Online Appendix 1: Editorial - ABC #2207

The programme for the 43rd Annual Research Symposium on the Management of Biological Invasions in South Africa

43rd Annual Research Symposium on the Management of Biological Invasions 18–20 May 2016

Goudini Spa, near Worcester, Western Cape

Source: This is a word cloud drawn using www.wordle.net online based on the abstracts and titles of the symposium programme (Appendix 1).

FIGURE 1: The 43rd Annual Research Symposium on the Management of Biological Invasions in South Africa covered a range of topics.

Chair of the organising committee: Dave Richardson

Scientific sub-committee: Brian van Wilgen, Candice Lyons, Fiona Impson, Jaco le Roux, John Wilson, Karen Esler, Mirijam Gaertner, Sabrina Kumschick, Sebataolo Rahlao.

Logistics sub-committee: Philip Ivey, Ruqaya Adams, Sarah Davies

Programme

Wednesday 18 May 2016, afternoon

12:30–13:45	ARRIVE + LUNCH	
13:50–14:00	David Richardson	Opening of the meeting
SESSION 1: Chair—Fiona Impson		
14:00–14:45	Robert Scholes	KEYNOTE: Scientific assessments: matching the approach to the problem
14:45–15:00	John Wilson	A national status report on biological invasions in South Africa: what do we need to do and what should we do?
15:00–15:15	Jennifer Fill	A new assessment of the costs required to bring invasive alien plants under control in the protected area network of the Cape Floristic Region
15:15–15:30	Tineke Kraaij	Assessing the effectiveness of invasive alien plant management in a large fynbos protected area
15:30–16:00	TEA	
SESSION 2: Chair—Candice Lyons		
16:00–16:15	Michelle Greve	Status of invasions on sub-Antarctic Marion and Prince Edward islands
16:15–16:30	Charles Griffiths	Marine bioinvasions in South Africa–status and states of knowledge
16:30–16:45 4 × 3 minute Speed talks	Tamara Robinson	Invasions within South Africa's Marine Protected Areas network
	Clova Mabin	Controlling *Carcinus maenas* in Hout Bay harbour: the first attempted extirpation of a marine invasive species in Africa
	Ana Nunes	Freshwater crayfish invasions in South Africa
	Stefan Foord	Invertebrate diversity in response to the removal of alien invasive plants in the Luvuvhu river catchment: indications of recovery
16:45–17:00	Martin Hill	The contribution of biocontrol of aquatic weeds to water and biodiversity
17:00–17:15	Jaclyn Hill	The functional response of aquatic plant invaders
17:15–17:30 4 × 3 minute Speed talks	Tamzin Griffith	Does phenotypic plasticity influence the thermal physiology of *Eccritotarsus catarinensis*?
	Nomvume Petela	Interactions between two biological control agents of *Eichhornia crassipes* (Mart.) Solms-Laub (Pontederiaceae), the weevil *Neochetina eichhornia* Hustache (Coleoptera: Curculionidae) and the plant hopper *Megamelus scutellaris* Berg (Hemiptera: Delphacidae).
	Samella Ngxande-Koza	Induced chemical compounds: attractants or repellents to *Falconia intermedia*?
	Ludzula Mukwevho	Influence of climatic factors and varietal resistance on the establishment, performance and geographic distribution of the eriophyid mite *Aceria lantanae* (Cook) (Acari), a biocontrol agent for *Lantana camara* L. (Verbenaceae), in South Africa
17:40–18:00	Discussion with authors of papers proposed for the Special Issue of Bothalia: African Biodiversity and Conservation	
19:00	BRAAI	

Thursday 19 May 2016, morning

SESSION 3: Chair—Tineke Kraaij		
09:00–09:15	Llewellyn Foxcroft	Biological invasions in South Africa's National Parks
09:15–09:30	Mirijam Gaertner	What does it take for municipalities to become compliant with the regulations on biological invasions? Lessons from the city of Cape Town

Programme

09:30–09:45 4 × 3 minute Speed talks	Ashlyn Padayachee	Cities as hotspots for invasions: The case of the eThekwini municipality
	Phil McLean	Where are the invaders hiding? Insights on the compilation of species and occurrence data for alien plants in small urban areas: Examples from Riebeek Kasteel, Western Cape, South Africa.
	Errol Douwes	The Durban Invasives Website: tracking and control of selected invasive alien plants, in an urban context
	Philip Ivey	Invasive species research funding futures–bright or bleak?
09:45–10:00	Costas Zachariades	Biological control as a management tool for suppression of terrestrial invasive alien plants in South Africa
10:00–10:15	Lorraine Strathie	Towards understanding field performance of introduced insect agents on *Parthenium hysterophorus* in South Africa
10:15–10:30 4 × 3 minute Speed talks	Zezethu Mnqeta	Interactions between two biological control agents of *Pereskia aculeata*
	Pippa Muskett	The Pereskia stem-wilter, *Catorhintha schaffneri* (Coreidae), a new biological control agent for *Pereskia aculeata* (Cactaceae). Eighteen months since release, where are we now?
	Lumka Mdodana	A new candidate biological control agent for the control of *Pereskia aculeata* Miller (Cactaceae) in South Africa.
	Guy Sutton	What are the factors that influence successful biological control of *Cereus jamacaru* De Candolle (Cactaceae) in South Africa?
10:30–11:00	TEA	
SESSION 4: Chair—Phetole Manyama		
11:00–11:45	Melodie McGeoch	KEYNOTE: From global to local and back in support of invasion management
11:45–12:00	Katelyn Faulkner	The balance of trade — the contribution of Africa to biological invasions in South Africa and vice versa
12:00–12:15	Sebataolo Rahlao	Framework for monitoring the status of biological invasions in South Africa
12:15–12:30	Darragh Woodford	A review of the current legal status and management options for invasive fishes in South Africa
12:30–12:45	Olaf Weyl	Alien fishes: do we know enough for effective management?
12:45–14:00	LUNCH	

Programme

Thursday 19 May 2016, afternoon

SESSION 5: Chair—Jennifer Fill		
14:00–14:15	Haylee Kaplan	History, status, and effectiveness of species-based management in South Africa
14:15–14:30	Vernon Visser	Grasses as invasive plants in South Africa revisited: patterns, pathways and management
14:30–14:45 4 × 3 minute Speed talks	Kim Canavan	The potential of a pre-introductory survey on *Arundo donax* (L.) to guide a biological control program in South Africa
	Sasha-Ann Pillay	Climatic suitability of South Africa for giant reed, *Arundo donax* (Poaceae) and a candidate biological control agent, the rhizome- and stem-feeding scale insect, *Rhizaspidiotus donacis* (Hemiptera: Diaspididae)
	Susan Canavan	Status report on alien bamboos: The emergence of temperate woody species
	Pieter Winter	An assessment of the taxonomic underpinning of the NEM:BA A&IS Regulations
14:45–15:00	Susana Clusella-Trullas	Impacts of alien vegetation on animal diversity in South Africa: a synthesis
15:00–15:15	Jan-Hendrik Keet	Legume–rhizobium symbiotic promiscuity does not determine plant invasiveness
15:15–15:30 4 × 3 minute Speed talks	Ingrid Minnaar	Research on *Harmonia axyridis* in South Africa: knowns, unknowns and flags
	Alan Wood	Fungi and invasions in South Africa
	Jolanda Roux	Invasive tree pathogens and pests in South Africa: can we stem the tide?
	Samuel Motitsoe	Investigating the ecological recovery and the restoration of aquatic ecosystem integrity post successful biological control of alien aquatic weeds
15:30–16:00	TEA	
SESSION 6: Chair—Darragh Woodford		
16:00–16:15	David Le Maitre	Invasive alien plants and water resources in South Africa: advances in understanding and predictive ability since 2004 and research challenges
16:15–16:30	Samalesu Mayonde	The role of molecular ecology in an invaded South Africa and its importance for biocontrol using *Tamarix* as a case study
16:30–16:45 4 × 3 minute Speed talks	Solomon Newete	The extent of the alien *Tamarix* invasion in South Africa
	Danica Marlin	Progress on the potential biological control programme for invasive *Tamarix* in South Africa
	Nkoliso Magona	Australian *Acacia* species in South Africa: an assessment of the current status of recorded introductions
	Sandiso Mnguni	Chemical ecology of cryptic species of *Eccritotarsus catarinensis* (Carvalho) (Hemiptera: Miridae), biological control agents of water hyacinth (*Eichhornia crassipes*)
16:45–17:00	John Measey	Invasive amphibians in South Africa
17:00–17:15	Lesley Henderson	Invasive, naturalised and casual alien plants in southern Africa: an update from the Southern African Plant Invaders Atlas (SAPIA)

17:15–17:30 4 × 3 minute Speed talks	Trevor Newby	The National Invasive Alien Plant Survey
	Philani Mbatha	Possible management options for *Ulex europaeus* L. and *Cytisus scoparius* (L.) Link in South Africa
	Desika Moodley	Assessing the distribution, invasion status and management of *Epipremnum aureum* in South Africa
	Serole Sehona	Investigating the impacts of *Salix babylonica* on urban riverine habitats
19:00	DINNER	

Friday 20 May 2016, morning

SESSION 7: Chair—Errol Douwes		
09:00–09:45	Reuben Keller	KEYNOTE: Promise and challenges of risk assessment as an approach for preventing the arrival of invasive species
09:45–10:00	Minette Karsten	Understanding invasions and pest risks in agriculture: current research status on invasive fruit flies (Diptera: Tephritidae) and new directions for management and intervention planning in South Africa
10:00–10:15	Tsungai Zengeya	Management of conflict invasive species in South Africa: challenges and trade-offs
10:15–10:30	Grant Martin	The potential economic implications of *Robinia pseudoacacia* L. (black locust) on agricultural production in South Africa
10:30–11:00	TEA	
SESSION 8: Chair—Jaclyn Hill		
11:00–11:15	Ana Novoa	A national strategic framework for the management of the family Cactaceae in South Africa
11:15–11:30	Moleseng Moshobane	The development of lists of regulated alien taxa in South Africa
11:30–11:45 4 × 3 minute Speed talks	Livhuwani Nnzeru	Trends in demands of listed invasive species in South Africa
	Blair Cowie	Exacerbation of photosynthetic damage through increased heat–light stress resulting from *Gargaphia decoris* sap-feeding
	Rosali Smith	The potential of *Hydrellia egeriae* sp. nov. (Diptera: Ephydridae) as a biological control agent for the submerged aquatic weed, *Egeria densa* Planch. in South Africa.
	Philip Weyl	The effects of water stress on the efficacy of the biological control programme against *Myriophyllum aquaticum*
11:45–12:00	Les Underhill	How the distributions of the major invasive alien bird species have changed in South Africa over two decades
12:00–12:15	Michael Picker	Composition, origins and distribution of the alien fauna of South Africa
12:15–12:30 4 × 3 minute Speed talks	Timia Sanchez Alcocer	Evaluating the invasion risk of mammals listed under Category 1a on NEM:BA
	Raquel Garcia	Shade or shun? Effects of plant invasions on native ectotherms under a warming climate
	Lulama Madire	Plant attributes contribute to the invasive *Tecoma stans* L. (Bignoniaceae) in South Africa
	Candice Lyons	The contribution of biocontrol implementation to managing weeds in the Western Cape

Programme

12:30–12:40	Philip Ivey	Arrangements for the next meeting & close
2:40–14:00	LUNCH & DEPARTURE	

Keynote Address 1

Scientific Assessments: matching the approach to the problem

Robert J. SCHOLES
GCSRI, Wits

Scientific assessments are a large part of the lives of many researchers. They aim to be an interface between science and society; and particularly between science and policy. As the nature of the problems demanding policy action becomes more and more technical and complex, so the need has arisen to have a process to collate and evaluate the relevant information, and then communicate it to policymakers, along with the associated uncertainties, in a clear fashion. There is a range of ways to conduct such assessments, which vary in how long they take, how many (and what type) of assessors they use, and how they engage with the users. The paper outlines some of the key attributes and success factors of several assessment approaches, and matches them to the circumstances where they are most likely to be successful.

Where the audience is other researchers, and the question being addressed is an emerging area in science, the scientific review is a well-established approach, taught at universities, and following certain conventions. It is performed by one or a few researchers, who cover a usually narrow area quite exhaustively. They tend to leave the assessment of what is reviewed to the reader. The approach is appropriate for an issue which is of scientific interest, but no great social prominence.

Where the science is relatively straightforward and well-established, and a quick but well-focused input to policy is needed, the ‘Briefing Note’ is a well-tested vehicle. It is typically written by one person, but benefits from both peer review, and an initial interactive process to define the scope. Brevity, focus and clarity are of the essence.

More complex issues, where the science may be difficult but is not in dispute are typically handled with a Contract Report: the team of experts is multidisciplinary but relatively small, and a single peer-review step is used. Often new data is presented. A summarising overview is helpful.

Where the public interest is high (and often polarised), the issue is complex (involving many sub-questions and disciplines, interactions and conditional outcomes) and the science is quite technical and often incompletely settled, the appropriate approach involves much greater two-way engagement with user groups for the assessors to understand policymaker’s needs, and for the policymakers to understand the strengths and limits of the science, and to participate in the selection of the expert teams. The opinion of the experts is actively but transparently sought; a multi-author team (often numbering hundreds) helps to provide a balanced assessment, along with extensive (repeated), documented and open review. A solid authorising environment is critical for success.

A national status report on biological invasions in South Africa: what do we need to do and what should we do?

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[3]Green Jobs Unit, Environmental Resource Management Department, City of Cape Town, Westlake Conservation Office, Ou Kaapse Weg, Cape Town

The impacts of biological invasions are increasing and are felt by all sectors of society in South Africa. In some cases mitigation and control measures have been very successful in reducing undesirable impacts, but in other cases control has been ineffective or the problem has not even been recognised. A key challenge is to develop a standardised system to monitor and report on the state of invasions. In response to this need, South Africa has committed to producing a national status report on biological invasions by October 2017 and thereafter every three years. In preparation for the first report we are editing a special issue of the journal *African Biodiversity and Conservation* linked to the 43rd Annual Research Symposium on the Management of Biological Invasions. There are about thirty papers planned as part of the special issue covering a range of issues from the threats from fungi to management on Marion Island. We discuss how the papers will contribute to the report in terms of developing species lists, collating data on distributions, and assessing the effectiveness of interventions. In also focus on how they contribute from species-based, area-based and pathway-based perspectives. Finally we stress that the report is simply a starting point. For it to be of value, subsequent reports need to build on each other in a way that is useful for policy and management.

A new assessment of the costs required to bring invasive alien plants under control in the protected area network of the Cape Floristic Region

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Fynbos vegetation is relatively well represented in protected areas of the Cape Floristic Region. However, these protected areas are under serious threat from invasive alien plants, especially woody genera such as *Pinus*, *Hakea* and *Acacia*. Although a large amount of money is being spent on control in these areas, there are concerns that current approaches are failing to reduce the problem. To find effective solutions, it is necessary to more accurately estimate the extent of the problem within protected areas, and the effectiveness of current control operations. This paper outlines a joint initiative by the Centre for Invasion Biology, SANParks and CapeNature to assess the situation in a comprehensive manner, and to suggest changes to current approaches that will be needed to secure the conservation of this unique ecosystem within a network of protected areas. The objectives of this paper include (i) an assessment of the magnitude of the invasive alien plant problem in fynbos protected areas; (ii) an estimation of resources needed to bring the problem under control; (iii) formulation of best management practices; (iv) an assessment of current practice against best practices; and (v) recommendations to improve future implementation of control programmes. We present data on the first two objectives, based on alien plant distribution mapping by CapeNature and SANParks, and cost estimates derived from Working for Water's norms and standards of invasive alien plant clearing. We suggest that the current state of invasion and the projected future costs call for strategic management and allocation of resources.

Assessing the effectiveness of invasive alien plant management in a large fynbos protected area

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Concern has been expressed about the effectiveness of invasive alien plant (IAP) control operations of Working for Water (WfW). Recommended remedial measures included improved planning and prioritisation, and efficiency and professionalism of operations. We assessed the effectiveness of IAP management practices in a large fynbos protected area, the Garden Route National Park. We found that although substantial effort was invested in sound planning and prioritisation, implementation was poorly aligned with plans. Field surveys in 103 management units (4280 ha) suggested that the general quality of treatments was poor, with work done to standard in only 23% of the area. Deviations from acceptable work standards included a complete absence of work despite payment of contractors (occurring in 33% of assessed area), partial work done (38%), not all the IAP species (11%) or age classes (8%) present being treated, wrong choice of treatment method (9%), and treatments not being applied to standard (7%). Field surveys and interrogation of WfW's database suggested that inaccurate (or lack of) in-field estimation of IAP cover prior to contract generation resulted in erroneous estimation of effort required, and expenditure disparate with industry norms. Successive follow-up treatments furthermore did not necessarily effect reductions in IAP infestations. We advocate rigorous, compulsory, in-field assessment of IAP cover prior to contract allocation, and assessment of the quality of treatments applied prior to contractor payment. In line with legislative requirements, this will enable tracking of both the state of invasions and the effectiveness of interventions, and improve the efficiency of control operations.

Status of invasion on sub-Antarctic Marion and Prince Edward islands

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The sub-Antarctic Prince Edward Islands (PEIs), South Africa's southern-most territories, are of high conservation value as they are one of the few unique systems of their nature that are in existence globally. Despite their isolation and the strict management policies against the introduction of alien species to sub-Antarctic islands in general, and more specifically to the PEIs, several invasive plants have established on the PEIs and the introduction of propagules continue. Here we review the history and agents of alien species on the PEIs and explore their impacts on the region. This review will provide a comprehensive evaluation of the status of biological invasions in the PEIs. This will include lists of species, descriptions of how their distribution status has changed over time, the trends in, and the scale of the impact of invasion, the extent of invasion across the islands, pathways of invasion and eradication efforts. In addition, gaps in our knowledge of the identity and effects of alien species on the PEIs will be discussed. Finally, this paper will provide information on the management approaches in place on the PEIs, how they have changed over time, and their effectiveness.

Marine bioinvasions in South Africa – status and states of knowledge

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This presentation aims to gives an updated overview of the current status and state of knowledge of marine bio-invasions in South Africa. The last major published reviews of this topic were those of Mead et al. in 2011. Since then, four species have been removed from the introduced list, one being reassigned as cryptogenic, two having become locally extinct and one being transferred to the terrestrial list. Six species have also been formally added to the list, while others (several barnacles, a porcelain crab, a littoral earwig and a starfish) have been reported, but are yet to be formally included in the list. We introduce these new species and summarise the taxonomic composition of the introduced biota, review their probable vectors of introduction, their areas of origin, their current distributions patterns and their rates of introduction. By applying standardised terminology to categorise the 89 formally accepted species as either 'alien' (i.e. species whose presence is attributable to human mediated transport) or 'invasive' (i.e. species having self-replacing populations over several generations and which have spread from their point of introduction) we currently recognise 36 alien species and 53 invasive species. We also reflect on the research done on this topic in South Africa to date. Numbers of publications are increasing, but are focussed on few species and largely on distributional studies, with little emphasis of mode of introduction or impacts, and little experimental work. We conclude by identifying 10 species we consider most in need of further investigation.

Invasions within South Africa's Marine Protected Areas network

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Despite an increasing research focus on marine invasions along the South African coastline, the presence of alien species has previously only been considered in three marine protected areas (MPAs). To address this gap in current knowledge this study surveyed nineteen of South Africa's 23 MPAs for alien species and applied Classification and Regression Tree Analysis (CART) to identify drivers of invasions in these protected areas. Non-indigenous species were recorded in all except two MPAs i.e. Sixteen Mile Beach and Helderberg MPAs, the only two MPAs to support only sandy beach habitat. Langebaan Lagoon was the most invaded MPA supporting nine alien species, followed by Betty's Bay and Amathole MPAs, which supported seven species each. The invasive Mediterranean mussel, *Mytilus galloprovincialis*, was the most widespread alien species, occurring in 68% of MPAs visited. It was most prominent on the island MPAs of the West Coast National Parks. The bryozoan, *Bugula dentata*, was also widespread, occurring across all three ecoregions. This study documented the hydrozoans *Obelia dichotoma* and *Obelia geniculata*, the bryozoan *Cryptosula pallasiana* and the ascidians *Microcosmus squamiger* and *Diplosoma listerianum* outside of harbours for the first time, highlighting the need for monitoring of natural habitats. CART analysis identified the presence of large harbours in the vicinity of MPAs and the close proximity of yacht marinas as important predictors of invasions. This highlights the need for consideration of marine invasions during spatial planning of MPA networks, if these protected areas are to achieve their conservation goals.

Controlling *Carcinus maenas* in Hout Bay harbour: the first attempted extirpation of a marine invasive species in Africa

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The European shore crab, *Carcinus maenas*, is a global invader with ecological impacts across most of its invasive range. It was first detected in South Africa in 1983 and is currently confined to two large harbour populations, approximately 30 km apart. In 2013, the population in Hout Bay harbour was estimated to support 6 700 mature individuals. The crab is listed as a NEM:BA 1b species (i.e. a species requiring control) and as a result, a pilot control programme was initiated in Hout Bay. After 218 trapping days, 36 244 crabs were captured. Catch Per Unit Effort (CPUE) declined over the 12 month project. Following the termination of the programme, the population was monitored for six months and CPUE increased over this period. We conclude that eradication of *C. maenas* from South Africa would require resource-intensive control programmes in both harbours. However, without strong evidence of impacts by this species in South Africa and knowledge of why control failed in Hout Bay, it is hard to justify a large-scale eradication programme. This study was the first attempt at controlling a marine invasive species in Africa and provides important insights for the control of other marine species.

Freshwater crayfish invasions in South Africa

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No indigenous freshwater crayfish species exist in continental Africa, but several North American and Australian species have been introduced since the 1970s. In South Africa, four species of alien crayfish are listed under NEMBA's National List of Invasive Freshwater Invertebrate Species: the Danube crayfish (*Astacus leptodactylus*), the common yabby (*Cherax destructor*), the Australian redclaw crayfish (*Cherax quadricarinatus*) and the marron (*Cherax tenuimanus*). Although freshwater crayfish have been reported as high-impact invaders that can cause serious negative environmental impacts, no detailed information exists on crayfish distribution, abundance and impacts in South Africa.

The aim of this study is to present an overall view of the current situation of crayfish invasions in South Africa, mostly by focusing on the Australian redclaw crayfish (*C. quadricarinatus*), the only species that appears to be present and widely distributed in some areas of South Africa. Here we show the results of initial crayfish surveys performed in South Africa and Swaziland, for which collapsible baited traps were set along water bodies, left overnight, and checked the following morning for crayfish presence. We report on the presence of established populations of *C. quadricarinatus* in Mpumalanga and in different areas of Swaziland. We discuss the implications of these results regarding the potential impact of *C. quadricarinatus* on native biota and natural habitats. This information is essential to support the development and implementation of adequate action plans for the management and control of this invasive species in South Africa.

Invertebrate diversity in response to the removal of alien invasive plants in the Luvuvhu river catchment: indications of recovery

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Invasive alien plants (IAP's) have considerable negative impacts on freshwater habitats. South Africa has implemented an innovative programme for the systematic removal of these plants aimed at, amongst other objectives, restoring biodiversity and ecosystem services in these threatened habitats. These restoration processes are expensive and have to be evidence-based. Few studies include invertebrates as indicators of efficacy of these interventions. In this study we use in-stream macroinvertebrate and adult Odonata assemblages as indicators of restoration success by quantifying the response of biodiversity metrics for these two groups to the removal of IAPs in a strategic water resource of South Africa that is extensively invaded by IAPs. The study consisted of a replicated design that included at least two cleared, invaded and uninvaded sites in the upper reaches of six sub-catchments of the Luvuvhu river catchment, Limpopo Province. Three metrics of water quality based on macro-invertebrates did not respond to clearing but the SASS5 total score responded positively to the number of times cleared. Although clearing only had a weak positive effect on adult odonate species richness it had a positive impact on DBI scores. These differences were mainly the result of significantly larger DBI scores in the cleared sites as compared to the invaded sites. Results suggest that water quality is positively impacted by repeated clearing pointing to the importance of follow up procedures after initial clearing. The adult odonate diversity as measured by richness, endemicity, threat and distribution, respond positively to all forms of clearing.

The contribution of biocontrol of aquatic weeds to water and biodiversity

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Aquatic ecosystems in South Africa are prone to invasion by several invasive alien aquatic weeds, most notably, *Eichhornia crassipes* (water hyacinth); *Pistia stratiotes* (water lettuce); *Salvinia molesta* (salvinia); *Myriophyllum aquaticum* (parrot's feather), and *Azolla filiculoides* (red water fern). Despite their long history in South Africa, there are only a few studies on the impacts of these species on biodiversity and water loss, while the benefits of the biological control programme against these species have been poorly quantified. We have used two case studies to show that water hyacinth in particular results in significant water loss, and another two case studies that show its negative impacts on aquatic biodiversity in the field. Further, in controlled large pool experiments, aquatic biodiversity was shown to recover relatively quickly (within one year) after the introduction of biological control on water lettuce. These studies provide justification for the control of invasive alien aquatic weeds in South Africa. Thus, the long-term management of alien aquatic vegetation relies on the correct implementation of biological control for those species already in the country, and the prevention of other species entering South Africa.

The functional response of aquatic plant invaders

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Refining the protocols for risk assessment is one of the major challenges in invasive species management. Invasive species impacts are often highly speculative and as a consequence, developing robust predictions about the potential impacts of invasive species can be challenging. Invaders are regularly associated with rapid and efficient resource allocation; accordingly, comparing the functional response (defined as resource uptake as a function of resource density) of invasive and native species

may help predict impacts of emerging invaders. The functional responses of three South African native (*Lagarosiphon muscoides, Myriophyllum spicatum and Lagarosiphon major*) and one invasive (*Egeria densa*) submerged macrophyte species were compared under two temperature regimes; 20°C and 30°C. Functional response was defined as nitrogen uptake rates (as a function of nitrogen concentration) of ammonia (NH_3) over 4 hours under full light. All plants demonstrated a clear Type II functional response characterised by a decelerating intake rate, where plants were likely limited by their capacity to take up nitrogen. Functional response curves and maximum uptake rates (Vmax) were similar between species at 20°C, but *L. major* showed a significantly reduced Vmax at 30°C. Nitrogen affinity (1/Ks) was slightly higher in both temperature regimes for all native species, with *L. major* showing the highest affinity for nitrogen at 30°C. Overall, despite the clear Type II curves, functional response was a poor predictor of invasion potential. However, nitrogen affinity appears to be marginally higher in the native species, suggesting some potential for native plants to outperform their invasive counterparts.

Does phenotypic plasticity influence the thermal physiology of *Eccritotarsus catarinensis?*

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Lantana camara is one of the most problematic invaders in South Africa contributing to the degradation of land value. It has been over 50 years since *L. camara* has been targeted for control using biological control agents in South Africa. In 2001, a biological control agent, *Falconia intermedia*, was released in the Eastern Cape in an effort to control the varieties of the highly invasive weed, *Lantana camara* with little success. A post-release evaluation study conducted discovered that the weed induces physical responses for defence post-herbivore feeding in varieties tested. In a subsequent study, one of the *L. camara* varieties tested, Whitney Farm was shown to induce chemical responses after feeding by *F. intermedia*. The results of the current study identified chemical profiles of *L. camara* varieties for both before and after feeding by *F. intermedia* using GC-MS. The findings of our study reported the chemical distinction across *L. camara* varieties tested and the feeding causes the changes in the quality and quantity of chemical compounds. Of all the chemical compounds identified, there were common compounds identified amongst the varieties and these are caryophyllene, hexane, naphthalene and copaene. Furthermore, the investigation of the effect of major compounds on *F. intermedia* behaviour by means of olfactometry bioassays indicated the repellence of *F. intermedia*. These results show the effect the induced chemical compounds have on the success of biological control of *L. camara* varieties

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Interactions between two biological control agents of *Eichhornia crassipes* (Mart.) Solms-Laub (Pontederiaceae), the weevil *Neochetina eichhornia* Hustache (Coleoptera: Curculionidae) and the plant hopper *Megamelus scutellaris* Berg (Hemiptera: Delphacidae)

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Interactions between biological control agents may have important consequences for the control of target weeds. In 2013 *Megamelus scutellaris* (Ms) was the latest of several biological control agents of water hyacinth released in South Africa. Little is known about how it will interact with the agents already established, such as the weevil, *Neochetina eichhornia* (Ne), the most widely established and successful biological control agent of water hyacinth. The purpose of this study was to quantify interactions between the two agents and to record effects of the interaction on the control of water hyacinth under controlled conditions at the Waainek Research Facility at Rhodes University, Grahamstown, South Africa. Plants that had been exposed to extensive herbivory by *N. eichhornia* were collected from New Year's Dam to emulate conditions that the hopper would be exposed to upon release, while insect-free plants were used as controls. Different combinations of Ne and Ms were maintained on the plants for 12 weeks, and plant growth and insect damage were recorded. The agents

appear to complement each other. The results will improve the management decisions for water hyacinth in South Africa.

Induced chemical compounds: attractants or repellents to *Falconia intermedia*?

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Eccritotarsus catarinensis (Carvalho) (Miridae), a biological control agent for water hyacinth, *Eichhornia crassipes* (Mart.) Solms (Pontederiaceae), has failed to establish in some parts of South Africa due to climatic incompatibility. Some insects have the ability to change their thermal tolerance according to the temperatures they are exposed to, without a change in their genotype. This is known as phenotypic plasticity. Thermal tolerance of two populations of *E. catarinensis* from different climatic regions of the native range was tested using degree day models. This showed that each population's thermal physiology matched their particular climate. However, after years of being reared under the same conditions in quarantine, experiments showed that their thermal physiologies have converged, which may be the result of adaptation or thermal plasticity. Samples of *E. catarinensis* have been collected from the hottest and coldest establishment sites in South Africa. Thermal plasticity will be investigated by determining their critical and lethal thermal limits. This will be done in summer and winter for comparison. Thermal limits will be tested before and after cold hardening using *E. catarinensis* from the BCRG mass rearing facility. Preliminary results have shown that insects from the colder site have lower thermal tolerances compared to those of the warmer site. If the thermal physiology of *E. catarinensis* has the ability to change due to phenotypic plasticity then it would be beneficial to exploit that characteristic, thus increasing their chances of establishment in colder regions. This will be done through cold hardening during mass rearing.

Factors affecting the establishment, performance and geographic distribution of the eriophyid mite *Aceria lantanae*, a biocontrol agent for *Lantana camara*, in South Africa

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The study was undertaken to assess climatic and host plant varietal effects on the establishment, distribution and performance of *Aceria lantanae* Cook (Acari: Eriophyidae), a biocontrol agent of *Lantana camara* (Verbenaceae) in South Africa. The CLIMEX program was used to predict and map areas that are climatically suitable for the performance of *A. lantanae* in Africa, while seasonal climatic data were collected at various release sites in South Africa to measure the response of the mite to four climatic factors. Although the current distribution of *A. lantanae* in South Africa falls within that predicted by CLIMEX, establishment and infestation levels differed considerably from site to site. There was a slight decline in *A. lantanae* infestation levels with increasing elevation and annual rainfall, although these trends were not statistically significant. Infestation levels of *A. lantanae* were not related to either temperature or relative humidity. The differences in performance levels of *A. lantanae* among release sites typified by the same climatic and environmental conditions suggested that some varieties of *L. camara* may be unsuitable for the mite. Therefore, a study was conducted to measure and compare the susceptibility of ten common lantana varieties to *A. lantanae*. Mite infestations differed significantly amongst the ten varieties, with infestations ranging from 0 to 61.2%. These data support the contention that varietal resistance and not climatic factors is the major determinant of the efficacy of *A. lantanae*, and this explains the varying performance levels of the mite observed throughout the distribution range of the weed in South Africa.

Biological invasions in South Africa's National Parks

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The South African National Parks (SANParks) estate includes 19 national parks, covering about 39 000 km^2. SANParks has a primary mandate of biodiversity conservation and providing human benefits, and invasions by alien species compromise the ability of the organisation to achieve these objectives. All 19 national parks have been invaded by alien plants, while alien mammals occur in 18, and alien birds in 17 parks. While not all are invasive, about 781 alien species (including 76 extralimital species) have been recorded across SANParks. The majority of alien species (663) are plants, followed by mammals (26, including extralimitals), gastropods (19) and freshwater fish (16). Kruger National Park (400) and TMNP (291) have the highest number of alien and invasive species. SANParks are governed by the legislative requirements of NEM:PA (No. 57 of 2003), and NEM:BA (Act No. 10 of 2003) and its associated Regulations (2014), both requiring landowners to develop plans for the control, eradication and monitoring of alien and invasive species. The 2014 NEM:BA regulations however pose substantial challenges. The regulations list 559 invasive and 560 prohibited species, of which 204 plants and 32 animals are found within SANParks. Kruger National Park and TMNP have over 100 listed species, and more than 80 species each listed as category 1a or b. SANParks has developed a framework in an attempt to comply with the NEM:BA legislation, whereby each species is prioritised and assigned to the group of species for which prevention, monitoring, containment, asset protection or local extirpation is planned.

What does it take for municipalities to become compliant with the regulations on biological invasions? Lessons from the City of Cape Town

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This paper will examine the case of Cape Town to: (1) underline the requirements for municipalities to become NEM:BA compliant; (2) emphasise the challenges; and (3) to provide guidelines for developing a strategy for managing urban invasions. Achieving NEM:BA compliance in an urban environment requires a number of challenges to be overcome. Firstly invasive non-native species are often more prevalent in urban areas than in rural areas. Attempts to manage invasive species in urban areas are controversial due to a diversity of stakeholder views, and challenging because of budgetary constraints, institutional arrangements and differing mandates. To become NEM:BA-compliant a municipality will have to go through different phases:

1) *Planning phase:* It is advisable that municipalities develop an Invasive Species Management Strategy and pass it through the appropriate municipal processes to achieve departmental buy-in and successfully delegate responsibilities. The second step is to draw up an Invasive Species Monitoring, Control and Eradication Plan. This plan needs to be incorporated into the Integrated Development Plan (IDP).
2) *Implementation phase:* To tackle the diverse challenges that managers in urban environments are faced with management frameworks have to be in place. These should include political, social and ecological aspects.
3) *Monitoring and reporting phase:* Monitoring is required to determine the efficacy of control interventions. Information gathered here is vital for updating the municipal management plan and to incorporate into the status report for protected areas.

Cities as hotspots for invasions: the case of the eThekwini municipality

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This study focuses on four broad themes regarding biological invasions in urban environments: 1) policy; 2) pathways and vectors; 3) prioritisation tools for management; and 4) preparedness and response – all in the context of the eThekwini (Durban) Municipality in KwaZulu-Natal. A review of the invasive species strategy implemented in the eThekwini municipality will be done and the differences in plans between other major cities around the world will be compared to plans implemented in eThekwini, highlighting advantages and disadvantages. This comparison will be used to determine if the successfully implemented plans in other major cities can be incorporated, in full or in part, into the IAS control and management plans for the eThekwini municipality. I will review invasion pathways and vectors in urban environments, highlighting the management practices of invasion pathways in the eThekwini municipality. The issue of management prioritisation of invasive species will be addressed by investigating how invasion debt and predictive models can aid decision makers in setting management priorities. Lastly, as a species-focus example, an assessment of the preparedness of the eThekwini municipality in the event of an invasion of Little Fire Ants (*Wasmannia auropunctata*) will be conducted and possible contingency plans will be suggested.

Where are the invaders hiding? Insights on the compilation of species and occurrence data for alien plants in small urban areas: examples from Riebeek Kasteel, Western Cape, South Africa

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More than half the world's population live in towns or cities. Among urban environments, small urban centres (towns) that harbour invasive species have a large edge-effect that exposes the surrounding natural environment to elevated levels of invasive propagule pressure. Despite this threat, there are very few studies globally that investigate any patterns and processes evident in alien invasions within urban environments. For this study, I undertook a detailed analysis of the invasive species load (type, number and location) within the small urban centre of Riebeek Kasteel in the Berg River Catchment, Western Cape, South Africa. Total numbers of all alien woody and succulent plant species were recorded at 10 m intervals on every road surface throughout the town and further categorised by land-use type. The status of invasion Riebeek Kasteel is comprehensively mapped and analysis of the data reveals hypotheses around the density, location and possible spread of alien plant taxa within this town. Lessons learned allow the search methodology to be refined and these hypotheses tested on other small urban centres in the catchment to determine whether trends are uniform across towns or particular to them. This has application for determining how and where to search for similar species or growth forms in other small towns as well as how much search effort is required to sufficiently determine a given town's invasive species load.

The Durban Invasives Website: tracking and control of selected invasive alien plants, in an urban context

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Early detection and control of invasive alien plant (IAP) infestations, is a strategic approach that can ensure optimal results over the long term, even with relatively small budgets. In 2013, several organisations operating within the broader Durban area, including the South African National Biodiversity Institute, the Duzi Umgeni Conservation Trust, Kloof Conservancy, and eThekwini Municipality initiated a website-based Early Detection and Rapid Response (EDRR) Project. This Durban Invasives website (www.durbaninvasives.org.za) project has allowed for the reporting of selected IAP species, as are featured on the website's target list. The partner organisations all use data from the website to guide simultaneous targeted IAP control efforts, as well as for research and planning purposes. The website, which allows for status updates of target species, is considered a successful platform for sharing field observation data, in real-time. Website visitors, which can include members of the public, must register as 'spotters' should they wish to report a sighting. To date, the five most commonly reported species include: *Parthenium hysterophorus, Campuloclinium macrocephalum, Triplaris americana, Furcraea foetida* and *Lilium formosanum.* The website has ensured improved rates of detection, removal and in some instances, extirpation/local eradication of IAPs. Current indications are that the website has also improved coordination activities between the various partner organisations, the benefits of which extend well beyond the control of the listed target species.

Invasive species research funding futures—bright or bleak?

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In the mid to late 1980s, at the height of the Apartheid government's war against the perceived communist threat posed by Angola and Namibian independence movements, it was estimated that South Africa spent more in a day on the war than it allocated annually to environmental research. This may be an extreme case of National Fiscal neglect but it illustrates that environmental concerns are frequently the last item on the finance minister's list. We outline a plan to undertake a global review of funding allocated for research on invasive species in order to assess and interrogate the source and sustainability of funds. This information may be difficult to access, particularly for historical expenditure. Information may be available in government and project reports and annual reports of organisations responsible for implementing projects.
For each country an assessment will be made of the following:

- How large is the National Budget?
- What is the budget allocation to the environment relative to other budget demands?
- How much of the environmental budget is allocated to protecting the environment from the threat of invasive species?
- Is there a relationship between budget allocation and number of rare and endangered species, size of land surface protected in formal conservation areas and number of invasive species present in the country threatening biodiversity, ecosystems and human livelihoods?
- Are there alternative funding sources for work in the environment and invasive species in particular?

Biological control as a management tool for suppression of terrestrial invasive alien plants in South Africa

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Biological control of invasive alien plants has the ability to contribute significantly to sustained, cost-effective management of natural resources of South Africa. The status of and prospects for the biological control of terrestrial plants in South Africa is therefore integral to the national status report. Considerable advances in the processing of new agents for release and successes in field on a number of invasive alien plants have been achieved in South Africa in recent years. The highlights and constraints in the biological control of major terrestrial IAPs within South Africa, as well as the prospects for success, are discussed. Major IAPs include those species that are currently considered the most damaging in the country as well as those of historical importance that would be major problems if biological control had not been implemented. The role of biological control in the management of both established and emergent terrestrial IAPs (in some cases grouped according to taxonomy or growth habit) is also discussed. Candidate terrestrial IAP targets for management using biological control are prioritised. An opinion is provided on where biological control might facilitate a change in the NEM:BA categorisation for some terrestrial species. The implications of implementing recommendations contained in the *National Strategy on Biological Invasions in South Africa* that explicitly call for improvements to the capacity for research and implementation of weed biological control are explored. The need for broader understanding and adoption of the practice of biological control of IAPs is emphasised as essential to the realisation of the full benefits of investment of resources.

Towards understanding field performance of introduced insect agents on *Parthenium hysterophorus* in South Africa

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Successful management of *Parthenium hysterophorus* (Asteraceae; known as parthenium or famine weed) in various invaded environments requires a suite of natural enemies. Each agent has unique attributes and limitations that contribute to levels of success that may be achieved. In recent years, three imported insect agents (*Listronotus setosipennis* (Coleoptera: Curculionidae), *Zygogramma bicolorata* (Coleoptera: Chrysomelidae) and *Smicronyx lutulentus* (Coleoptera: Curculionidae)) have been introduced into multiple sites within subtropical regions of South Africa that are severely invaded by parthenium. Highly variable establishment and field performance is apparent, likely due to a combination of intrinsic and external factors. Despite several desirable biological characteristics and reasonable field establishment of the endophagous stem-boring weevil *L. setosipennis*, distribution is localised. Field evidence of temperatures that reach critical or lethal limits, together with demonstrated variability in the thermal tolerance of the defoliating beetle *Z. bicolorata* of different ages, feeding status and thermal pre-treatments under laboratory conditions, suggest some causative influences on its field establishment. Resultant implications for improved biological control of parthenium, and the need for additional complementary agents that can address local limiting factors, are discussed.

Interactions between two biological control agents of *Pereskia aculeata*

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Pereskia aculeata Miller (Cactaceae) is an alien invasive plant introduced into South Africa from Brazil. In South Africa, it is a problematic plant that has negative impacts on native biodiversity. *Pereskia aculeata* has two biocontrol agents, *Phenrica guerini* Bechyne (Chrysomelidae) and *Catorhintha schaffneri* Brailovsky & Garcia (Coreidae), released against it in South Africa. This study evaluated interactions between the agents, by investigating whether both agents, individually or jointly, enhanced or reduced the impact on *P. aculeata*. Potted *P. aculeata* plants were exposed to one of four treatments: control (no agents), *P. guerini* only, *C. schaffneri* only and both species in combination. Four stocking densities ranging from 2 to 12 insects per plant were used. Plant parameters including the change in number of leaves and change in shoot lengths were recorded. *Catorhintha schaffneri* alone at high densities was more damaging than other treatments with a significantly greater reduction in the number of leaves (-11.7 ± 1.29) and the shoot lengths (-2.17cm ± 0.75 cm) in this treatment. Even at lower density treatments, the combination of the two agents was not significantly more effective than *C. schaffneri* alone and *C. schaffneri* was always more effective than *P. guerini* alone. Mortality of *P. guerini* (14.7 ± 2.39) was significantly higher than *C. schaffneri* (6.20 ± 0.90) at all stocking densities when in combination. *Catorhintha schaffneri* should therefore be the priority species for further mass-rearing and releases on *P. aculeata*.

The Pereskia stem-wilter, *Catorhintha schaffneri* (Coreidae), a new biological control agent for *Pereskia aculeata* (Cactaceae). Eighteen months since release, where are we now?

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Catorhintha schaffneri Brailovsky & Garcia (Coreidae), a biological control agent for the invasive alien plant, *Pereskia aculeata* Miller (Cactaceae), was first released in South Africa in 2014. The first releases resulted in variable success with establishment at some sites but populations quickly dying out at others. This study aims to determine which factors may impact establishment success so that release efforts can be optimised. Climatic conditions were investigated in an experiment where 30 adults were released at sixteen sites in different climatic zones. Establishment through winter was only recorded at two sites, one in Amanzimtoti and another in Port Alfred. Low establishment rates were likely due to the low release effort at all sites. The fact that the population survived winter in a relatively cold site, such as Port Alfred, indicates that the thermal tolerance of the agent is likely to be suitable for it to survive winter at most sites, given that *P. aculeata* is most abundant in the warm sub-tropical parts of the country. The importance of release effort was investigated in another experiment where low release effort (30 adults), medium (60 adults), high (120 adults) and multiple releases (30 adults released every week for four consecutive weeks), were tested. Establishment was successful at all the multiple release sites, only 33% of sites with releases of 60 and 120, and 16% of sites where 30 adults were released. By conducting multiple small releases at each site the establishment success rate for *C. schaffneri* will be increased.

A new candidate biological control agent for the control of *Pereskia aculeata* Miller (Cactaceae) in South Africa

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Pereskia aculeata Miller (Cactaceae) is an invasive alien plant in South Africa that is a threat to indigenous biodiversity*. Pereskiophaga brasilensis* Anderson (Curculionidae) is a promising potential biological control agent for *P. aculeata* that has been imported from the native distribution of southern Brazil into quarantine in South Africa for host specificity testing*.* The adults of *P. brasilensis* feed on the leaves and shoot tips of *P. aculeata* and the larvae mine inside the stems, destroying the vascular tissue. Thirty test plant species from eight closely related families have been tested in no-choice oviposition trials and no development was recorded on any of the test plant species. Larval no-choice tests were also conducted in which larvae hatched on *P. aculeata* were transferred to test plant species and *P. aculeata* controls. Fifteen plant species have been included in these tests and feeding and survival was only recorded on *P. aculeata. Pereskiophaga brasilensis* also had a significant impact on *P. aculeata* growth parameters*.* Shoot length was significantly reduced in plants exposed to *P. brasilensis* by an average of 11.9 cm (±2.07), (T test; $t = -42.9$, $p<0.001$), and the average number of leaves was also reduced by 45.3 leaves (±11.9), (T test; $t = -4.65$, $p<0.001$). An application for release is being prepared and will be submitted to the relevant authorities. This new agent could significantly impact *P. aculeata* in South Africa and help protect indigenous biodiversity

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What are the factors that influence successful biological control of *Cereus jamacaru* DC. (Cactaceae) in South Africa?

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The success of biological control agents can be highly variable among target weed populations. The mechanisms that determine such variability are poorly understood, and an understanding of these factors would allow biological control practitioners to improve existing management programs. Field observations of an environment-transforming weed, *Cereus jamacaru* (Queen of the night cactus), indicate that biological control efforts employing the mealybug *Hypogeococcus pungens* (Hemiptera: Pseudococcidae) may be more effective against certain weed populations than others, suggesting that distinct genetic types may be present in South Africa. This study will investigate several factors which may explain the variable nature of the control of *C. jamacaru*. The factors investigated will include the suitability of the control agent *H. pungens*, incompatibility between *H. pungens* and *C. jamacaru* populations and the impact of top-down regulation on *H. pungens* by predators and parasitoids. The methods employed will include field surveys of *C. jamacaru* populations and their interaction with *H. pungens*, climatic matching, molecular and morphological taxonomic evaluation of the weed populations, herbivore performance bioassays on different weed populations and combined field and laboratory-based assessments of the impact of predation and parasitism on *H. pungens*. This research will indicate whether *H. pungens* is a suitable biological control agent of all forms of *C. jamacaru* and determine factors that must be taken into account when implementing biological control using this agent.

Keynote Address 2

From global to local and back in support of invasion management

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Effective governance of the environment, including the problem of biological invasions, includes consideration of biological, analytical, reporting and jurisdictional scales. Local benefits accrue from awareness and adoption of global approaches by (1) being able to motivate for the importance of local initiatives in a global context, (2) aligning activities with best practice, and (3) being able to draw on readily available information resources. Globally, the benefits lie with accumulation of national and local tests of these schemes so that they can be refined where necessary. Importantly, harmonised approaches across scales facilitate rapid transfer of information and its translation into more targeted and relevant policy.

In practice, however, there is often a disconnect between current, local scale information informing broader level policy, and also often a lag between international developments informing national scale action. In many cases global developments have lagged behind the varied national invasive species monitoring and information management solutions developed for specific applications. I will illustrate this with a selection of recent developments and examples in invasion science and policy in support of invasion monitoring and management.

An approach to keeping the pipeline of communication and information flow on biological invasions has recently been proposed and its further development and adoption is underway. This approach includes *inter alia*: (1) A small set of essential variables for invasion monitoring based on the concept of Essential Biodiversity Variables, and (2) a feasible, modular approach to the development of national (or finer scale) observation and monitoring systems for alien and invasive species. This approach will benefit efforts to slow the rate of biological invasions across local to national and international scales.

The balance of trade — the contribution of Africa to biological invasions in South Africa and vice versa

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Although alien organisms are often introduced directly from one biogeographical region to another, the spread of species within biogeographical regions also plays an important role in the movement of organisms around the globe. As South Africa shares land borders with six countries, multiple opportunities exist for the transfer of alien species. Here we present scenarios that describe how alien species might have been introduced to the region and spread between South Africa and other parts of Africa. We illustrate these scenarios using case studies and demonstrate that the scenarios are numerous, that their applicability varies across species and that for a species the applicable scenario might change over time. Despite the complex nature of alien species transfer in this region, relatively simple information on introduction and spread are required for management. We believe that by co-ordinating their alien species management responses and sharing information, countries within the region will improve the prevention and management of biological invasions. In an effort to inform such co-operative management, details are provided on the actions that should be taken by invaded countries and their neighbours following the detection of a new invader in the region.

A framework for monitoring the status of biological invasions in South Africa

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Despite the threats posed by biological invasions, there have been no comprehensive national monitoring processes to assess the status of this threat. South Africa has an obligation under the CBD (Aichi Target 9) to identify, prioritise and engage in research and monitoring for management of pathways to prevent IAS introduction and establishment. The South African National Biodiversity Institute (SANBI) is required to lead and coordinate research for monitoring and reporting on the state of biodiversity in South Africa. The Essential Biodiversity Variable (EBV) Approach to Monitoring Biological Invasions provides a guide to how countries can develop national observation and monitoring systems for management of biological invasions, and recommends focusing on alien species occurrence and status, and their impacts on biodiversity. We propose a framework and indicators that can serve as the basis of a national monitoring programme, following the EBV approach, but broadened in scope to meet South Africa's needs for monitoring the status of IAS and the effectiveness of its legislative measures for management. We propose the following groups of indicators (1) regulatory (effectiveness of the regulations and other legislation), (2) status of invasions (EBV-based approach), and (3) processes and systems for long-term monitoring. This paper provides a framework for monitoring the status of biological invasions as part of the National Invasives Status report in South Africa.

A review of the current legal status and management options for invasive fishes in South Africa

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South Africa has a long history of non-native fish introductions, and continues to see new introductions as well as range-expansions within its borders. The historical response of government and conservation agencies to this biodiversity threat has been negligible, with few successes. The Alien and Invasive Species (A&IS) Regulations of the National Environmental Management: Biodiversity Act are meant to set the legal framework under which invasive fishes can be managed in South Africa, although there are several complications to assessing or enforcing compliance with the new legislation.

A chief aspect of invasive fishes is that many were introduced for, and continue to provide, recreational and subsistence fisheries in South Africa. This means that any management action taken under NEM:BA has to take the local socio-economic value of an invasive species into account, particularly as many species are legally entitled to remain within their current distribution under the A&IS regulations. Furthermore, two invasive species, rainbow trout and brown trout, are currently excluded from the AIS lists and are being managed under a separate process involving the mapping of 'trout areas'.

In this paper, we discuss the current implications of the A&IS regulations for conservation management, and assess the value of a recently-developed decision support tool for managing invasive fishes. We employ the tool in three case studies to demonstrate how current legislation, the practical limitations for control, and socio-economic impact of a particular invasive fish population can be used to determine a reasonable management goal for that population.

Alien fishes: do we know enough for effective management?

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Fifty-five fish species have been introduced into novel environments in South Africa. While pathways for initial introductions are fairly well understood, there is a paucity of information on subsequent spread, establishment and impact for many of these species. Effective management of these invasions requires not only current knowledge of invasion status and invasion risk so that species or ecosystems can be prioritised for intervention. This paper will provide: (1) a review of drivers, pathways and the invasion status of introduced fishes; (2) a summary of impacts and utility (e.g. potential for management conflicts); and (3) a measure of invasiveness derived from an adaptation of the Freshwater Fish Invasiveness Scoring Kit (FISK) to South African conditions. These data are then used to prioritise species for management intervention. The contribution of this paper to the national status report on invasive species is evaluation of management priorities based on an up-to-date synopsis of the current status and risk of spread for alien and extralimital fishes in South Africa.

History, status, and effectiveness of species-based management in South Africa

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South Africa's NEM:BA Alien and Invasive Species Regulations require that plans to manage all listed invasive species be developed and reported on in the national status report. While the NEMBA Regulations are largely based around listing species, much of the management has been focussed on controlling areas. The rationale for this area-based approach is to protect key natural resources, but under certain circumstances targeting specific species of concern for management is necessary and preferable. Here we describe instances where species-based management is effective, focussing on species-specific goals and management approaches. We review the history and application of these species-based approaches and give examples of their effective implementation globally (e.g. Australia's Weeds of National Significance; USA Department of Forestry's Slow-the-Spread project). Several types of species-based management are used in South Africa, including biological control, eradication, prevention, pre-border risk assessment and containment. This paper assesses the current status of South Africa's species-based management for all listed invasive taxa. It aims to identify key operational, political and environmental/biological elements that might have influenced the management success of these particular species; we only consider management plans that aim to protect or restore biodiversity (i.e. excluding agricultural pests). Based on this assessment we make recommendations for improvement of species-based management in order to fulfil the requirements and intent of NEM:BA.

Grasses as invasive plants in South Africa revisited: patterns, pathways and management

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In many countries around the world the most damaging invasive plant species are grasses. However, the group has received little attention in South Africa. Here we expand upon Sue Milton's 2004 review of grasses as invasive alien plants in South Africa. Specifically we provide the first detailed species-level inventory of introduced grasses in South Africa, and use this and other literature sources to elucidate the history of grass introductions, identify possible pathways of introduction and spread, determine which species are having impacts, and predict possible future trends.

We found that over 200 non-native grass species have been introduced to the country, 37 of which have become invasive. This reflects in part an extensive historical effort to introduce non-native grasses via formal pasture introduction programmes, but more recently an increasing number of horticultural species have been introduced. Most grass introductions into South Africa have been of species native to Eurasia, although more recent introductions have often been from regions other than Eurasia.

Non-native grass species richness and abundance is highest in the south-west of the country, but has recently increased much more in other parts of the country. We found at least 21 species with recorded environmental and economic impacts in South Africa. There is little literature on the management of these species, and current legislation does not adequately cover these species. We discuss our results with regards to previous findings on grass invasions and make suggestions for possible future problems with non-native grasses in South Africa.

The potential of a pre-introductory survey on *Arundo donax* L. to guide a biological control program in South Africa

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A pre-introductory survey is a method used to assess an invasive alien plant in its adventive range in order to gain information on the status of the species prior to the establishment of a biological control program. This study investigated the invasive alien reed *Arundo donax* L. in South Africa prior to the release of biological control agents. The genetic structure of *A. donax* populations in South Africa, as well as the herbivores associated with the plant was investigated. Genetic structure was investigated by sequencing three regions of the chloroplast and combining this information with four microsatellite regions. From this it was determined that all populations of *A. donax* in South Africa are haplotype M1; the most widely distributed haplotype worldwide believed to originate from the Arabian Peninsula. In addition, no genetic diversity was found, indicating that reed stands in South Africa are essential one clone. The diversity of herbivores associated with this haplotype was then recorded. Seven herbivores were recorded feeding on *A. donax* with two of these species having been introduced from the host plant's native distribution. A potential biological control agent, the monophagous gall-forming *Tetramesa romana* Walker (Hymenoptera: Eurytomidae), was found to already be established at all sites investigated in this study. Overall the study was able to determine the region of origin of South African *A. donax* and record all known herbivores already established in the adventive range. This information will play an important role in guiding the future biological control programme.

Climatic suitability of South Africa for giant reed, *Arundo donax* (Poaceae) and a candidate biological control agent, the rhizome- and stem-feeding scale insect, *Rhizaspidiotus donacis* (Hemiptera: Diaspididae)

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Arundo donax L. (Poaceae) is a widespread and highly invasive reed in South Africa. Following progress in the USA, the scale insect, *Rhizaspidiotus donacis* Leonardi (Hemiptera: Diaspididae) is being considered as a candidate biological control agent in South Africa. An important component of pre-release evaluations in weed biological control programmes is to evaluate the climatic niches of candidate agents and the target weed to identify areas that are climatically suitable for their persistence in areas of introduction. This study aims to determine whether *A. donax* has reached its optimum invasion distribution in South Africa and whether South Africa is climatically suitable to support *R. donacis* populations. The climate-modelling program CLIMEX was used to model climatic similarities between native range locations of *R. donacis* and South Africa, and the climatic suitability of South Africa for *R. donacis* and *A. donax*, using model parameters based on both native and introduced range (i.e. USA) distribution data. The results indicated that most regions of South Africa are climatically suitable for *R. donacis* establishment or are climatically similar to locations in the USA where the scale insect has established following deliberate release. Predictions from the combined use of native and introduced range parameters indicate that *A. donax* is likely to have reached its fundamental distribution range in South Africa. Furthermore, the improved model predictions obtained through the use of both sets of parameters demonstrate the potentially limited predictive value of using native range parameters alone when modelling distributions of invasive alien plants.

Status report on alien bamboos: the emergence of temperate woody species.

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Early agricultural journals indicate that tropical bamboo species were introduced from India into South Africa by the forestry department. Experimental plantations were established in Mpumalanga and KwaZulu-Natal, and from there propagules of bamboo were reported to be distributed to farms for small-scale use. Herbarium records indicate that tropical and herbaceous bamboos have been found over the past 200 years in line with the literature. During my MSc research, we aimed to understand the current status and extent of bamboos. We expected to find similar trends to these herbarium records in terms of the species present and their distribution in South Africa. Results found that there is a legacy of tropical bamboos that can still be found on older farms, with most bamboo populations seeming to be contained and in general a valuable asset to farmers. However during sampling we also found that more than 50% of naturalised bamboo populations in the Western Cape, Free State and KwaZulu-Natal were temperate bamboos from China, mostly *Phyllostachys* species. Unlike tropical species, there are no herbaria records of these bamboos prior to my sampling, suggesting that the introduction of these species is recent and most likely for horticultural purposes. The *Phyllostachys* genus is considered to be the most invasive and weedy of bamboos. We found numerous cases of bamboo escaping in urban environments and giving the appearance of spread in abandoned land. Further assessment is needed to monitor spread and whether management is needed for this genus.

An assessment of the taxonomic underpinning of the NEM:BA A&IS Regulations

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Any work involving management of plant species requires a sound scientific basis; thus a solid taxonomic underpinning of the South African Invasive Species Programme (ISP) and its outputs is essential. The aim of this paper is to assess whether this is being achieved. This will strengthen the reporting framework required for the national status report on biological invasions.

South Africa has a long history of effectively managing plant taxon information, but this has historically had a strong bias to indigenous plants, thus virtually ignoring our alien taxa. The result is that our biodiversity collections are very poor in alien representatives, and that the taxonomic underpinning of the knowledge of our alien Flora is neglected. This bias was not limited to the collections, but is also evident in the databasing efforts to date. The priority for mobilising plant data from botanical collections has been indigenous plants to the virtual exclusion of alien taxa.

In an assessment of taxonomic needs of the ISP, we prioritise the current state of knowledge for plants requiring compulsory control. Each species is assessed as to whether we have on record the particular taxon circumscription applied by a specific author in a specific reference and whether we have a selected voucher specimen that serves to pin down the application of the name. We also assign a confidence level to the application of the name used and recommend any further steps as would be necessary to fix the taxonomic scope of knowledge.

Impacts of alien vegetation on animal diversity in South Africa: a synthesis

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Increasing numbers of invasive alien plant (IAP) species are establishing around the globe and can have negative effects on resident species diversity. These impacts depend on a variety of factors, including the extent of the plant invasion, the region and taxonomic group affected. These context dependencies make extrapolations of the effects of IAPs on resident biota from region to region a substantial challenge.

Here, we aim to synthesise studies that have examined the effects of IAPs on animal diversity in South Africa. We focus on ectothermic organisms (reptiles, amphibians and arthropods) as the environment more directly influences their energy budgets, they generally have smaller dispersal distances than mammals and birds, and they make a large contribution to overall animal diversity. Relevant articles were sourced using a combination of key words relating to i. the effects of IAPs on species diversity (richness, abundance and composition), ii. the invasive plant and iii. the native ectotherm. We also extracted information on mechanisms driving the impacts such as changes in habitat structure, thermal opportunities, prey and predator data, and refuge/nest site availability and explore if these are related to the growth form, stand age and spatial coverage of the IAP.

By assessing the status of knowledge regarding the impacts of IAPs on resident animal species in South Africa, and underlying mechanisms, this study identifies information gaps and research priorities at the country-level with a view to inform monitoring and conservation efforts such as alien plant removal and control programmes.

Legume–rhizobium symbiotic promiscuity does not determine plant invasiveness.

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The fixing of atmospheric nitrogen is thought to play an important role in the invasion success of legumes. Interactions between legumes and nitrogen-fixing bacteria (rhizobia) span a continuum of specialisation, and therefore promiscuous legumes should have higher chances of forming effective symbioses in novel ranges. Using eight widespread and eleven localised acacias, we aimed to determine host promiscuity and its link to invasion success by assessing the diversity and structure of rhizobia communities associated with these acacias in South Africa. We hypothesised widespread acacias to be more generalist in their symbiotic requirements, thus associating with a higher rhizobial diversity and differing in community composition, compared to localised acacias. Also, we predicted symbiotic effectiveness to have a strong host plant phylogenetic signal. Using next generation sequencing data for the nodulation gene, *nodC*, we compared the identity, richness, diversity and compositional similarity of rhizobia associated with these acacias. Using the latest acacia phylogeny and published data, we also explored symbiotic response between various cross-inoculated acacias as a function of host phylogenetic relatedness. Overall, widespread and localised acacias did not differ significantly in rhizobia richness and diversity. However, some diversity metrics were dependent on geography, status and their interaction. Widespread and localised acacias associated with compositionally different suites of rhizobia. Symbiotic responses of cross-inoculated acacias declined as host phylogenetic distance increased. These results suggest that differences in invasion success for these trees may be driven by symbiotic effectiveness rather than rhizobia diversity.

Research on *Harmonia axyridis* in South Africa: knowns, unknowns and flags

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The harlequin ladybird *Harmonia axyridis* is a globally invasive beetle native to Asia. Its establishment and spread has led to the decline of native ladybird species in many regions of the world. In South Africa, it was first detected in the early 2000s in the Western Cape Province and has rapidly spread so that it is currently found in all nine provinces. My PhD research has shown that *H. axyridis* has similar or a narrower temperature tolerance range than native ladybird species, but has increased plasticity of upper temperature tolerance. Annual field collections of *H. axyridis* from 2013 to 2016 in Stellenbosch have highlighted how little we know about the species' abundance and phenology, its interactions with native and other alien ladybirds and its impact on native species in South Africa. Current work includes the plasticity of life-history traits and starvation resistance of *H. axyridis* and its native counterpart *Cheilomenes lunata* in order to model these species' potential distributions and population growth under future climate change scenarios. We have also uncovered new records of a parasitoid wasp and an ectoparasitic fungus that infest *H. axyridis*. These findings may contribute to devise methods to regulate invasive populations of *H. axyridis*. Finally, we have started a citizen science initiative with the aim to educate the public about this species, gather distribution records and collect specimens across the country. These data will be used to determine pathways of introduction, dispersal rates between geographic regions, and test hypotheses of invasion history using molecular techniques, thereby greatly informing management policies.

Fungi and invasions in South Africa

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Fungi are a major component of the functioning of any terrestrial ecosystem, however they are generally hidden from view and therefore little considered. There is an increasing awareness of fungi as drivers of ecosystem processes including invasion. The fungal dimension of invasions in South Africa is reviewed, both from the viewpoints of fungi as invaders and the association of alien and indigenous fungi with plant invaders. Available literature is reviewed, and placed within a South African context. Various hypotheses relating to invasion science and fungi are discussed within a local context. Examples of fungi known to be invasive in natural ecosystems and problems associated with identifying whether a fungus is indigenous or an invasive are discussed. Fungi associated with crop and forestry plants are excluded. For almost all aspects considered, it is concluded that we simply do not have sufficient data to begin to understand the role of fungi in invasion in South Africa.

Invasive tree pathogens and pests in South Africa: can we stem the tide?

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The past decade has seen a significant increase in the number of insect pests and plant pathogens (pests) of tree species in South Africa. In the last five years the Myrtaceae rust pathogen, *Puccinia psidii*, the Cycad Asian Scale (CAS), *Aulacaspis yasumatsui*, and several damaging insect pests of plantation forestry species appeared in the country. The previously recorded non-native pathogens, *Phytophthora cinnamomi* and *Armillaria mellea* has spread into natural environments, threatening native ecosystems. These, and other pathogens, most likely entered the country on infected plant material and/or soil.

The unregulated trade in non-native ornamental plants is a major contributor to the local spread of pests in South Africa. The spread of CAS, for example, has been accelerated by the nursery and collector's trade and is resulting in large populations of CAS, posing a threat to the survival of native South African species.

It is crucially important that the South African public be sensitised to the threat that invasive alien pests pose to the natural environment. Here, responsible trade in plants is a key issue. Quarantine regulations must be emphasised and actively communicated, alongside law enforcement. Experience from other countries has unequivocally illustrated the fact that a failure to take a strong stand on quarantine and the management of the trade in non-native plant species will result in South Africa losing important components of a rich and irreplaceable native plant biodiversity and the associated ecosystems in which this natural resource occurs.

Investigating the ecological recovery and the restoration of aquatic ecosystem integrity post successful biological control of alien aquatic weeds

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The establishment of aquatic alien species has recently been recognised as the second major contributor to loss of ecosystem biodiversity after habitat loss. Reversing the impact of alien aquatic weeds would be of major benefit to the ecosystem following the recovery of indigenous biodiversity. In South Africa, studies have shown that biological control programmes against floating water weeds have been largely successful, with effective control (where no other intervention is necessary) of water lettuce (*Pistia stratiotes*), red water fern (*Azolla filiculoides*) and Kariba weed (*Salvinia molesta*). However, despite successful host specificity testing, release and establishment of biological control agents and eventual effective control of multiple invasive aquatic plants, the indirect and long-term aquatic ecosystem effects of biological control are currently poorly understood. Therefore, this study is aimed at investigating the long-term ecological contribution post successful biological control of alien aquatic weeds. It is anticipated that this research will resolve some of the major uncertainties associated with biological control of aquatic weeds e.g. does successful biological control result in long-term (1) enhancement in aquatic biodiversity and/or changes in food webs, (2) ecosystem recovery (i.e. healthier habitat and better water quality) and (3) promotion of ecosystem ecological benefits? Addressing the above-mentioned ecological concerns in a series of mesocosm experiments (invaded, controlled and reference study sites) with a main focus on aquatic ecosystem biological components, this study will investigate the role and effectiveness of biological control in ecosystem integrity recovery, restoration and ultimately the provisioning of freshwater ecosystem services.

Invasive alien plants and water resources in South Africa: advances in understanding and predictive ability since 2004 and research challenges

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A key motivation for initiating of the Working for Water programme in 1995 was predictions that invasive alien plants would use significant amounts of water and that clearing invasions would protect water resources. These predictions were based on the results of hydrological experiments on the impacts of commercial tree plantations on water resources and the estimates of the biomass present in invaded areas. During the past 20 years there has been significant progress in the understanding of biophysical processes and the factors that control vegetation and plant water-use, as well as datasets that enable comparisons between indigenous and alien plant species. These include the development, and ongoing improvement in, methods of measuring transpiration and evaporation at levels from the individual plants to stands of plants using sap flow and micro-meteorological techniques. The development and of remote-sensing-based methods of estimating evaporation opens up new approaches to scaling-up invasive tree water use from the site or small catchment level measurements to large catchments and

even regions of South Africa. Challenges remain, including adequate data on some major invaders, and robust methods for modelling the impacts of invasions on water yields. We require more long-term catchment-based studies of invasions and their control on the water balance. Knowledge of their impacts has not been effectively integrated into catchment management practices and water resource planning, or into funding for catchment management. These knowledge gaps and failures in translating knowledge into action should be given a high priority in research and in knowledge transfer.

The role of molecular ecology in an invaded South Africa and its importance for biocontrol using *Tamarix* as a case study

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The use of molecular techniques in invasion biology is regarded by many as a fairly new approach. Current research uses genetic tools to better understand the histories, processes and effects of plant invasions that are critical to improving control success of these organisms. The role of this presentation is to provide an overview of how molecular techniques can be used to aid the management of alien invasive plants in South Africa. *Tamarix* species are known to have considerable morphological and ecological similarities, which generate confusion when trying to identify them morphologically. Genetic analyses identified three species of *Tamarix* in South Africa with hybrids between all the parental species, removing the taxonomic confusion. Further analyses examining the intraspecific genetic diversity showed that 64% of *Tamarix* invasion is hybrids. Hybridisation and introgression are known to be a significant component of *Tamarix* invasion as they increased genetic diversity, generated potential successful novel genotypes and can swamp the native *T. usneoides* gene pool, all of which can be a limiting factor to biocontrol, i.e., the hybridisation in knapweed. Molecular techniques have many applications in biocontrol and invasion biology. These include instances where source populations of pompom weed in South Africa were identified; tracking of introduction routes of pompom weed and *Tamarix* in South Africa; and elucidating mechanisms of local spread and adaptations. All of these can be invaluable for host specificity testing of potential agents for biocontrol of existing invasive plants.

The extent of the alien *Tamarix* invasion in South Africa

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Tamarix L. is one of four genera from the Old world family of Tamaricaceae. In South Africa it is represented by one indigenous (*Tamarix usneoides*) and two exotic (*T. chinesis* and *T. ramosissima*) species. The first record of the exotic species in this country is from the early 1900s, when they were introduced for erosion control on mine dumps. These plants have however escaped their original sites and invaded several riparian zones across South Africa. This study investigates the extent and identity of the exotic *Tamarix* species and their hybrids in the Eastern, Western and Northern Cape provinces, where they are most prevalent. Twelve different riparian zones were surveyed by recording plant density/quadrat, stem density/plant, plant canopy area and height. Leaf specimens were randomly collected from eight different plants for molecular identification of the *Tamarix* in each site. Only one of the 12 sites had a pure population of the native *T. usneoides* (Kakamas River, Northern Cape) and the insect abundance and diversity was greater on the indigenous species. Hybrids of the two exotic *Tamarix* species were the most widespread taxon found, followed by hybrids of the native *T. usneoides* with the exotic *T. chinesis*, which accounted for 80% of the total sites with exotic/native hybrids. *Tamarix* canopy covers 15–90% of the river bank, with the highest being in the Eastern and Western Cape provinces. This study therefore, gives evidence that these two provinces require an urgent management intervention to contain the spread of the weed and its hybrids.

Progress on the potential biological control programme for invasive *Tamarix* in South Africa

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Tamarix is a riparian tree with tiny white to pink flowers. All of the species in the genus except *T. usneoides*, which is indigenous to South Africa, originated in Eurasia and at least four have become invasive in South Africa. South Africa is using the successful USA biological control programme as a template to develop biocontrol agents against the same invasive *Tamarix* species. However, the South African programme is complicated by firstly, the presence of the indigenous *T. usneoides*, which raises the precision of host-specificity required, and secondly, all *Tamarix* species have a high intrinsic value for phytoremediation of mine tailings dams in South Africa. The potential biocontrol agents, Tamarisk beetles (*Diorhabda* spp.), were imported into quarantine in South Africa during September 2015. Preliminary results in quarantine indicate that oviposition (number of egg clusters) is higher on the invasive species (*T. chinensis*), but the egg clusters are larger (number of eggs/cluster) on hybrids with the indigenous species (*T. ramosissima* × *T. usneoides*) than on the invasive *T. chinensis*. The larvae had a faster development rate and more larvae survived to 3rd instar on the hybrid compared to the invasive species. Furthermore, additional and preliminary field host-specificity test conducted in the USA showed that the beetles do not have a preference for *T. usneoides* under field conditions. Thus, the prospects for successful biological control of *Tamarix* in South Africa are good.

Australian *Acacia* species in South Africa: an assessment of the current status of recorded introductions

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The history of forestry plantings of Australian acacias in South Africa has been well documented by Poynton (2009). However, the work is incomplete as it focusses primarily on forestry introductions, and is also in need of updating (most of the work was done in the 1970s). Here we review the status of all introduced *Acacia* species in South Africa, focussing particularly on species that are less widespread. Biodiversity data from museums and herbaria contain several sources of errors and biases, and, as a result, current data and distribution of many species may be inaccurate and incomplete. It is important to re-evaluate current and historical data from these sources as well as from expert knowledge to supplement recent field survey data and create updated distribution maps of alien species. Assessment of current invasion status will play a major role in determining which management strategies are needed.

Chemical ecology of cryptic species of *Eccritotarsus catarinensis* (Carvalho) (Hemiptera: Miridae), biological control agents of water hyacinth (*Eichhornia crassipes*)

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Water hyacinth, *Eichhornia crassipes* (Martius) Solms-Laubach (Pontederiaceae), is a floating aquatic macrophyte and is one of the world's worst weeds. In South Africa, its distribution is most prominent in the southern and eastern regions, particularly in coastal regions of KwaZulu-Natal, and in the Vaal and Crocodile rivers of the North West Province. The mirid, *Eccritotarsus catarinensis* (Carvalho) (Hemiptera: Miridae), one of several biological control agents used against the weed, has two highly differentiated and distinct populations, one from Brazil and the other from Peru, which have recently been confirmed as reproductively isolated cryptic species. This study aimed to determine the chemical composition of the pheromones produced by the two species, and to determine whether pheromones have played a role in speciation. Odour–source experiments using Y-tubes and aeration chambers, and

behavioural–observation experiments are in progress to investigate the attraction of males towards females in both populations. Y-tube experiments demonstrated minimal attraction of one sex towards the other across both populations. Solid-phase micro-extraction (SPME) analysis using live mirids of both populations showed that hexadecanoic acid is common either as primary or secondary compound in newly emerged adults whereas trans-2-hexenyl acetate is common as a major compound in adults of known (6–8 days old) and unknown age. Both compounds differed in area percentages, thus their differences in quantity suggest that they are species specific, hence future research needs to investigate their role as sex pheromones. It is possible that the compounds have a role to play in the reproductive incompatibility found between the two cryptic species.

Invasive amphibians in South Africa

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Globally, invasive amphibians are known for their environmental and social impacts that range from toxicity to local fauna and human populations, to direct predation on other amphibians. Although several countries on most continents of the globe have had multiple introductions from many species, South Africa appears to have escaped from allochthonous introductions but instead has a small number of domestic exotics: *Hyperolius marmoratus*, *Sclerophrys gutturalis* and *Xenopus laevis*. Here we present updated information on the invasion of all three South African domestic exotics, and ask how their invasion pathways differ. In each case, genetic studies show human-mediated initial introduction, which is generally unintentional, and perhaps unsurprisingly, all species have an element of leap-frog dispersal between artificial impoundments. However, the movement of South African frogs has not always been unintentional, and intentional introduction of *X. laevis* for scientific and medical purposes has resulted in invasions by this species on four continents. Results from a survey of stowaway amphibians entering and moving around South Africa suggest that while this is still an unusual phenomenon, there are indications of increasing numbers of amphibians being imported into the country. This increase in propagule pressure suggests that preventing new introductions will become a key challenge for the future. Despite the low numbers of invasive species, South Africa is currently the most highly invaded for amphibian species on the African content.

Invasive, naturalised and casual alien plants in southern Africa: an update from the Southern African Plant Invaders Atlas (SAPIA)

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The Southern African Plant Invaders Atlas (SAPIA) is a mapping project, launched in January 1994, to collate data on the distribution, abundance and habitat types of invasive alien plants (IAPs) in southern Africa. The SAPIA database is a computerised catalogue of some 86 000 locality records of close on 800 alien plant species growing outside of cultivation. The database incorporates records gathered by about 600 participants, since 1994, and from roadside surveys by the author since 1979.

The first comprehensive overview of species in the SAPIA database was done in 2006, with a listing of 601 species. Ten years later, in 2016, a further 180 species have been added to the database, bringing the total number of listed species to 781. Of the 180 species added to SAPIA, 100 are newly emerging species and 33 are established species, but not previously documented in the Pretoria National Herbarium or literature. Although the SAPIA database is the most comprehensive database on IAPs in South Africa, it does not include all naturalised species. A further 500 or more species are known from the Pretoria National Herbarium.

National Invasive Alien Plant Survey

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The negative impact of Invasive Alien Plant (IAP) species on natural areas, but also on areas such as agricultural land, has been extensively researched. Certain mitigation strategies and programmes have been put in place such as the internationally recognised Working for Water Programme. Such an initiative requires objectively determined spatial distribution data of IAP species at the required scale to allow for effective planning, implementation and future monitoring of IAP distribution changes.

The National Invasive Alien Plant Survey project was initiated by the Working for Water Programme and implemented by the Agricultural Research Council. The project objectives are to establish and implement a cost-effective, objective and statistically sound IAP monitoring system for South Africa at a quaternary catchment level.

A complete inventory and a standard sampling approach both have limitations, mainly due to the size of the study area (123 million hectares), variation in the natural environment, and therefore the associated costs. An innovative sampling approach was required to meet the project aims. Sampling orientated along an environmentally variable gradient that contributes the most to species occurrence, would detect the maximum variation in an area, therefore resulting in a stratified proportional sampling approach. A further riparian sample layer was allocated. A third regular grid point layer was created for selected quaternary catchments to serve as an independent source of verification. Different field survey approaches were simulated and the most suitable was an aerial approach. An extensive field survey was conducted of the sample points. Field data was analysed and the relevant IAP maps were produced.

Possible management options for *Ulex europaeus* L. and *Cytisus scoparius* (L.) Link in South Africa

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Ulex europaeus (gorse) and *Cytisus scoparius* (scotch broom) are widespread invaders worldwide and were introduced into South Africa during the 1930s and 1940s respectively. This study investigated their distribution, population size and structure, reproductive biology, seed bank characteristics and possible management options (i.e. burning and herbicide use (Garlon, triclopyr butoxy ethyl ester 480 g/L)). The distribution of both species was limited to the eastern part of South Africa, consisting of 14 gorse and 46 scotch broom populations, which collectively comprised 3 951 individuals (over 16 508 m^2) and 121 135 individuals (over 97 262.5 m^2), respectively. There was evidence of high seed set and seed bank loads for both species. Herbicide treatments (2–4% of Garlon trclopyr applied via foliar spray on seedlings and to cut stumps on adult plants) were effective in managing both species, resulting in ≥95% plant mortality. Fire promoted seedling emergence from scotch broom seed banks, possibly as consequence of breaking seed dormancy (which appears to be physical), and this could possibly assist in reducing seed bank loads. Given the large seed-banks present, integrated management options with protracted periods of management and monitoring will be required to control both species. Eradication from South Africa will be very difficult to achieve and will take many years, but it is feasible if control is persistent. As such, both species should provisionally remain as category 1a.

Assessing the distribution, invasion status and management of *Epipremnum aureum* in South Africa

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Epipremnum aureum, a creeper and climber, from the family Araceae, is highly invasive in Hawaii and Sri Lanka, and recently considered as a potential invader in South Africa. However, no study has examined the invasiveness of the species. We mapped the species' current distribution in South Africa, modelled its potential distribution, identified factors that drive its invasiveness, and explored control methods. We only found records of the species from KwaZulu-Natal, and all surveyed populations were already naturalised. *E. aureum* tended to invade sites that have high numbers of stems in the population (used as proxy for propagule pressure), tall plants, as well as illegal dump sites. The species has a high potential to expand its range into other parts of KwaZulu-Natal and the Eastern Cape if introduced to these areas. Therefore, we recommend that all populations be removed. To achieve this, herbicide application is the best option for controlling the species. These results provide correlates on the invasiveness of *E. aureum*, its potential range and control options which can be used for proactive management.

Investigating the impacts of *Salix babylonica* on urban riverine habitats

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Salix babylonica is a widespread and successful invasive species in riverine areas in South Africa, but its impacts on its immediate environment have received little attention. The tree is listed as a Category 2 species in the CARA but not NEM:BA. In this study, we assessed the impacts of *S. babylonica* on plant communities and soil properties along two rivers in Gauteng. To measure the impact of *S. babylonica* on plant communities, two 1 × 1 m plots were laid out underneath trees and paired plots were laid 1 m away from the tree canopy edges. In each plot, percentage cover of bare soil, root, rock and vegetation were measured. The effect of *S. babylonica* on soil properties was evaluated by collecting soil samples underneath the tree canopy and 1 m away from the tree canopy, which were analysed for pH levels, macronutrient and micronutrients. Soil moisture was measured where the tree is rooted, 1 m away from the tree trunk, but still underneath the tree canopy, and 1 m away from the tree canopy of each tree. Bare soil cover and root cover was significantly higher underneath *S. babylonica*. Species composition underneath and away from *S. babylonica* canopy differed significantly. Among the soil nutrients that were analysed we found significantly higher levels of potassium underneath *S. babylonica* than away from the trees' canopy.

Keynote Address 3:

Promise and challenges of risk assessment as an approach for preventing the arrival of invasive species

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Invasive species are a major threat to agriculture, environments and economies around the world. One main method for reducing this threat is to implement risk assessment programmes that proactively estimate whether non-native species are likely to cause harm. When these programmes are coupled with efforts to prevent the arrival of high risk species, they have been shown to be effective at reducing invasive species harms. Several recent studies have also shown that although risk assessment programmes reduce the number of species available for trade, they produce large economic benefits for nations because invasive species impacts are relatively expensive compared to the benefits of species in trade. Risk assessment tools clearly have great potential and although they are not yet widely implemented there are increasing efforts by nations to develop them. Despite this, these programmes are often poorly coordinated both within and among nations, and many taxa are not adequately covered. Additionally, a bewildering range of approaches to risk assessment have been developed, with a particularly sharp divide between the approaches favoured by academics and managers. In this presentation I will discuss the progress that has recently been made in risk assessment and the promise of additional benefits from wider coordination and implementation. I will also discuss the main challenges to increased use of risk assessment and how I believe those challenges can be overcome.

Understanding invasions and pest risks in agriculture: current research status on invasive fruit flies (Diptera: Tephritidae) and new directions for management and intervention planning in South Africa

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Research in the field of biological invasions has increased dramatically in the last two decades, especially due to the impact of human activity such as, transport, travel and international trade. Therefore, developing a general management framework for monitoring and reporting biological invasions based on past research are crucial to assist decision making and actions to be taken. Here we make use of a range of different datasets for significant economic agricultural fruit fly pests to gain insight into potential intervention strategies. First we review the pest and invasion status, economic impact and current control of fruit flies in South Africa. Then we highlight the importance of monitoring data and how timing and location can influence monitoring outcomes. Moreover we show the importance of accurate identification of new interceptions and discuss some challenges in doing so. Furthermore we illustrate that once a species has been correctly identified as an invader, information on invasion pathways can be used to identify, monitor, reduce and ultimately remove existing or potential new movement pathways, hindering the continued spread of the pest. Finally, once a species is established in a new area, natural dispersal becomes an important consideration in the subsequent spread of the species. We demonstrate how population genetic estimates of landscape structure can provide insight into management units, and test whether the landscape offers any intrinsic resistance to this movement (e.g. natural barriers). Using fruit flies we illustrate the concepts outlined above in a management decision flowchart/tree for integrating pest management and invasion management into a common framework.

Management of conflict invasive species in South Africa: challenges and trade-offs

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South Africa has a long history of non-native species introductions and the primary reasons for these introductions include provision of food and raw materials, biocontrol, ornamental and recreational purposes. Of concern is that despite the considerable socio-economic benefits derived from some of the non-native species, they can also cause adverse ecological impacts in recipient areas. As a result non-native species with a high societal value are now considered to be conflict species where there is a direct dissension between attaining biodiversity goals and human interests. Yet, despite many cases of conflicts that have arisen, there has been no systematic review of the common principles/trends in conflicts across taxa. This paper proposes to systematically review cases of conflicts in invasive species management in South Africa and provide a conceptual framework to identify types of conflicts, ways in which conflict has been avoided, and where it has not.

The potential economic implications of *Robinia pseudoacacia* L. (black locust) on agricultural production in South Africa

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Robinia pseudoacacia is an invasive deciduous, strongly suckering, broad-leaved tree that has the potential to further its distribution across a large portion of South Africa. Black locust has already invaded all nine of South African provinces. The invasive trees potential to spread into livestock grazing lands in South Africa has not been investigated. The potential economic impacts of *R. pseudoacacia* on agricultural production stem from the trees ability to reduce the livestock carrying capacity of grazing land. This study estimated the potential economic implications of *R. pseudoacacia* on agricultural production in South Africa, specifically looking at the livestock sector. The prevalence of *R. pseudoacacia*'s potential distribution was calculated by using a maximum-entropy predictive habitat model, MAXENT. The distribution of livestock, based on grazing capacity (ha/LSU), in South Africa was then determined. The potential direct economic impacts were estimated by assessing the impact of the potential distribution of *R. pseudoacacia* on the carrying capacity of livestock. The results showed that an infestation of *R. pseudoacacia* has the potential to reduce the gross margin in the livestock sector from approximately R130 million to R961 million, dependent on the probability of invasion. Therefore, *R. pseudoacacia* can have detrimental effects on the livestock sector in South Africa. The potential high levels of foregone income and business activity found in this study reaffirm the need to devote resources to develop viable, economical and effective control methods.

A national strategic framework for the management of the family Cactaceae in South Africa

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Cacti (Cactaceae) are among the most widespread and damaging groups of invasive plants in South Africa. There are currently 35 cactus species known to be naturalised or invasive in South Africa, most of which cause considerable ecological, social and economic impacts. However, despite a long history of controlling cactus invasions, management to date has lacked effective cohesive strategic planning at a national scale. In response to this need, a South African Cactus Working Group (SACWG) was established in 2013 to develop guidelines for a national strategic framework. This paper summarises the status of cactus invasions and management in South Africa and presents the national strategic framework developed by the SACWG. The overarching aim of the framework is to reduce the negative impacts of cacti to a point where their benefits significantly outweigh the losses. Four strategic objectives designed to achieve the desired outcome are proposed: 1) all invasive and potentially invasive cactus species should be prevented from entering the country, 2) new cases of naturalisation of cactus species must be rapidly detected and eradicated, 3) the impacts of invasive cacti must be reduced and contained, and 4) socio-economically useful cacti (both invasive and non-invasive species) must be utilised sustainably and the risk of further negative impacts must be minimised. A decision-support tool for guiding assignment of species to each of the above-mentioned objectives is described. Indicators for evaluating the progress of strategic management of cacti are discussed in the context of the national status report.

The development of lists of regulated alien taxa in South Africa

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The process of developing regulatory lists of alien and invasive taxa should be based on scientific evidence through an objective, transparent and consistent process. Here we review the development of the lists for the South African National Biodiversity Management Act (NEM:BA) alien and invasive species regulations.

We compared the lists published in the national Government Gazette and assessed the changes in the taxa listed and their status. Minutes from expert workshops convened to inform the listing were reviewed and relevant information like the criteria for listing taxa were extracted from the minutes. Three draft lists were published in the Government Gazette for public comment before the final list was published in August 2014, coming into force in October 2014. This list was further amended in May 2015.

Species on the NEM:BA Alien and Invasive species list were listed for various reasons. The main goal was to list species known or suspected to have pronounced negative impacts on natural ecosystems, or congeners of such species. The process endeavoured to get engagement with academics, conservation experts, managers and various stakeholders through inclusion either actively in workshops or through a public commenting process to achieve shared governance. A scoring tool based on the likelihood of invasion versus the impact of invasion was recommended for evaluating the risk of a species, but rarely used. We conclude with some recommendations for future refinements in the process.

Trends in demands of listed invasive species in South Africa

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Invasive alien species are a major global concern due to their widespread negative impacts on biodiversity and agriculture. Invasion biology is inextricably linked to both biological phenomena and societal phenomena. Many factors influence the spread dynamics and distribution of species including human-mediated dispersal, because humans move species beyond their native ranges, intentionally or accidentally, and these species then become established and spread.

DEA species permitting application database records from 2014 to 2015 were studied. The records were analysed and compared between listed invasive species and across provinces and taxa. The DEA dealt with 221 applications and issued 223 permits for 48 species. The DEA permitting records indicated that mammals have the highest number of applications and permits issued, followed by freshwater fish, reptiles, marine invertebrates, plants and freshwater invertebrates. No permits were issued for other taxa. The human element is manageable effectively through legislation and public awareness. Therefore, successful management of AIS requires an understanding of spatial patterns of dispersal as the driving factor. The results provide quantitative evidence in support of the hypothesis that human-mediated dispersal is a pivotal to estimations of current and future spread of alien invasive species across the world.

Exacerbation of photosynthetic damage through increased heat–light stress resulting from *Gargaphia decoris* sap-feeding

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Solanum mauritianum (bugweed) is one of the world's worst ecological weeds and has been targeted for biological control efforts in South Africa since 1984. One of two promising biological control agents released against bugweed was the sap-sucking lace bug, *Gargaphia decoris* (Hemiptera: Tingidae). Few studies have assessed the physiological effects induced by biological control agents feeding damage on their target weeds. Chlorophyll removal by *G. decoris* feeding caused metabolic impairment, which resulted in a reduction of photosynthetic rates of bugweed leaves, with a greater effect on plants growing in full sun conditions compared to plants growing in shade. This difference was related to higher leaf temperatures experienced under full sun conditions. Herbivory caused a 52% reduction in bugweed transpiration rates, impeding the ability of leaves cool via evaporation. Although *G. decoris*'s feeding rates were greater on plants in the shade, feeding per unit area was significantly more damaging to plants continually exposed to full sunlight. The increased physiological damage experienced by full-sun plants may be a combination of stresses, particularly the direct effect of chlorophyll removal via herbivory and the indirect effect of accumulated heat–light stress. Given the effectiveness of *G. decoris* for biological control, factors constraining its current performance in the field need to be identified and addressed.

The potential of *Hydrellia egeriae* sp. nov. (Diptera: Ephydridae) as a biological control agent for the submerged aquatic weed, *Egeria densa* Planch. in South Africa

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Egeria densa Planch. (Hydrocharitaceae) is the widest established invasive submerged aquatic weed in South Africa. Native to South America, it forms dense stands in water bodies, prohibiting water usage and threatening indigenous biodiversity. Surveys in its native region yielded a promising biological control agent, a leaf-mining fly from the Ephydridae family, *Hydrellia egeriae* Rodrigues. The damage capacity and host-specificity of the fly was investigated to determine its potential as a biological control agent in South Africa. Larvae consumed on average 14.8 ± 0.6 whole *E. densa* leaves; feeding from the crown of the shoot downwards. Damaged leaves are susceptible for further pathogenic infection resulting in shoot dieback. No-choice tests showed a small degree of larval feeding and development on non-target species within the Hydrocharitaceae and Potamogetonaceae families. However, during paired-choice tests, *H. egeriae* showed a strong preference for *E. densa*. Oviposition site selection ranged predominantly from protruding *E. densa* leaves to any other surface or plant material available. Larval survival was not affected by oviposition site, as larvae readily moved to *E. densa* leaves after eclosion. Damage inflicted by *H. egeriae* is significant, and given it's specificity for *E. densa*, should be considered for release in South Africa.

The effects of water stress on the efficacy of the biological control programme against *Myriophyllum aquaticum*

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There are several factors that may influence the efficacy of a biological control programme and one that has received relatively little attention is water stress. The biological control programme against *Myriophyllum aquaticum* has been extremely successful under most conditions in South Africa. However, field observations suggest that the beetle *Lysathia* sp. is not as effective in seasonal ponds where at certain times of the year the weed grows on the banks under water-stressed conditions. This study aimed to determine the effect of water stress on the ability of *Lysathia* sp. to feed and oviposit.

The study was conducted in two phases under controlled conditions. The first phase tested whether the females chose to oviposit on water-stressed plants and secondly whether the eggs and larvae would survive under water-stress conditions. The study showed that when given the opportunity the females chose to oviposit on healthy plants as opposed to water-stressed ones ($Z_{(1,20)} = 2.803$, $P = 0.0054$). However, the larvae of *Lysathia* sp. were able to feed and develop with no significant differences on both water stressed and non-stressed parrots feather ($U_{(1,10)} = 11.0$ $P = 0.834$). This study suggests that *Lysathia* sp. is capable of developing on water-stressed plants, however when given the choice adult females would rather disperse to another locality where plants are potentially under better conditions. This suggests that biological control of *M. aquaticum* on water bodies that are seasonally dry may not be as effective as on permanent water bodies.

How the distributions of the major invasive alien bird species have changed in South Africa over two decades

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Invasive alien bird species in South Africa form two categories: widespread (Common Myna, Mallard, Common Starling, House Sparrow and Rock Dove) and localised (Chukar Partridge, Common Peacock, Rose-ringed Parakeet, Common Chaffinch and House Crow). The first and second bird atlas projects (SABAP1, 1987–1991 and SABAP2, 2007–ongoing) demonstrate the change in distributions of these species over two decades. The centre of gravity of Common Myna distribution moved from KwaZulu-Natal to Gauteng, and it has spread several hundred kilometres in all directions from there. Expansion occurred along successive centres of human habitation. Mallards were concentrated mainly in Greater Cape and the Witwatersrand in the 1980s; there are now scattered records from all provinces of South Africa, with clusters around Pietermaritzburg, East London, Port Elizabeth, Bloemfontein, Nelspruit and the Garden Route. Common Starling continued a steady north-eastward expansion into the Free State, KwaZulu-Natal and Gauteng. House Sparrow was ubiquitous during the first bird atlas, and this has not changed. The abundance of Rock Dove increased with little range change.

The only feral population of Chukar Partridge is on Robben Island, where it has little impact and is not a conservation concern. Feral populations of Common Peacock are being reported by citizen scientists, from dispersed localities. Rose-ringed Parakeets increased in Gauteng and Greater Durban, with scattered records elsewhere. Common Chaffinch remains confined to small areas of the Cape Peninsula 120 years after its introduction. House Crow populations in Cape Town and Durban have been brought under control.

Composition, origins and distribution of the alien fauna of South Africa

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Study aims: to profile and compare the marine, freshwater and terrestrial alien fauna of South Africa, by providing a detailed breakdown of its species richness, taxonomic composition, patterns of geographical origins, modes of introduction, geographic distributions and impacts on local fauna.

Methods and data: the data used in the analysis are to be drawn from the 2011 book 'Alien & invasive animals' (Picker and Griffiths). The detailed appendix is to be used as the primary database, as it is the most complete documentation of the freshwater, marine and terrestrial alien fauna of the region. For the 571 listed species, the appendix includes information on their origin, SA distribution and habitat. Using this database, with more detailed data in the text of the book, the following trends are analysed; hotspot analysis for alien species richness across South Africa, invaded habitat by taxon, relative importance of different taxa, species accumulation curves for increase in numbers of alien species since first introduction to 2011 for vertebrates and invertebrates, mode of introduction pathway (deliberate,

accidental) for terrestrial, freshwater and marine introductions, and geographical source of introduction by taxon and habitat. For invertebrates the contribution of deliberate introductions for biocontrol purposes is included. The scale and trends (invasion history, sources of alien fauna, profiles of faunal species involved and habitats invaded) will provide a broad overview of the nature of the alien fauna of the region.

Evaluating the invasion risk of mammals listed under Cat 1a on NEM:BA

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Little is known about the invasiveness of exotic mammals in South Africa. Consequently this study will review the invasiveness of the four Category 1a mainland mammal species on the NEM:BA lists for South Africa (published in August 2014), two of which are listed only in KwaZulu-Natal: the patas monkey (*Erythrocebus patas*) and grey squirrel (*Sciurus carolinensis*); and the bongo (*Tragelaphus euryceros*) and lesser kudu (*Tragelaphus imberbis*). This study will elucidate the reasoning behind the listing of these species as Category 1a in KZN, as the record of the mammal stakeholder meeting does not include any of these species in this invasive category. The invasion risk of the different species will be evaluated using a generic impact scoring system (GISS). A detailed literature search will be conducted, but as very little information is available for the antelope species, information on related species may be used as well. The aim of this study is to establish whether or not these species would be able to invade, and if populations become naturalised, what risks they would pose to South African biodiversity. Once all the information is gathered, a risk assessment document will be developed for each of the species. The risk assessments will follow the format requested by the Department of Environmental Affairs, which will include distribution maps where possible. The results from this study will allow scientifically informed decisions on whether to recommend upholding the Category 1a NEM:BA listings, or to recommend listing in another category, or not at all.

Shade or shun? Effects of plant invasions on native ectotherms under a warming climate

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Ectothermic species, such as amphibians and reptiles, tend to follow environmental temperatures closely and are thus seen as particularly vulnerable to climate change. Changing climates translate into altered air temperature, but it is the interplay between air temperature and habitat structure that ultimately determines the range of microclimatic environments available to individuals. Alien plants modify vegetation structure and shade availability, thus affecting the thermal landscapes experienced by ectotherms and the options available to behavioural thermoregulators for shuttling between microclimates. Despite widespread concern about ongoing climatic changes and plant invasions, the synergistic effects of the two threats have hitherto received insufficient attention. In a warming world, are ectotherms likely to avoid invasive vegetation or seek their shade?

We start by reviewing the current state of knowledge about thermal effects of alien vegetation on native herpetofauna, and then illustrate potential hotspots of synergistic effects with climate change at a national scale. Using South Africa as illustration, we show the overlap between plant invasions, projected temperature changes, and diversity of reptiles and amphibians. We apply a biophysical approach to explore the effects of invasion-induced changes in shade availability on the operative temperatures of reptiles and amphibians, and discuss the potential implications for groups of species with different traits. Increasingly, prioritisation of conservation efforts needs to rely on knowledge of the spatial distribution of multiple threats such as shown here, and on an understanding of the mechanisms underlying potential synergistic effects between threats.

Plant attributes contribute to the invasive *Tecoma stans* L. (Bignoniaceae) in South Africa

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Tecoma stans L. ex Kunth (Bignoniaceae) was introduced into the country as an ornamental plant and was used as a garden plant because of its yellow, bell-shaped flowers and showy leaves. The absence of its natural enemies caused the plant to escape its original cause and end up invading roadsides, open and disturbed land, riparian zones and rocky sides. *Tecoma stans* produces thousands of papery winged seeds that are easily dispersed by wind and flood water. Seeds have contributed to the invasive behaviour of this plant as they are highly viable according to the germination trials that were conducted in the shade house under normal conditions and also according to field observations. The deep tap root also contributes to the invasive behaviour of this plant. When the plant is chopped or burned, it resprouts into multi-stems in the field. Several environmental factors also contribute to the invasiveness of this plant. This plant continues to extend its range because of its aggressive behaviour. The suitable biological control agents have been recently introduced in the field to control this plant, but it is still too early to determine their establishment and impact.

The contribution of biocontrol implementation to managing weeds in the Western Cape

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Since the year 2000, 'Biocontrol Implementation Officers' have been appointed in provinces across South Africa, through the Working for Water Programme (DEA: NRMP), to assist with the distribution and monitoring of biological control agents against weed species. In 2011 this was expanded through the appointment of two teams in the Western Cape, to increase capacity and further facilitate what was already being achieved. These specialist biocontrol teams comprise seven or eight trained implementers, headed up by a contractor. Their main purpose is the collection and redistribution of agents, both within and outside the province, thereby greatly enhancing what was achievable by a single provincial implementation officer together with the biocontrol researchers. In addition, the teams spend a portion of their time monitoring specific biocontrol programmes. Here, we present data from the two Working for Water teams within the Western Cape in an effort to showcase the work that has and is being done, in collaboration with the Agricultural Research Council and the University of Cape Town. Thus far, biocontrol implementation in the province has focused largely on *Hakea* and *Acacia* species with more recent inclusion of several species of water weeds.

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APPENDIX 2: Call for papers for a special issue of ABC Bothalia on Assessing the Status of Biological Invasions in South Africa.

Open Access Journal

Call for paper proposals to

African Biodiversity and Conservation (Bothalia)

2017 Special Issue

AOSIS Publishing | SANBI Biodiversity for Life, South African National Biodiversity Institute

Call for paper proposals

Assessing the Status of Biological Invasions in South Africa

Submission deadline: 26 February 2016

Send proposals to: John Wilson, jrwilson@sun.ac.za

Guest editors:
John Wilson; Brian van Wilgen; Mirijam Gaertner; David Richardson

Overview:
The impacts of biological invasions are increasing and are felt by all sectors of society in South Africa. In some cases mitigation and control measures have been very successful in reducing undesirable impacts, but in other cases control has been ineffective or the problem has not even been recognised. A key challenge is to develop a standardised system to monitor and report on the state of invasions. In response to this need, South Africa has committed to producing a National Status Report on Biological Invasions by October 2017 under the NEM:BA Alien & Invasive Species Regulations. The National Status Report will be the theme of both a Special Issue of the journal African Biodiveristy and Conservation, and the 43rd Annual Research Symposium on the Management of Biological Invasions, to be held on 18-20 May 2016 at Goudini Spa, Western Cape.

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Questions to be addressed in the Special Issue include:

- What is the state of invasions across different areas, pathways, and taxa?
- What are the scale and trends in the impacts of invasions?
- How effective are management and policy interventions?

We invite researchers, managers and policy makers to submit one page proposals for papers on a topic relevant to the National Status Report. Submissions will be reviewed and potentially invited to present at the Symposium with the proposal included in the Symposium booklet. Based on the presentations and the feedback received, it is expected that manuscripts will be developed into full papers to be submitted to the ISI-listed ABC Bothalia for peer review and potential inclusion in the Special Issue.

Visit the 43rd Annual Research Symposium on the Management of Biological Invasions website:
http://academic.sun.ac.za/cib/workshops/2016MAY/index.asp

Important dates:

- **26 Feb 2016:** Submission of paper proposal to jrwilson@sun.ac.za
- **25 Mar 2016:** Decision on proposal
- **18-20 May 2016:** Presentations at the symposium
- **27 May 2016:** Submission of manuscripts to ABC Bothalia opens
- **29 July 2016:** Submission of manuscripts to ABC Bothalia closes
- **31 May -Dec 2016:** Review of submissions
- **March 2017:** Special Issue published

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