

 the CoE in Birds as Keys to Biodiversity Conservation

University of origin	No. of students
Cape Town	5
Fort Hare	2
Free State	2
KwaZulu-Natal	4
Limpopo	2
North West	1
Rhodes	3
Stellenbosch	3
Venda	3
Walter Sisulu	7
Total	39





Natasha Mothapo (pictured), Marguerite Blignaut and Bernard Coetzee were recognized at the New Voices in Science event for outstanding communication of their Ph.D. projects

Natasha Mothapo was a finalist in the oral category and intrigued the audience with her research on highly invasive Argentine ants and their destructive influence on both our native ants and the Fynbos biome.



Marguerite Blignaut accepts her award from Prof. Eugene Cloete, Vice-Rector: Research

Marguerite Blignaut and Bernard Coetzee were both finalists in the popular science article competition, and their articles are published, together with 22 others, in the New Voices in Science 2013 publication. Marguerite Blignaut walked away with the category prize for her piece entitled "Secret agents and the survival of aliens", which looks at the role of epigenetics in invasive fountain grass.

Box: 2012 student highlight

For the second year running, Stellenbosch University's Post Graduate Skills Development Programme organised the New Voices in Science workshops and competition, aiming to teach Ph.D. students to communicate their research so that "your mother can understand it", as coordinator Ronel Steyn describes it.

Two workshops were hosted by Stellenbosch University and presented by well-known science journalist and editor George Claassen and author Leonie Joubert. The workshops focused on presentation skills, sound bites and the art of describing your research in a concise yet exciting manner, as well as writing about the impact of research so that it is understood by both journalists and diverse audiences without over-selling, being informative and thought provoking with as little jargon as possible.

The C·I·B was wellrepresented at the workshops which finally culminated in a prestigious colloquium held at STIAS on the 5th of December and hosted by Prof Eugene Cloete, Vice-Rector for Research at Stellenbosch University. Of the 14 Ph.D. students who were selected to present at the gala event, three were C·I·B students.

Where are they now?

C·I·B graduates and associated researchers have gone on to make important contributions in ecology, biology, capacity-building and the environment, building upon the strong base of their training:

- Dr Lukeshni Chetty (Ph.D., University of Free State) leads the GMO Research and Monitoring unit at SANBI.
- Dr Benis Egoh (Ph.D., Stellenbosch University) is now working at the European Commission - Joint Research Centre, Institute for Environment and Sustainability (IES) Rural Water and Ecosystem Resources Unit in Italy.
- Mr Anton Hough (M.A., Stellenbosch University) conducts social science impact assessments for Coastal and Environmental Services, Grahamstown.
- Dr Rembuluwani Magoba (Ph.D., Stellenbosch University) researches biocontrol measures of invasive alien plants at the Agricultural Research Council: Plant Protection Research Institute.
- *Mr Mohlamatsane McDonald Mokhatla* (M.Sc., University of Pretoria) has an intern position as clinical data coordinator with Quantiles.
- *Mr Duncan Nkhangweleni Nengwenani* (Honours, University of Venda) is an environmental control officer at the Medupi Power Station.
- Ms Keafon Jumbam (M.Sc., Stellenbosch University) applies her taxonomic and organisational skills as a technical officer in our limbovane Outreach Project. Her enthusiasm and knowledge encourages Grade 10 biodiversity learners to better understand their environment, to appreciate our local biodiversity and to consider careers in science.
- *Ms Alexis Olds* (M.Sc., Rhodes University) is an intern with NRF-South African Environmental Observation Network (SAEON) monitoring estuaries.
- *Mr Tshililo Ramaswiela* (M.Sc., Stellenbosch University) is field technician for SAEON's Arid Lands Node, based in Kimberley. Tshililo collaborates with the Grootfontein Agricultural Development Institute.
- Dr Charmaine Uys (Ph.D., University of Cape Town) is Grassland Programme Manager for BirdLife South Africa. In addition, Charmaine is author of two children's books, My first book of Southern African Insects and My first book of Southern African Creepycrawlies (Struik Nature, 2009 and 2010 respectively).
- Dr Nicola van Wilgen (Ph.D., Stellenbosch University) is a Global Change Scientist at the SANParks Cape Research Centre, Cape Town.



Some of the C·I·B graduates of 2009, including the first two Ph.Ds. graduated from the Centre - Charlene Janion-Scheepers (M.Sc.), Elrike Marais (Ph.D.), Ethel Phiri (M.Sc.), Keafon Jumbam (M.Sc.), Thomas Lado (Ph.D.)

Besides building the skill sets and knowledge base of these 'home-grown' scientists, we have trained African researchers, thereby helping to strengthen SADC and other intra-Africa relations. In line with DST Strategic Initiative 5.5 (b) and Presidential mandates 4 (Strengthen the Skills and Human Resources Base); 8 (Pursuing African Advancement and enhanced international co-operation) and 9 (Sustainable Resource Management and use) we have built African continental capacity, for example:

- Dr Thomas Lado (Ph.D. August 2008, citizenship Sudan) lectures on various investigation techniques and on conservation genetics at the University of Juba's College of Natural Resources & Environmental Studies, South Sudan.
- Dr Sebataolo Rahlao (Ph.D. November 2009, citizenship Lesotho) is a researcher and lecturer at the University of Cape Town's Energy Research Centre.
- Dr Donald Midoko-Iponga (post-doctoral associate 2009, citizenship Gabon) is with the Tropical Research and Ecology Institute (IRET) of the National Centre for Scientific Research and Technology (CENAREST) in Libreville, Gabon.
- Mr Dickson Mgangathweni Mazibuko (M.Sc. 2012, citizenship Malawi) lectures in biology, plant physiology, biodiversity conservation and food security at the University of Malawi's Chancellor College.

C·I·B interns, hosted and trained by our researchers, have also gone on to have an impact in the field, for example:

- Mr Tshilidzi Cedric Muofhe provides support to forestry small growers, contractors and land reform beneficiaries As an Assistant Director, Post-Settlement Support, at the Dept. Agriculture, Forestry and Fisheries as an Assistant Director, Post-Settlement Support, at the Dept. Agriculture, Forestry and Fisheries.
- *Ms Leri Koegelenberg* is a now manufacturing chemist with a pharmaceuticals firm in Gauteng, having worked on numerous comparative plant genomic projects with core team member Dr Jaco le Roux of the C·I·B's Molecular Biology Lab.
- Mr Dane Paijmans, who contributed to our DNA barcoding research collaboration with SANBI, is pursuing his M.Sc., studying oystercatchers with Prof. Phil Hockey of the Centre of Excellence for Birds as Keys to Biodiversity at the University of Cape Town.
- *Ms Melanie de Morney* (B.Sc., University of the Western Cape), an intern under a C·I·B-SANBI collaboration, joined the limbovane team after her internship, using her background in Biodiversity and Conservation Ecology to educate high school learners about biodiversity in their own school grounds.
- Mr Vuledzani Mukwevho (B.Sc. (Hons), University of Venda) has been awarded a C-I-B open bursary for his M.Sc. studies at Stellenbosch University, starting in 2013.

We have earned an international reputation for outstanding ecological, environmental and invasion biology research such that young researchers from across the globe compete for post-doctoral positions. In turn, this brings diverse foreign expertise to the C·I·B, to our mutual benefit:

Dr Marc Rius (Spanish; post-doc.; University of Cape Town) has gone on to further research, as a Marie Curie Post-doctoral Fellow at the Department of Evolution & Ecology, University of California, Davis, where he is working on marine species as ecosystem engineers.

NETWORKING

The C·I·B forms partnerships and collaborates extensively, thus creating networks larger than our own direct membership, and extending the impact of C·I·B work. This has allowed the C·I·B to leverage extra expertise in such areas as student supervision and policy. For example, our relationship with the City of Cape Town via the Biodiversity Management Branch of its Environmental Resource Management Department enables our broader supervision of students to restore Fynbos in a newly-created nature reserve. Collaboration with SANBI has resulted in the C-I-B hosting and training several interns in all aspects of lab and field work. It has also led to the C-I-B making substantial contributions to the Regulations for NEM:BA⁶; and has facilitated joint training of both students and, via a short Foundation Course on Biological Invasions, of WfW field managers.

Recognition of the C-I-B's shared commitments led to the creation of a joint research chair (South African Research Chair Initiative) with the University of Venda, and to substantial participation in SANBI's EDRR initiative. EDRR is tasked with identifying potential invasives before their spread becomes problematic, and at an early stage when relatively small investment of time and resources may prevent a far more costly and wide-spread invasion from becoming established. EDRR relies, in part, on the participation and awareness of the public, which also serves to advertise our overall efforts and the threat of biological invasions.

Our networked partners extend across South Africa, from peer universities housing our extended core team members and open bursary programme supervisors to fellow research institutions such as the Centre for Scientific and Industrial Research (CSIR), SANBI and South African Institute for Aquatic Biodiversity (SAIAB). In addition, we collaborate with SANParks, where our research has been instrumental in shaping policy (as cited under Research, above).

The C·I·B interacts directly with scientific peers at national and international conferences, and has organised and hosted key conferences. In November 2008, the C·I·B hosted an international symposium to commemorate the 50th anniversary of the publication

⁶ The C·I·B's NEM:BA research was commissioned by the Department of Environmental Affairs

of the book that launched the systematic study of biological invasions '*The ecology of invasions by animals and plants*' by Charles Elton. One hundred and forty delegates from 12 countries attended the 3-day meeting, which provided an exciting forum for scientists and managers to interact, as well as 37 post-

graduate and 10 post-doctoral students, many from historically-disadvantaged groups of whom six were (non-South) Africans. Contributions from the symposium formed the basis for an edited book '*Fifty years of invasion ecology*' published by Wiley-Blackwell in 2011.



Participants in a workshop on 'Human-mediated introductions of Australian Acacia species—a global experiment in biogeography' hosted and organised by the Centre in October 2010. The workshop resulted in a special issue of 21 papers in the journal Diversity and Distributions (18 of them with at least one C-I-B-affiliated author).

The C·I·B also hosted the 10th meeting in the conference series on Ecology and Management of Alien Plant Invasions (EMAPI), the premier international forum for scientific research in the field of plant invasions. EMAPI10 was held in Stellenbosch in August 2009 and was the first EMAPI conference in Africa. Shortly after EMAPI10, the C·I·B presented a five-day course on Biological Invasions: Recent Advances and Traditional Tools in collaboration with WfW and SANBI's EDRR programme. The course aimed to serve the needs of middle- to upper-level regional managers in WfW and EDRR throughout South Africa, and to present an overview of international best practice in environmental management with a strong emphasis on requirements for managing invasive species. In 2010, the C·I·B hosted an international, interdisciplinary workshop on the ecology of one of the most notoriously invasive groups of plants worldwide - Australian Acacia species. The workshop brought together 62 researchers from 15 countries and led to the production of a special issue of 21 papers in the international journal Diversity and *Distributions* in 2011.

In May, 2011 the C-I-B organised an Antarctic Conservation Workshop attended by 28 researchers, journalists and officials from 8 countries. The programme included discussions and papers on diverse topics, ranging from ecology, conservation and climate change to Antarctic tourism, politics and treaties. This workshop resulted in a paper published in *Science* (Chown *et al.* 2012c).

Also in 2011, the C-I-B hosted the 7th Scientific Committee on Antarctic Research History Workshop at Stellenbosch University with the theme 'Antarctic History: Probing the Unknown'. Delegates from ten countries reflected on the current historical and archaeological research being done in Antarctica and sub-Antarctic islands. 'The workshop was an opportunity for South African and international academics to discuss and critically evaluate how historians with Antarctic interests can most fruitfully use the growing accessibility of diverse source material to further research' said Dr Cornelia Luedecke, who chairs the SCAR History committee. Workshop attendees noted the successful efforts by the Antarctic Legacy Project to provide online archival databases containing the history of South African research in the Southern Ocean and Antarctic territories over the past six decades. An online database is being compiled that includes oral, visual and tangible memories of the thousands of men and women who have worked in these cold regions over the years as part of, among others, SANAP. The Antarctic Legacy project⁷ is supported by the DST and NRF through SANAP.

Table 2: Partners, funders and collaborators of the Centre for Invasion Biology (2008-2012)

Partners(hosting one or more core team members)
Stellenbosch University
University of Pretoria
University of Venda
University of Cape Town
University of Johannesburg
University of KwaZulu-Natal
Council for Scientific and Industrial Research (CSIR)
South African Institute for Aquatic Biodiversity
South Africa National Biodiversity Institute
South African National Parks

Major funders and donors

Stellenbosch University and the Hope Project Department of Science and Technology National Research Foundation AfriSam Anglo American Chairman's Fund (concluded) Rand Merchant Bank Fund The Darwin Initiative (concluded) The Drakenstein Trust May and Stanley Smith Charitable Trust (concluded)

Collaborators

Working for Water CapeNature City of Cape Town Czech Institute of Botany Iziko Museums of Cape Town Institute for Biological Invasions, University of Tennessee Biodiversity and Macroecology Group, Department of Animal and Plant Sciences, University of Sheffield (concluded) British Antarctic Survey (concluded) Centre for Advanced Studies in Ecology and Biodiversity, Pontificia Universidad Católica de Chile (concluded)

Two major meetings were arranged by the C·I·B in 2012. The first, in August, was entitled Rapid Response,

⁷ http://academic.sun.ac.za/cib/antarcticlegacy/

Early Detection & Risk Assessment of Invasive Species (RREDRA). The workshop presented the opportunity for invited international experts to exploration key themes that are central to advances in the field of risk analysis and management of invasive species. A workshop on tree invasions was arranged by the C-I-B in association with the University of Tennessee's Institute of Biological Invasions. This meeting, held in Bariloche, Argentina, investigated many aspects of human-mediated transport and dissemination of thousands of tree species for a wide range of uses, including forestry and ornamental horticulture. The workshop will result in a special issue of the international journal *Biological Invasions* during 2013.



Dr Piero Genovesi, Chair of the Invasive Species Specialist Group, IUCN Species Survival Commission, speaks at the C·I·B's annual research meeting in 2012

INFORMATION BROKERAGE

The C-I-B contributes to the knowledge economy by using our research to inform society by raising awareness and educating through broad-based information brokerage. We have published a range of research papers and conference proceedings, book chapters, and scientific books (Table 3) during the past four and a half years. One of our most notable popular books was 'Invaded - The Biological Invasion of South Africa' (2009), by award-winning freelance writer and former C-I-B associate, Leonie Joubert. Our website is another important platform through which we communicate and inform the public about issues surrounding invasive species. It achieved an average of 1380 hits per month between 2009 and 2011.

We also informed the public about our research using several platforms. In 2010, we hosted a very successful public lecture series on the International Year of Biodiversity which informed the public about the successful efforts of the Convention on Biological Diversity (CBD) in halting biodiversity loss. We have also informed about invasive species' role as agents of environmental change through a number of publications in popular science publications, news articles, public lectures, science and environmental expos; through the broadcast media; and through our renowned limbovane Outreach Project (more details on this project below). Furthermore, we share knowledge more indirectly through primary scientific literature; scientific books; popular articles and books; print, broadcast and online media; and through up-to-date websites, online resources and via radio programmes (Table 3).

Research outputs:		Media interactions	
Primary research papers	459	Popular articles	61
Books	10	Popular talks	38
Book chapters	57	Broadcasts	53
Published conference proceedings	22	Print media articles	169
Conference presentations:	288	Online media items	241
Keynote addresses	36		
Oral presentations	180		
Poster presentations	72		

Table 3. Research, networking and information brokerage indicators for the review period (Jul. 2008 – Dec. 2012)

Besides generating knowledge and sharing it, the C-I-B created a knowledge management system to secure and manage long-term research data and outputs, the Information Retrieval and Submission System (IRSS). The IRSS currently stores more than 6o2 research papers, 177 theses and data sets, including data sets from graduated students and long-term projects. These resources will gain value over time in facilitating the recognition of long-term patterns and opening opportunities for broader collaborations.

The limbovane Outreach Project⁸ uses an experiential learning approach to help learners and educators who are not regularly exposed to scientific projects appreciate South Africa's biodiversity and learn how science works. limbovane, undertaken in collaboration with WCED, has benefited science education and conservation by (1) improving understanding of the concept of biodiversity among Life Science learners and educators; (2) establishing a monitoring and inventory protocol for an ecologically important and poorly understood taxonomic group (ants), which assists South Africa in implementing and contributing to the

http://www.youtube.com/watch?v=sRC6AEX3Jkk

monitoring goals of the Convention of Biological Diversity; and (3) generating valuable information on the diversity and distributions of invertebrates (native and alien species).

One of the key interventions identified to stem biodiversity loss is increased general public education on the importance of biodiversity and problems associated with its loss. As a signatory to the Convention on Biological Diversity, South Africa has made a commitment to raise public education levels and to identify and monitor key species. The C-I-B identified ants as a suitable group of organisms on which to base an innovative outreach and awarenessraising project (limbovane) because ants are common in the environment, are easy to collect, and are mostly completely harmless to humans.

limbovane involves secondary school learners and educators in biodiversity science. Biodiversity was not explicitly included in the South African secondary school curriculum before 2006, but this changed with the South African National Curriculum Statement for Grade 10–12 Life Science, which introduced a major component dealing with biodiversity, continuity and environmental change. When the new curriculum was introduced, a substantial knowledge gap became evident, as educators were not well-equipped to teach the concept and practice of biodiversity science to learners or had not received formal training in this

⁸ Home page at <u>http://wwwo.sun.ac.za/limbovane/</u> and short film on the project at

relatively new field. limbovane fills this gap and also provides important additional support services to educators and learners. For example, educators and learners are invited to workshops at Stellenbosch University, and to voluntary 'winter weeks' where interested individuals can enhance their learning. To date, 32 microscopes, 12 laptop computers and 17 data projectors have been donated to participating schools, allowing them to teach biodiversity in a more visual, hands-on and accessible manner. Educators and Western Cape Education Department (WCED) curriculum planners emphasize the positive effect of these limbovane educational resources on educators and the quality of teaching in life science classrooms, even if they are used to support existing practice: 'In this digital age, no biology class can be without a microscope and data projector. From the WCED side, we are thankful [to] the project for making it easier for our educators to teach our learners.' (Mr Tommy Botha, WCED Senior curriculum planner for FET Life Sciences).

Recent changes in the national curriculum have further emphasised the importance of limbovane in the classroom. From 2012 onwards, practical experiments across all the Knowledge Strands, including biodiversity, are compulsory. As a consequence, limbovane schools are well-positioned to take up the new challenges, having taken part in real field and laboratory experiments for several years.

⁹ Ballouard *et al.* (2011) recognise limbovane as an innovative, leading science education programme in an international publication: 'The rarity of educational programmes based on both field experience and noniconic animals is particularly unfortunate considering successful initiatives such as the limbovane Outreach Project in South Africa that explores biodiversity in school grounds and surrounding natural areas based on ants' ecology and diversity as a mean to connect children to their environment.'

'Prior to limbovane it was a great effort for my learners to come to terms with biodiversity science. They simply learned the prescribed definitions but had no way of applying it to a practical investigation. This year, however, the learners showed a real understanding of the content because they could relate the theory to their own experience in the field.' (Ms Nxele, Life Science educator, Luhlaza Secondary School, Khayalitsha, Western Cape).

Educators benefit from the project through the assistance they receive in development of educational resources such as worksheets, activities and projects for learners, which use data from the limbovane Project. All these activities are aligned with the National Curriculum Statement Grades 10-12 (Life Sciences) to ensure that Specific Aims and Assessment Standards for Knowledge Strand 3 (Diversity, Continuity and Change) and 4 (Environmental Studies) in Grade 10 can be achieved: 'As life science educator I struggle to develop sufficient assessment activities especially on topics related to biodiversity monitoring and South African biodiversity in general. After being introduced to limbovane and receiving outreach visits from the team, I have access to assessment activities for my class. From a personal perspective, the worksheets are very educational and thorough. It provides a great reference guide for life science educators who constantly need to develop practical ways of presenting biodiversity science.' (Ms. Bentele, Head of Life Science Department, Manzomthombo Secondary School, Blackheath, Western Cape).

The limbovane Outreach Project has reached a large number of educators and learners in recent years. Initially benefiting only ten schools in its first year, we have expanded substantially and now work with learners and educators from 18 schools. limbovane's positive impacts on education were recognised by the corporate sector, which is now a regular funder of limbovane's activities. Corporate funding is used to further expand the project on a reduced participation model, in which interested schools can subscribe to the limbovane Outreach Project and implement the project independently using a custom-designed 'starter kit'. The subscription system is being implemented successfully in ten additional secondary schools.

Of the total of 28 participating schools, 17 are located in rural areas and 11 in urban areas. Ninety three percent (26 out of 28 schools) of schools serve previously disadvantaged communities. Since 2006, we have trained six WCED curriculum advisors, approximately 210 educators and 8 900 Grade 10 and 11 learners have been introduced to biodiversity science. A further 108 learners attended voluntary project workshops at the limbovane labs in Stellenbosch

⁹ Ballouard J.-M., Brischoux, F. & Bonnet, X. 2011. Children prioritize virtual exotic biodiversity over local biodiversity. *PLoS One*, 6, e23152. doi:10.1371/journal.pone.0023152 e23152



limbovane learners at work in the classroom

'limbovane helped learners to understand the abstract theory of species diversity'

Participating educator

'It is amazing to see ants under the microscope; I never knew that ants have hair on their bodies! The experience was more than just learning about ants; we also observed how a laboratory work and what a day in the life of a 'scientist' looks like. We loved working at the limbovane ant lab and would like to help again.' Nathi Ngwane, learner from Mazomthombo Secondary

School, Blackheath, Western Cape

A less tangible but extremely important effect of the project is to promote post-school study in the scientific fields, through having regular contact with scientific staff employed in the field, enjoying their jobs. The C-I-B staff who work on limbovane are all women, which sends a powerful message to young people about traditional gender roles: 'The Ant ladies [the limbovane project team] are role models to our learners, especially the girls. Many girls were inspired to continue with their studies after school' (Participating educator).

SERVICE PROVISION

In addition to providing information, above, the C-I-B also provides service as an application of our researchers expertise and of our research itself. We have contributed extensively to legislation such as NEM:BA (see below) and the Prince Edward Islands protected area management plans under the National Environmental Management: Protected Areas Act (No. 57 of 2003); and to international guidelines such as Global Indicator for Invasive Species (see below) and both national body level and international contributions to Scientific Committee for Antarctic Research (SCAR).

Our expertise has been sought by our African neighbours, as in an Environmental Impact Assessment for a proposed hydro-electric development in Malawi, as well as in response to information sought by international coordinating bodies such as the United Nations (Section 3.4 on Invasive aliens In: South Africa's Second National Contribution to the United National Framework Convention on Climate Change).

The C·I·B has devoted considerable resources to feeding key research findings from its own programmes and from the international literature into assisting with the formulation of the NEM:BA regulations relating to alien and invasive species. Chapter 5 of NEM:BA deals with alien and invasive species, and provides for the integrated management of alien and invasive species in all taxonomic groups. Several of our core team members participated in a Task Team assembled by the DEA and SANBI to develop objective, science-based lists of alien and invasive species, to compile a risk-assessment framework based on the international best-practice and advances in invasion biology in South Africa, and to participate in the overall drafting of the regulations.

New research was commissioned to address key areas identified in NEM:BA and its requirements. In particular, focussed work was done on updating the knowledge base on poorly-studied alien species (notably marine species); aspects of risk assessment (in particular the modification of systems used elsewhere for application in South Africa); protocols for the objective listing of alien species in different categories (all taxa); the determination of natural ranges of native South African biota (especially ungulates); factors driving the importation of alien species to South Africa (with special emphasis on amphibians and reptiles, and plants for use in forestry and for biofuel production); and assessments of the feasibility of eradication of select species. Outcomes from diverse C·I·B research were used in the process, and our expert insights ensured that the regulations were grounded in international best practice from the fields of invasion biology and environmental management (please see the National Biodiversity Assessment 2011 Synthesis Report¹⁰.

10

http://bgis.sanbi.org/nba/NBA2011 SynthesisReport lowres. pdf (Section 11 of this document synthesizes much of the work of the C-I-B towards understanding the threats of invasive species on South Africa's biodiversity; seven C-I-Bfunded papers are cited as key evidence in this 14-page section)

The Convention on Biological Diversity selected key indicators to measure progress towards the Millennium Development Goals and the target of reducing the rate of loss of biodiversity by 2010. As invasive alien species are a major threat to global biodiversity, the 'trends in invasive alien species' indicator was selected as one of these key indicators to measure progress towards the target of reducing the rate of loss of biodiversity by 2010. The C·I·B was contracted to develop and apply this indicator; thus we developed three component indicators which demonstrated that the global threat from invasive alien species is not adequately being reduced. Although there has indeed been some response, countries have not sufficiently responded to the threat to biodiversity and livelihoods posed by invasive alien species.

The 2010 Biodiversity Indicators Partnership brought together over 40 organizations working on a suite of indicators to assess progress in different environmental sectors. GISP and the IUCN were the key partners in this project: the C-I-B's work was incorporated into a substantial report on the experiences and lessons learnt from the indicator development. Factsheets on the indicators have also been developed and are available online¹¹.

We maintain a website dedicated to the indicators and a database of alien species in the target countries¹² that is used to assess trends in invasive alien species. Two hundred and thirty two users from 56 countries have registered to use the database. These users have made 457 enquiries on the database, viewing or downloading information on 58 countries. The invasive alien species target (No. 9) of the Aichi Biodiversity Targets now paves the way for both further development and testing of the invasive alien species indicator.

Editorial boards and reviewing

Between July 2008 and December 2012, our core team members participated in numerous editorial and reviewing duties. C-I-B core team members served as editors or associate editors of 28 journals, and on 51 different editorial boards (Table 4).

<u>http://www.gisp.org/science/BIP.asp</u> which details our role in developing the indicator for invasive species)

Table 4. Editorial service provision by C·I·B team members

ROLE	NUMBER OF PUBLICATIONS
Editor/Editor-in-Chief – international	3
Editor – national	3
Associate Editor - international	18
Associate editor - national	4
Editorial Boards - international	35
Editorial boards - national	16
Grand Total	79

MANAGEMENT

The C·I·B has a hub-and-spoke structure, with its headquarters at Stellenbosch University, a secondary hub at the University of Pretoria, and 23 core team members and 13 research associates at many other institutions throughout South Africa and in other parts of the world.

The Director and Deputy-Director: Operations are based at Stellenbosch University, as are all administrative and technical support staff, apart from one position at the University of Pretoria. Details of the staff are provided in Table 5. Activities of the C·I·B are quided by the C·I·B Board which is chaired by the Vice Rector: Research and Innovation, Stellenbosch University, and comprises representatives of the DST, NRF, key partner organizations, and two international science advisors. The Board approves the budget and plans for the C·I·B's activities and priorities as set out in the C·I·B Strategic Plan which is revised periodically (the current Strategic Plan was approved in 2011 to guide activities between 2012 and 2014). The Board meets twice a year. The full C·I·B team gathers for an annual research meeting (ARM) of 2-3 days once a year during November. The ARM serves both as a forum for reporting on and discussing progress in all KPAs and for workshopping priorities for the future. In some years the ARM is combined with a symposium or workshop. Besides the international science advisors, an international keynote speaker addresses the ARM in most years.

¹¹ <u>www.bipindicators.net/invasivealienspecies (see also</u> Biological Indicators Partnership website

¹² www.sun.ac.za/iasi

Name	Employer	Position	Condi <u>tions</u>	Status	Race	Gender
Management staff						
Prof. David Richardson	SU	Deputy-Director: Science Strategy (until April 2012); Director (since May 2012)	Full time	Current	White	Male
Prof. Steven Chown	SU	Director	Full time	Resigned May 2012	White	Male
Ms Sarah Davies	SU	Deputy-Director: Operations	Full time	Current	White	Female
Dr Elrike Marais	SU	Research Manager: Contracts	Part time	Current	White	Female
Ms Dorette Du Plessis	SU	Outreach Manager	Full time	Current	White	Female
Researchers						
Dr Susana Clusella-Trullas	SU	Researcher: Environmental Physiology	Full time	Dept. Botany & Zoology, SU	White	Female
Dr Mirijam Gaertner	SU	Researcher: Eucalyptus	Full time	Current	White	Female
Dr Cang Hui	SU	Researcher: Mathematical Ecology	Full time	Current	Asian	Male
Dr Jaco le Roux	SU	Manager, Molecular Laboratory	Full time	Dept. Botany & Zoology, SU	White	Male
Dr John Wilson	SANBI	Researcher: Invasive Species	Full time	Current	White	Male
Support staff (permanent)						
Ms Karla Coombe-Davis	SU	Principal Technical Officer: Databases	Full time	Current	White	Female
Ms Erika Nortje	SU	Technical Officer: Lab Management	Full time	Current	White	Female
Ms Suzaan Kritzinger- Klopper	SU	Senior Technical Officer	Full time	Current	White	Female
Ms Anél Garthwaite	SU	Personal Assistant to the Part time Current Director		White	Female	
Mrs Christy Momberg	SU	Management Assistant	Part time	Current	White	Female
Mrs Chantal Ferreira	UP	Administrative Officer	Part time	Current	White	Female
Ms Mathilda van der Vyver	SU	Administrative Officer	Full time	Current	White	Female
Ms Josephine de Mink	SU	Editorial Assistant: Wiley- Blackwell Publishing	Part time	Current	Black	Female
Ms Keafon Jumbam	SU	Technical Officer: limbovane Outreach Project	Full time	Current	Black	Female
Ms Thembile Khoza	SU	Technical Officer: Long Term Sites	Full time	Current	Black	Female
Ms Tlou Manyelo	SU	Technical Officer: Long Term Sites	Full time	Resigned July 2012	Black	Female
Mr Mawethu Nyakatya	SU	Senior Technical Officer: Project Management	Full time	Resigned March 2010	Black	Male
Support staff (contract)						
Ms Dora Scott	SU	Technical Officer: Antarctic Legacy Project	Full time	Current	White	Female
Ms Charlene Janion- Scheepers	SU	Technical Officer: Norway- Sweden Projects Part time Current		Current	White	Female
Ms Melanie de Morney	SU	Assistant Technical Officer: limbovane		Black	Female	
Ms Olivia Fragale	SU	Assistant Technical Officer: limbovane	Full time	Current	White	Female
Ms Ria Olivier	SU	SANAP Assistant	Part time	Current	White	Female
Dr Marienne de Villiers	SU	Researcher: Prince Edward Islands Management Plan	Full time	Apr. 2010-Sep. 2010	White	Female
Ms Ulrike Irlich	SU	Researcher: Climate Change	Full time	July 2009-May 2010	White	Female
Ms Elizabeth Kleynhans	SU	Researcher: GISP	Full time	Apr. 2009-Apr. 2010	White	Female
Ms Rhoda Moses	SU	Administrative Assistant	Part time	Aug. 2009-Jan. 2012	Black	Female

Table 5: Staff at the Centre for Invasion Biology during the review period (Jul. 2008 – Dec. 2012)

Name	Employer	Position	Conditions	Status	Race	Gender
Ms Asanda Phiri	SU	Technical Officer: Marion I.	Full time	To Apr. 2010	Black	Female
Ms Nicole Southaate	SU	Assistant Technical Officer:	Fulltime	Perigned Ian 2012	Black	Female
	50	limbovane	i un unne	Resigned Jan. 2012	DIACK	remale
Interns						
Ms Leri Koegelenberg	SANBI	Intern: SA IBOL	Full time	Aug. 2011-Nov. 2011	White	Female
Mr Dane Paijmans	SANBI	Intern: SA IBOL	Full time	Aug. 2011-Dec. 2011	White	Male
Mr Cedric Muofhe	DWAF	Intern: WfW	Full time	Resigned Mar. 2012	Black	Male
Ms Megan Koordom	NRF	Intern: NRF	Full time	Current	Black	Female
Mr Vuledzani Mukwevho	SANBI	Intern: SA IBOL	Full time	Current	Black	Male
Ms Khensani Rakgalakane	SANBI	Intern: SA IBOL	Full time	Current	Black	Female

Outstanding institutional support is provided by Stellenbosch University in the form of a substantial direct financial contribution, waiving of infrastructure costs, and access to research funding through the University's Sub-committee B. Salaries of the Director and two core team members are paid by the Department of Botany & Zoology. All C·I·B staff and research associates have access to facilities at Stellenbosch University, including human resources management services, the excellent library and information services and the vehicle pool.

FUNDING

The income of the Centre has grown steadily through its life, and the Centre's now generates annually 40 to 50% of total income from sources other than the -DST-NRF.

CONCLUSION

The C·I·B has achieved all objectives set out in its Strategic Plan. It is firmly established as **THE** centre for research, student training and service provision in issues relating to biological invasions in South Africa. We aim to strengthen this position through further engagement with all organizations involved with policy and management of invasive species in the country.

The Centre is already recognized as one of the top centres for innovative research in invasion ecology worldwide. Plans to build on this reputation include strategies to focus research on the hottest topics in the field internationally (using South Africa as a model system wherever possible) through increased collaboration with key international partners, convening workshops and symposia, and encouraging international transfers of researchers and students.

Table 6: Income of the Centre for Invasion Biology for the review period

Note: Income reflected in Table 6 does not include grants made to individual researchers, but only funds for core Centre activities managed in audited cost centres at Stellenbosch Unviersity. (2008 is covered in full because it is impossible to split accurately the income received for annual tranches of long term grants and shorter projects. However, it is feasible to obtain a notional figure for 1 July - 31 December 2008 from 50% of the annual income, i.e. approximately R 6 174 505.).

	052744	1 314 000	/41 452	394 /90	110 045
International	652744	1 21 / 806	7/1/52	201 706	118 0/ 5
National: Other	1 145 680	2 315 381	2 266 690	1 427 480	1 882 895
Interest on credit balances	287 464	207 204	164 447	201 496	221 235
Stellenbosch University	3 712 808	4 747 706	4 351 890	4 277 796	3 453 346
DST-NRF CoE grant	6 548 306	6 818 362	7 748 899	7 772 174	8 096 985
	2008	2009	2010	2011	2012

Appendix: C•I•B Publications

PEER-REVIEWED JOURNAL ARTICLES

The ten best cited papers are indicated with asterisks. On 10 January the publications listed here had received 4492 citations, with an H-index of 31.

- Abdel-Rahman, E.H., Taylor, P.J., Contrafatto, G., Lamb, J.M., Bloomer, P. and Chimimba, C.T. (2009). Geometric craniometric analysis of sexual dimorphism and ontogenetic variation: A case study based on two geographically disparate species, *Aethomys ineptus* from southern Africa and *Arvicanthis niloticus* from Sudan (Rodentia: Muridae). *Mammalian Biology* 74, 361-373.
- Abdoullaye, D., Acevedo, I., Adebayo, A.A., Behrmann-Godel, J., Benjamin, R.C., Bock, D.G., Born, C., Brouat, C., Caccone, A., Cao, L.Z., Casadoamezua, P., Cataneo, J., Correa-Ramirez, M.M., Cristescu, M.E., Dobigny, G., Egbosimba, E.E., Etchberger, L.K., Fan, B., Fields, P.D., Forcioli, D., Furla, P., de Leon, F.J.G., Garcia-Jimenez, R., Gauthier, P., Gergs, R., Gonzalez, C., Granjon, L., Gutierrez-Rodriguez, C., Havill, N.P., Helsen, P., Hether, T.D., Hoffman, E.A., Hu, X.Y., Ingvarsson, P., Ishizaki, S., Ji, H.Y., Ji, X.S., Jimenez, M.L., Kapil, R., Karban, R., Keller, S.R., Kubota, S., Li, S.Z., Li, W.S., Lim, D.D., Lin, H.R., Liu, X.C., Luo, Y.Y., Machordom, A., Martin, A.P., Matthysen, E., Mazzella, M.N., McGeoch, M.A., Meng, Z.N., Nishizawa, M., O'Brien, P., Ohara, M., Ornelas, J.F., Ortu, M.F., Pedersen, A.B., Preston, L., Ren, Q., Rothhaupt, K.O., Sackett, L.C., Sang, Q., Sawyer, G.M., Shiojiri, K., Taylor, D.R., van Dongen, S., Jansen van Vuuren, B., Vandewoestijne, S., Wang, H., Wang, J.T., Lewang, Xu, X.L., Yang, G., Yang, Y.P., Zeng, Y.Q., Zhang, Q.W., Zhang, Y., Zhao, Y. and Zhou, Y. (2010). Permanent Genetic Resources added to Molecular Ecology Resources Database 1 August 2009-30 September 2009. *Molecular Ecology Resources* **10**, 232-236.
- Abraham, S., Somers, M.J. and Chown, S.L. (2011). Seasonal, altitudinal and host plant-related variation in the abundance of aphids (Insecta, Hemiptera) on sub-Antarctic Marion Island. *Polar Biology* 34, 513-520.
- Abril, S., Roura-Pascual, N., Oliveras, J. and Gomez, C. (2009). Assessing the distribution of the Argentine ant using physiological data. *Acta Oecologica-International Journal of Ecology* **35**, 739-745.
- Agenbag, L., Esler, K.J., Midgley, G.F. and Boucher, C. (2008). Diversity and species turnover on a climatic gradient in the Riviersonderend Mountains, Western Cape. *Bothalia* **38**, 1-5.
- Allen, J.L., Clusella-Trullas, S. and Chown, S.L. (2012). The effects of acclimation and rates of temperature change on critical thermal limits in *Tenebrio molitor* (Tenebrionidae) and *Cyrtobagous salviniae* (Curculionidae). *Journal of Insect Physiology* **58**, 669-678.
- Alves da Mata, R., McGeoch, M.A. and Tidon, R. (2008). Drosophilid assemblages as a bioindicator system of human disturbance in the Brazilian Savanna. *Biodiversity and Conservation* **17**, 2899-2916.
- Andresen, L., Everatt, K.T., Somers, M.J. and Purchase, G.K. (2012). Evidence for a resident population of cheetah in the Parque Nacional do Limpopo, Mozambique. *South African Journal of Wildlife Research* 42, 144-146.
- April, V., Robertson, M.P. and Simelane, D.O. (2011). Interaction between Uroplata girardi (Coleoptera: Chrysomelidae) and Ophiomyia camarae (Diptera: Agromyzidae) on a shared host Lantana camara (Verbenaceae). Environmental Entomology 40, 1123-1130.
- *Archibald, S., Roy, D.P., van Wilgen, B.W. and Scholes, R.J. (2009). What limits fire? An examination of drivers of burnt area in Southern Africa. *Global Change Biology* **15**, 613-630.

- Aronson, J., Blignaut, J.N., Milton, S.J., Le Maitre, D., Esler, K.J., Limouzin, A., Fontaine, C., de Wit, M.P., Mugido, W., Prinsloo, P., van der Elst, L. and Lederer, N. (2010). Are socioeconomic benefits of restoration adequately quantified? A meta-analysis of recent papers (2000-2008) in *Restoration Ecology* and 12 other scientific journals. *Restoration Ecology* 18, 143-154.
- Bairstow, K.A., Clarke, K.L., McGeoch, M.A. and Andrew, N.R. (2010). Leaf miner and plant galler species richness on *Acacia*: Relative importance of plant traits and climate. *Oecologia* **163**, 437-448.
- Barbet-Massin, M., Walther, B.A., Thuiller, W., Rahbek, C. and Jiguet, F. (2009). Potential impacts of climate change on the winter distribution of Afro-Palaearctic migrant passerines. *Biology Letters* 5, 248-251.
- Barnaud, A., Deu, M., Garine, E., Chantereau, J., Bolteu, J., Koida, E.O., McKey, D. and Joly, H.I. (2009). A weed-crop complex in Sorghum: The dynamics of genetic diversity in a traditional farming system. *American Journal of Botany* **96**, 1869-1879.
- Bastos, A.D., Nair, D., Taylor, P.J., Brettschneider, H., Kirsten, F., Mostert, E., Von Maltitz, E., Lamb, J.M., van Hooft, P., Belmain, S.R., Contrafatto, G., Downs, S. and Chimimba, C.T. (2011). Genetic monitoring detects an overlooked cryptic species and reveals the diversity and distribution of three invasive *Rattus* congeners in South Africa. *BMC Genetics* 1218 pages. DOI: 10.1186/1471-2156-12-26.
- Becker, P.A., Miller, P.S., Gunther, M.S., Somers, M.J., Wildt, D.E. and Maldonado, J.E. (2012). Inbreeding avoidance influences the viability of reintroduced populations of African Wild Dogs (*Lycaon pictus*). *PloS One* 7, e37181. DOI: 10.1371/journal.pone.oo37181.
- Beekman, M., Allsopp, M.H., Holmes, M.J., Lim, J., Noach-Pienaar, L.A., Wossler, T.C. and Oldroyd, B.P. (2012). Racial mixing in South African honeybees: The effects of genotype mixing on reproductive traits of workers. *Behavioral Ecology and Sociobiology* 66, 897-904.
- Bengtsson, J., Janion, C., Chown, S.L. and Leinaas, H.P. (2011). Variation in decomposition rates in the fynbos biome, South Africa: The role of plant species and plant stoichiometry. *Oecologia* **165**, 225-235.
- Bengtsson, J., Janion, C., Chown, S.L. and Leinaas, H.P. (2012). Litter decomposition in fynbos vegetation, South Africa. *Soil Biology and Biochemistry* **47**, 100-105.
- *Bergstrom, D.M., Lucieer, A., Kiefer, K., Wasley, J., Belbin, L., Pedersen, T.K. and Chown, S.L. (2009). Indirect effects of invasive species removal devastate World Heritage Island. *Journal of Applied Ecology* 46, 73-81.
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