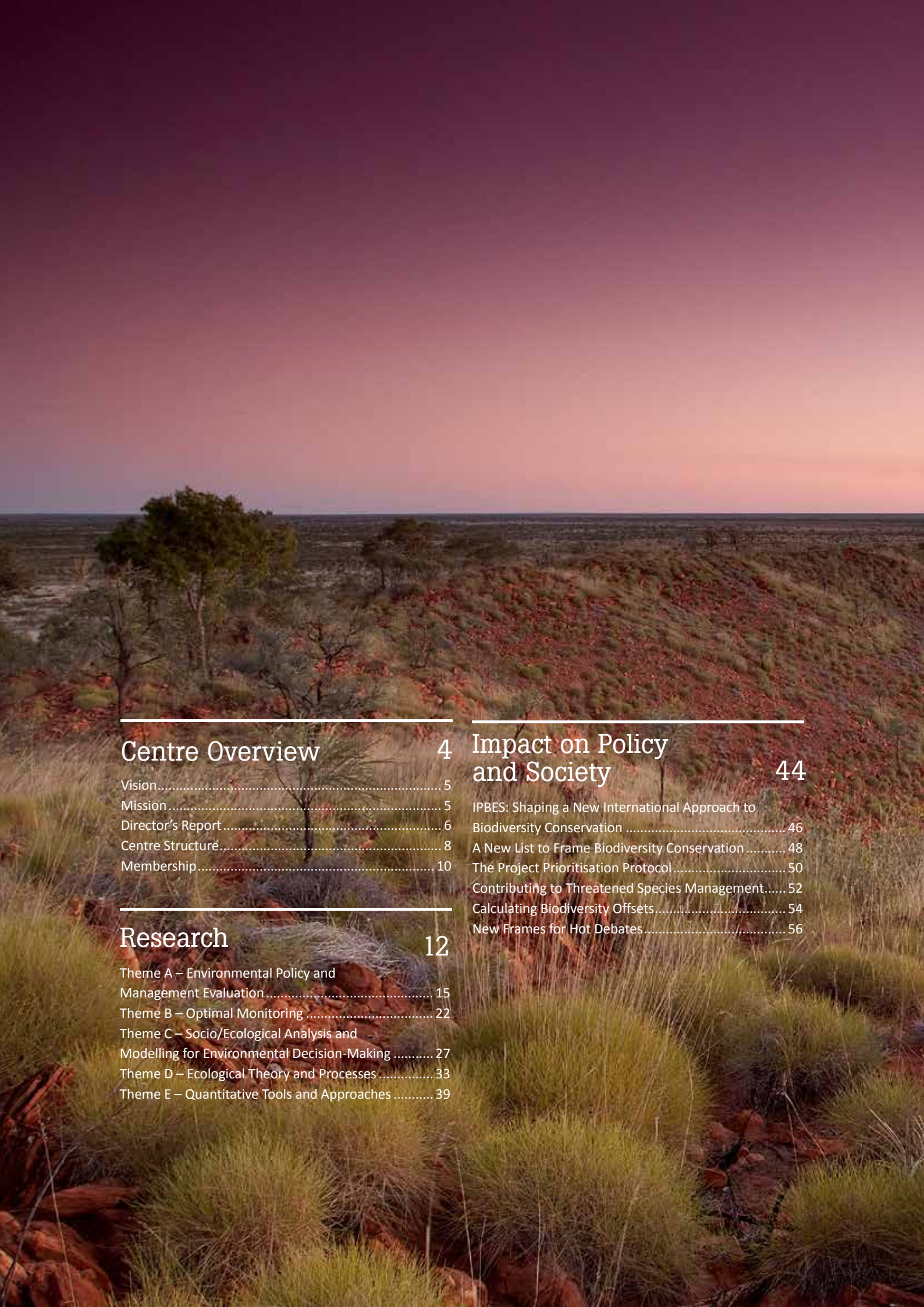
ANNUAL REPORT 2013

ARC ceed
Centre of Excellence for Environmental Decisions



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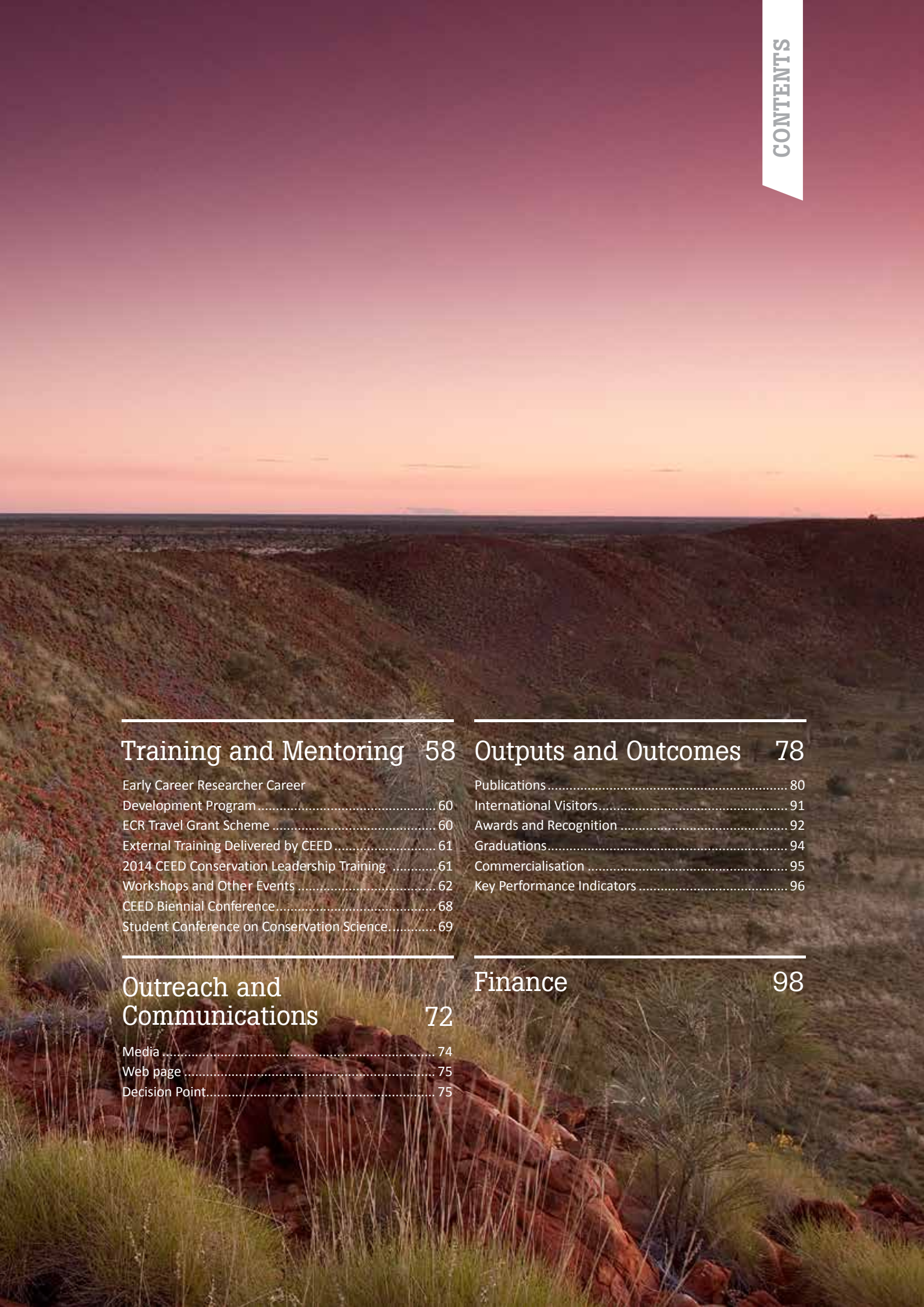


Our Vision

To be the world's leading research centre for solving environmental management problems and for evaluating the outcomes of environmental actions.

Our Mission

We will benefit environmental science, policy and management across Australia and around the world by solving complex problems of environmental management and monitoring in a rapidly changing and uncertain world.

Director's Report

CEED is one of the world's leading institutions working on environmental decision science. The dedication of our staff and students has made 2013 a remarkably successful year with a rich mix of world-class papers, substantial capacity building and innovative ideas that have delivered significant policy and management outcomes.

Publications in the world's top journals are one of the key early indicators that our research is at the cutting edge globally and, as in past years, CEED has been successful (see page 80). As one example, we published five articles in *Science*, one of the world's most prestigious science journals. This represents more than 5% of all the articles with an Australian address published in *Science* in 2013.

Research highlights over the past year have covered a wide range of topics, including: practical ways for conservation managers to use models to deliver effective solutions; how to counter international rhinoceros poaching; the impact of fossil fuel extraction on biodiversity; the effectiveness of the focal species approach in conservation; the effectiveness of conservation fences on islands; biodiversity offsets as a strategy to protect mobile species; guidelines on how and why to monitor the effectiveness of conservation actions; optimising strategies to reduce water pollution; and the value of coordinating conservation efforts across the Mediterranean Sea. Details of some of these projects appear later in this report.

Publishing high impact papers is, of course, but one step on the pathway to making a difference. More so than most research centres, CEED has developed additional strategies and relationships to ensure the uptake of our research. Most of our projects are written up in engaging plain English in our popular research magazine, Decision Point (I encourage to you subscribe if you don't already, see page 75). We have excellent relationships with the primary end users of our research: governments and non-government organisations (at all levels including institutions operating at the international level). These relationships are borne out by joint publications with people from as far and wide as The Wildlife Conservation Society (USA), The Nature Conservancy (USA) and WWF Australia. On top of this we can boast many joint projects with Australian government researchers and agencies. Indeed, a substantial fraction of our overall funding, over $2.5 million per year, is provided by the National Environmental Research Program (NERP) administered by the Federal Department of the Environment. That funding contributes substantially to our more applied research and outreach.

Good science completed with quality partners makes it a lot easier to generate meaningful outcomes. While outcomes on the ground are slow to develop, this year CEED can boast several (see Impact on Policy and Society, pages 45). Here are three I'd like to highlight.

PROJECT PRIORITISATION:

The NSW Government has recently released a new plan titled "Saving our Species". It's based on our project prioritisation research which allocates funding to threatened species using a cost-effectiveness framework. The framework, known as the Project Prioritisation Protocol (or PPP), was first adopted by the New Zealand Government. It is undergoing further development and refinement by CEED researchers to deal with uncertainty, phylogenetic relatedness and partial allocation to species.

BIODIVERSITY OFFSETTING:

The Commonwealth of Australia has released an environmental offsets policy as part of the Environment Protection and Biodiversity Conservation Act. A central part of this policy is the application of an offsets assessments "calculator" developed by our team in close cooperation with Commonwealth staff. This product was based on fundamental research within CEED on calculating biodiversity benefits, biodiversity banking and threatened species, delivered to Government through NERP.

STRATEGIC ASSESSMENTS AND REGIONAL SUSTAINABILITY PLANS:

These plans are a new mechanism for Australian governments to allow development while minimising impacts on biodiversity. They take a bigger-picture approach to planning and development, and enable a more integrated assessment of biodiversity impacts and the available alternatives. This contrasts with the more traditional case-by-case development application that saw biodiversity loss occurring through "death by a thousand cuts" – that is, a myriad of small development proposals each implemented in isolation. Our innovative research on species distribution modelling, threat mapping, and spatial prioritisation is increasingly influencing these plans.

Leaving a legacy of highly trained researchers is core business for all ARC Centres of Excellence, and CEED has performed well in this area. We are very proud that 64% of our high-impact publications (impact factor >5) were co-authored by early career researchers (ECRs). These high-impact papers allow the ECRs to start their careers with a bang.

The fact that five CEED-associated researchers will commence DECRAs in 2014 is a testament to this success (CEED-CI Eve McDonald-Madden, Oscar Venter, Rob Salguero-Gomez, Sam Banks and Hawthorne Beyer). Further success of our researchers is evidenced by CI Sarah Bekessy being awarded an ARC Future Fellowship. Dr Bekessy and the new DECRA recipients join several other CEED researchers already holding DECRAs and ARC Fellowships.

Director's Report

A research strategy that is particularly prominent in CEED – more than in most centres – is the use of research workshops (see section on Workshops on page 62). CEED workshops involve between 5-20 researchers from across the nodes and external leaders and/or end users who focus on a single rich topic in decision science for conservation over a three-to-five-day period. Typically, these workshops involve deep discussion of issues and concepts, scoping out of new ideas, modelling, analysing and writing. Importantly, they are not mere "talkfests". These highly targeted, outcome-oriented events are extremely successful at bringing researchers together to generate emergent ideas that could not occur in isolation. These ideas then form the research agendas of PhD students and postdoctoral researchers. In 2013 we adopted a strategy of asking Early Career Researchers (ECR's) to initiate and drive the bulk of the workshops in association with relevant CIs (as suggested by our International Scientific Advisory Panel in 2012).

CEED's legacy in cultivating ECRs extends beyond our own people. We organised, and partly sponsored, Australia's first Student Conference in Conservation Science (in Brisbane, Jan 2013). More than 100 post-graduate students from 30 countries attended this inaugural student meeting. The feedback we received shows that the students considered it enormously valuable. This looks set to become a regular event and the benefits to conservation science, policy and management in our region of the world will be long-lasting. To further enhance our legacy, we have new initiatives in leadership and training (see section on Training and Mentoring on page 59).

That CEED played a central role in this event is testament to our commitment to enhancing Australia's international reputation and improving our standing in the world of conservation science. CEED already has strong relationships with labs around the world with associate partners based in Europe, the USA and the Middle East, and 2013 saw further movement on this front. We are very excited that one of our overseas Principal Investigators, Salit Kark of Hebrew University, is joining us as a Chief Investigator, funded by an ARC Future Fellowship. Dr Noam Levin has taken over Dr Kark's role as the PI at Hebrew University. And Prof Yvonne Buckley has moved from Australia to Trinity College, Dublin, which will become a new partner organisation.

In addition to our strengthening international networks and world-class publication record, our researchers continue to bring home a raft of national and international awards and honours. To highlight a few, CEED CI Dr Kerrie Wilson won the 2013 Eureka Prize for Outstanding Young Researcher, Prof Richard Hobbs was awarded a Special Recognition Award by the Society of Ecological Restoration, Dr Carissa Klein was awarded the APEC Science Prize for Innovation, Research and Education and I was elected as a Fellow of The Ecological Society of America (a first for an Australian).

Continuous review is the key to a successful centre. This year we are looking forward to the mid-term review of the centre. To prepare for this we invited Dr Steve Morton, a CSIRO lead scientist and one of Australia's foremost ecologists, to run us through our paces. He made us look hard at the purpose and focus of our research and looked for even more ways in which the centre could be more than the sum of its parts. His advice, and substantial input and ideas from our International Scientific Advisory Panel and our Advisory Board, are helping to ensure that we remain innovative and effective.

The importance of decision science in conservation is growing. We are excited about the prospect of not just solving difficult conservation decision problems, but also continuing to change policy and management at national and global scales.

Hugh Possingham
Director
ARC Centre of Excellence for Environmental Decisions

Centre Structure

The Australian Research Council Centre of Excellence for Environmental Decisions (CEED) officially commenced its operations in July 2011, with a $11.9 million grant from the ARC for a seven-year period from 2011 to 2017. CEED is a partnership between five Australian and two international Universities, the CSIRO and the US Geological Survey.

BACKGROUND

Despite facing the sixth global mass extinction of species and scarce conservation funds, most environmental decisions are unevaluated and inefficient. Conservation problems are often not properly formulated and there is a legacy of past mistakes. CEED is providing international leadership in tackling complex problems of environmental management and monitoring in a changing world. The Centre's success is demonstrated by our staff continuing to produce papers in the top international scientific journals that also have significant policy and management impact. Collaboration with researchers all over the world is essential to our success, and this is reflected in the fact more than half of our research papers have international co-authors. Training, outreach and communication continue to be a priority, and we continue to generate a new cohort of quantitatively skilled conservation researchers, in Australia and around the world.

GOVERNANCE

Individually our key researchers are acknowledged as global leaders in fundamental environmental science, as recognized by more than half of our CIs holding ARC fellowships. Drawing this expertise together has produced a centre of international scale and calibre to achieve our mission. While the goal of being the world leader in a research field seems lofty, our track record of publications in the world's top journals, and the fact that the disciplines of ecology and environmental science are amongst Australia's strongest research areas, make our mission ambitious and also feasible.

Leading our Centre are our Executive and Node Directors:

MANAGEMENT:

Prof Hugh Possingham, Director
The University of Queensland

Prof Michael McCarthy, Deputy Directory
The University of Melbourne

Dr Alvin van Niekerk, Chief Operations Officer
The University of Queensland

NODE DIRECTORS:

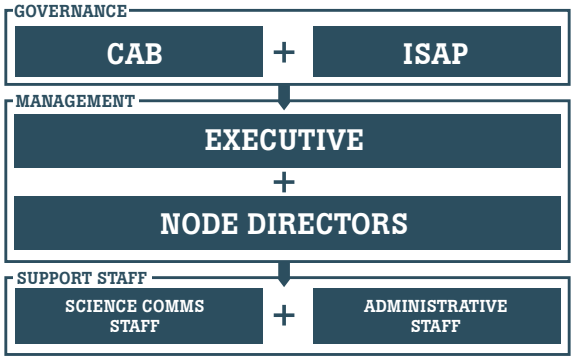
Prof David Lindenmayer,
The Australian National University

Prof David Pannell,
The University of Western Australia

Dr Jonathan Rhodes & Dr Kerrie Wilson, (joint)
The University of Queensland

Dr Brendan Wintle,
The University of Melbourne

Dr Sarah Bekessy, RMIT University



Centre Structure

CENTRE ADVISORY BOARD (CAB)

CEED management is supported by an Advisory Board comprised of Australian scientists with outstanding track records of research leadership. The Advisory Board provides strategic advice to the centre management and node directors with a particular focus on issues of governance, communication, impact, outreach and research management.

The Centre Advisory Board met twice during 2013 – 28th May and 16th September. Prof Stephen Walker chaired both meetings. Overall they confirmed the success of the centre in surpassing almost all of its Key Performance Indicators, especially in research and media, and delivering substantive outcomes for policy, management and training.

The Board recommended that the number of Board members be expanded to include industry-related members. Two invitations have been extended.

Communication and outreach are a major part of CEED. In this regard The Board noted the improved CEED website and stressed the importance of keeping the website current. The Board was impressed with the magazine Decision Point that is produced by the Centre and the Chair noted that its impact extends well beyond CEED. The Board suggested that more could be made of Decision Point by coupling it with blogging and online discussions.

In a review of the 2012 Annual Report, the Board members liked the overall design and content. They made some recommendations to improve future Annual Reports. These suggestions included more evidence of inter-node interactions and publications, plus much better introductory information for all sections.

The Board members discussed future funding of the Centre. At the second meeting a document outlining options for long-term centre funding elicited considerable discussion and numerous useful ideas. The Board's recommendation was that CEED continue to pursue diverse options for funding and that the options document be revised for discussion at future meetings.

The Centre underwent an internal review in September 2013. A report was tabled at the second board meeting which was endorsed by the Advisory Board. The Board also endorsed and commented on the change in research themes (see RESEARCH page 14).

The Board noted the remarkable success of the Early Career Researcher program which terminates at the end of 2014. The Board agreed that it would be very important to approach the ARC to extend this funding.

ADVISORY BOARD MEMBERS:

Prof Stephen Walker, Advisory Board Chair,
Dean of Science, The University of Queensland

Prof Andrew Cockburn, FAA,
The Australian National University

Prof Pauline Ladiges, FAA,
The University of Melbourne

Prof Alistar Robertson, PVC (Research),
The University of Western Australia

Prof Charlie Zammit
Commonwealth Dept of the Environment (retired)

Membership

INTERNATIONAL SCIENTIFIC ADVISORY PANEL (ISAP)

The function of the International Scientific Advisory Panel is to ensure CEED remains at the forefront of international research in its field. The ISAP is particularly important for helping the centre to enhance its international linkages and show international disciplinary leadership. The ISAP has five members, all of whom are world leaders in pure and applied ecological research

The board met in August 2013 at INTECOL, the world's largest international ecology meeting, held every four years. This maximized attendance, reduced costs and enabled Panel members to see several talks by CEED researchers at the conference.

The ISAP confirmed that CEED is the world leader in applying decision-making science to biodiversity conservation problems. They were particularly impressed by outreach through vehicles such as Decision Point, plus the remarkable impact the centre has on Australian policy. They also noted the impact of CEED in the global environmental NGO sector.

The Panel put three major challenges to CEED for the next four years. First, create an international alliance that would gather together like-minded partners in the CEED research space. Second, embrace industry, especially the mining industry, in partnerships. Third, find a mechanism to maintain Decision Point indefinitely. All of these are firmly on our agenda and will significantly influence our actions over the net three years.

ISAP MEMBERS:

Professor Antoine Guisan,
The University of Lausanne

Professor Peter Kareiva, FNAS,
Chief Scientist & Director of Science,
The Nature Conservancy

Professor Claire Kremen,
The University of California, Berkeley

Professor Bill Murdoch, FNAS,
The University of California, Santa Barbara

Professor Bill Sutherland,
Miriam Rothschild Professor of Conservation Biology,
Cambridge University

CHIEF INVESTIGATORS

THE UNIVERSITY OF QUEENSLAND

Associate Professor Yvonne Buckley (to the end of 2013)

Associate Professor Salit Kark from 2014 (Theme A leader)

Dr Eve McDonald-Madden (Training and Mentoring)

Professor Hugh Possingham (Director)

Dr Jonathan Rhodes (Brisbane Node Director/ Theme B leader)

Associate Professor Anthony Richardson

Dr Kerrie Wilson (Brisbane Node Director)

THE AUSTRALIAN NATIONAL UNIVERSITY

Professor David Lindenmayer (Canberra Node Director)

THE UNIVERSITY OF MELBOURNE

Dr Michael Bode (Theme E leader)

Professor Michael McCarthy (Deputy Director)

Assoc Professor Peter Vesk (Theme D leader)

Associate Professor Brendan Wintle (Melbourne Node Director)

RMIT UNIVERSITY

Associate Professor Sarah Bekessy (Theme C leader)

THE UNIVERSITY OF WESTERN AUSTRALIA

Professor Richard Hobbs

Professor David Pannell (Perth Node Director)

PARTNER INVESTIGATORS

Dr Noam Levin (The Hebrew University of Jerusalem, Israel) from 2014

Dr Tara Martin (CSIRO Ecosystem Sciences, Australia)

Professor. EJ Milner-Gulland (Imperial College, UK)

Dr Andrew Knight (Imperial College, UK)

Dr James (Jim) Nichols (US Geological Survey, USA)

ACADEMIC AND RESEARCH FELLOW STAFF AND ASSOCIATES

THE UNIVERSITY OF QUEENSLAND

Dr Joseph Bennett

Dr Hawthorne Beyer

Dr Maria Beger

Dr Duan Biggs

Dr Nathalie Butt

Dr Shaun Coutts

Dr Martina Di Fonzo

Dr Edd Hammill

Dr Carissa Klein

Dr Ramona Maggini

Dr Jason Maina Mbui

Dr Karen Mustin

Dr Anna Renwick

Dr Rob Salguero-Gomez

Dr Ayesha Tulloch

Dr Jessie Wells

Dr Howard Wilson

THE AUSTRALIAN NATIONAL UNIVERSITY

Dr Philip Barton

Dr Sam Banks

Dr Don Driscoll

Dr Karen Ikin

Dr Annabel Smith

RMIT UNIVERSITY

Dr Christopher Ives

Dr Georgia Garrard

Dr Ascelin Gordon

Membership

THE UNIVERSITY OF MELBOURNE

Dr Guru Arroita
Dr Jane Catford
Dr Geoff Heard
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Dr Tamsin Lee
Dr Alana Moore
Dr Brett Murphy
Dr Emily Nicholson
Dr Tracey Regan
Dr Libby Rumpff
Dr Reid Tingley

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr Morteza Chalak
Dr Graeme Doole
Dr David Duncan
Dr Fiona Gibson
Dr Sayed Iftekhar
Dr Marit Kragt
Dr Melinda Moir
Dr Maksym Polakov
Dr Jodi Price
Dr Rachel Standish
Dr Leonie Valentine

RESEARCH HIGHER DEGREE STUDENTS (PHD, MASTERS & HONOURS)

THE UNIVERSITY OF QUEENSLAND

Carla Archibald
Luis Verde Arregoitia
Nancy Auerbach
Payal Bal
Pei Ya Boon
Sugeng Budiharta
Abbey Camaclang
Xyomara Carretero-Pinzon
Kiran Danjal-Adams
Hong Du (China)
Veronica Gama
Angela Guerrero Gonzalez
Yi Han
Kate Helmstedt
Kendall Jones
Meera Joyce
Elizabeth Law
Hsien-Yung Lin
Azusa Makino
Chrystal Mantyka-Pringle
Maria Jose Martinez Harms
Fleur Maseyk
Tessa Mazor
Jane McDonald
Nicholas Murray
Chooi Fei Ng
Danielle Nilsson
Laurel Osborne
Tal Polak
Jeremy Ringma
Claire Runge
Rebecca Runting
Brigette Sommer
Patricia Sutcliffe
Vivitskaia Tulloch
Nicholas Wolff

THE AUSTRALIAN NATIONAL UNIVERSITY

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Laurence Berry
David Blair
Suzi Bond
Megan Evans
Kate Grarock
Brett Howland
Geoff Kay
Juliana Lazzari
Jane McDonald
Wendy Neilan
Sachiko Okada
Stephanie Pulsford
Laura Rayner
Chloe Sato
Ingrid Stirnemann
Martin Westgate
Ding Li Yong

RMIT UNIVERSITY

Ana Blackstrom
Mathew Hardy
Alex Kusmanoff
Laura Mumaw
Nooshin Torabi

THE UNIVERSITY OF MELBOURNE

Chris Baker
John Baumgartner
Tom Bird
James Camac
Stefano Canessa
Sarah DeVries
Dini Fardili
Imogen Fraser
Michelle Freeman
Katherine (Kate) Gilijohann
Madeleine Gorsuch
Chris Hallam
Chris Jones
Claire Keely
Bill La Marca
Darren Le Roux
Liz Martin
Kim Millers
William Morris
Esti Palma
Hannah Pearson
Michaela Plein
Gerry Ryan
Adam Smart
Paing Soe
Darren Southwell
Tom Stephens
Freya Thomas
Els Van Burm
Casey Visintin

UNIVERSITY OF WESTERN AUSTRALIA

Louise Blackmore
Katrina Davis
Christine Kershaw
Keren Raiter
Mike Wysong

RESEARCH OFFICERS

THE UNIVERSITY OF QUEENSLAND

Jutta Beher
Sean Maxwell
Jennifer McGowan
Matthew McKinney
Will Probert
Matthew Watts

OUTREACH AND COMMUNICATION STAFF

THE UNIVERSITY OF QUEENSLAND

Jane Campbell, Event Manager
Karen Gillow, Science Communication Technology

THE AUSTRALIAN NATIONAL UNIVERSITY

David Salt, Editor Decision Point

ADMINISTRATIVE STAFF

THE UNIVERSITY OF QUEENSLAND

Heather Christensen
Carol Fawcett
Melisa Lewins
Alvin van Niekerk, Chief Operations Officer

THE AUSTRALIAN NATIONAL UNIVERSITY

Claire Shepherd

THE UNIVERSITY OF MELBOURNE

Dolla Boutros
Pauline Byron

THE UNIVERSITY OF WESTERN AUSTRALIA

Sueli Maprino
Caroline Mitchell

IMPERIAL COLLEGE (UK)

Joe Bull


RESEARCH

Research

At its inception, the ARC Centre of Excellence for Environmental Decisions had three problem-based themes, underpinned by two research methods. In the intervening period the Chief Investigators, our International Advisory Panel and our centre Advisory Board have agreed that the original CEED themes are a sub-optimal packaging of our research. While we would not expect any person or project to be wholly in a single theme, too many projects and people cut across more than two themes. At our annual conference in September 2013 we agreed on five new theme names – again, three problem-based and two approach-based. They do not represent a significant change in focus, more a change in in the way we package our ideas and present ourselves externally.

These five themes are:

Theme A - Environmental Policy and Management Evaluation

Theme B - Optimal Monitoring

Theme C - Socio/Ecological Analysis and Modelling for Environmental Decision-Making

Theme D - Ecological Theory and Processes

Theme E - Quantitative Tools and Approaches

Our research is now coordinated through these five themes and dedicated theme leaders, making the focus of the new CEED themes easier to understand.

In the following sections, we describe some highlights of CEED's research in 2013 for each of our new themes, and our plans for 2014. We also profile the theme leaders, and some of our early career researchers and students.

Theme A

Environmental Policy and Management Evaluation

SALIT KARK, THEME LEADER

ABOUT THIS THEME

We study and evaluate the effectiveness of environmental management actions, such as establishing protected areas, habitat and ecosystem restoration at a landscape scale and marine zoning. Our work has ranged from the global and continental to local scales. Working across scales, we explore the implications of policy and management options for biodiversity and other ecosystem and environmental processes, such as water and carbon balances. Research in this area is expected to contribute to IPBES – the Intergovernmental Platform on Biodiversity and Ecosystem Services (see the impact story on IPBES, page 46). The research within this theme encompasses several sub-areas, two of which are highlighted here:

ENVIRONMENTAL POLICY DESIGN

The details of policy design can drive the effectiveness of outcomes. Strands of our research address various aspects of policy design, including research focussed on biodiversity offsets and carbon markets. Biodiversity offsetting aims to compensate damage to the environment in one place with improvements in other areas. Biodiversity offsets are increasing in popularity worldwide, as a mechanism that could potentially deliver robust biodiversity conservation alongside socio-economic development. While already applied by governments and industry globally, it remains poorly understood how to calculate losses in biodiversity and compare them to gains elsewhere. CEED researchers across several nodes are leading the world in improving this understanding, and advancing the way that offsets are implemented. Numerous challenges, both theoretical and practical, have been identified with the offset approach. CEED research has outlined the conceptual and technical challenges that surround biodiversity offsetting and we have revealed that the implementation of offsetting has been inconsistent in meeting conservation objectives because of the challenge of ensuring full compliance and effective monitoring (Bull *et al*., 2013) (see the impact story on Calculating biodiversity offsets, page 54).

CEED research has also appraised how international carbon policy and incentives from international carbon markets can contribute to sustainable development (Venter *et al*., 2013), providing a framework for ongoing work in this area.

FUTURE THREATS

CEED develops a range of novel approaches to prepare for future threats to biodiversity and ecosystem functioning, resulting from a range of human-related actions and processes, such as fossil fuel mining operations in terrestrial and marine systems, invasion of non-native species, and climate change. A recent paper published in *Science*, led by a group of CEED postdoctoral researchers (Butt *et al*., 2013), provides a first look at the potential impact of fossil fuel extraction on biodiversity at the global scale (see Theme A Case Study, page 19). The analysis used species richness, threatened species numbers, and fossil fuel reserve data to identify two regions where future fossil fuel developments overlap substantially with biodiversity rich areas: parts of northern South America on land and western Pacific regions in the sea.

Another major threat to biodiversity is invasion by alien species. We have examined how we can more efficiently direct management and policy options for dealing with alien species by taking into account not only single invasive species but also multiple species interactions. Our work in this area, ranging across ecosystems and continents and focusing on both island and continental environments, has improved our understanding of the complex interaction networks among invasive species and their implications for conservation, management and policy. For example, we found that interactions among different invasive alien birds in an urban Mediterranean system drive the outcomes of the invasion and its management implications (Orchan *et al*., 2013).

Theme A

Environmental Policy and Management Evaluation

RESEARCHERS

Dr Salit Kark
Theme leader (UQ)

Dr Joseph Bennett (UQ)

Dr Maria Beger (UQ)

Dr Duan Biggs (UQ)

Dr Michael Bode (UM)

Dr Yvonne Buckley (UQ)

Dr Nathalie Butt (UQ)

Dr Graeme Doole (UWA)

Dr David Duncan (UWA)

Dr Georgia Garrard (RMIT)

Dr Fiona Gibson (UWA)

Dr Ascelin Gordon (RMIT)

Dr Chris Ives (RMIT)

Dr Carissa Klein (UQ)

Dr Marit Kragt (UWA)

Dr Noam Levin (HEJ, Israel)

Prof David Lindenmayer (ANU)

Dr Luke Kelly (UM)

Dr Maina Mbui (UQ)

Prof Michael McCarthy (UM)

Prof EJ Milner-Gulland (Imperial College, London)

Dr Emily Nicholson (UM)

Prof David Pannell (UWA)

Prof Hugh Possingham (UQ)

Dr Reid Tingley (UM)

Dr Brendan Wintle (UM)

Dr Kerrie Wilson (UQ)

STUDENTS

Pei Ya Boon (UQ)

Louise Blackmore (UWA)

Sugeng Budiharta (UQ)

Joe Bull (Imperial College)

Abbey Camaclang (UQ)

Katrina Davis (UQ)

Kate Helmstedt (UQ)

Bill La Marca (UM)

Elizabeth Law (UQ)

Azusa Makino (UQ)

Maria Martinez (UQ)

Fleur Maseyk (UQ)

Tessa Mazor (UQ)

Jane McDonald (UQ)

Jennifer McGowan (UQ)

Tal Polak (UQ)

Rebecca Runting (UQ)

Gerard Ryan (UM)

Theme A

Environmental Policy and Management Evaluation

LEADER PROFILE

DR SALIT KARK

Salit Kark has been active in CEED from 2011, initially as an international Principal Investigator based at the Hebrew University of Jerusalem (Israel), and currently as a Chief Investigator based at the University of Queensland. Her research focuses on understanding the patterns and processes shaping diversity of native and invasive species and their implications for conservation and environmental decisions in a changing world. She focuses mainly on:

1. Biodiversity and conservation in human-dominated landscapes and across species ranges and ecological gradients. This includes studies on both native and alien invasive species in natural, agricultural and urban environs;

2. Conservation planning and prioritization at local, regional and global scales and the role of collaboration in conservation planning in marine, river and terrestrial systems; and

3. Systematic Conservation planning and the importance of collaboration in both marine and terrestrial environments.

Dr Kark is also interested in enhancing the links between scientists, practitioners, managers, policy makers and other stakeholders to achieve better science-based conservation and environmental decisions.

PROFILES

JOE BULL, PHD STUDENT

Joe's research interest lies in exploring mechanisms for effective landscape-scale ecological management that achieves both biodiversity conservation and sustainable natural resource use objectives. Joe's research, with PI Prof EJ Milner-Gulland, is contributing towards the development of a methodological basis for biodiversity offsets. He has explored problems with employing offset mechanisms under dynamic and uncertain conditions, using an Uzbekistan example as a case study. In this region an offset scheme has been proposed to conserve a population of critically endangered Ustyurt saiga antelope (Saiga tartarica) and its associated desert habitat, as compensation for the impacts of extractive industrial activity elsewhere on the Ustyurt plateau.

Bull JW, KB Suttle, A Gordon, NJ Singh and EJ Milner-Gulland (2013) Biodiversity offsets in theory and practice. *Oryx* 47:369-380

Bull JW, KB Suttle, NJ Singh and EJ Milner-Gull (2013) Conservation when nothing stands still: moving targets and biodiversity offsets. *Frontiers In Ecology and the Environment* 11:203-210

TESSA MAZOR, PHD STUDENT

Tessa's research interests include conservation planning for threatened marine species, with emphasis on the role of cross-country collaboration in conservation and the application of systematic planning tools in the marine realm. Her PhD focuses on advancing systematic conservation planning in the Mediterranean Sea, an important biodiversity hotspot and complex regional socio-politically, where only few effective marine protected areas exist. Tessa is particularly interested in sea turtles, exploring drivers of their nesting patterns and using decision support tools to select priority areas for sea turtle conservation. She is currently collaborating on examining a zoning plan for the territorial waters of Israel in cooperation with the CEED node at the Hebrew University of Jerusalem and with other conservation and government organizations in Israel.

Mazor T, HP Possingham and S Kark (2013) Collaboration among countries in marine conservation can achieve substantial efficiencies. *Diversity and Distributions* 19:1380-1393

Mazor T, N Levin, HP Possingham, Y Levy, D Rocchini, AJ Richardson and S Kark (2013) Can satellite-based night lights be used for conservation? The case of nesting sea turtles in the Mediterranean. *Biological Conservation* 159:63-72

THEME LEADER DR SALIT KARK

TESSA MAZOR

JOE BULL

Theme A

Environmental Policy and Management Evaluation

PLANS FOR 2014 AND BEYOND

This theme will establish new collaborations with managers and policy makers in Australia and globally on topics that include:

1. Fundamental and novel policy options: We will assess whether the terrestrial reserve system should be expanded or better managed. We will determine whether projects focussed on species, landscapes or threats will deliver the best conservation outcomes. In the context of assisted migration we will address questions such as: when is moving an ecosystem engineer a wise decision? We will also develop novel modelling approaches for regional-level scenario analysis and policy evaluation to feed into the Intergovernmental Panel on Biodiversity and Ecosystem Services (see impact story, page 46).

2. Environmental policy performance: An important new CEED project will bring together an international team of leading environmental economists to evaluate the performance of agri-environmental policies in nine developed countries around the world.

Billions of dollars are invested in these programs, but there has never previously been a comparative examination of the extent to which programs adequately consider social and economic factors in the design and implementation of environmental projects. On the topic of policy evaluation, we will also assess how to apply complexity theory and systems thinking to improve the effectiveness of evaluations.

3. Invasive species management: We will commence a project on halting the spread of invasive cane toads in Western Australia using integrated scenario analysis and mechanistic modelling approaches.

We will examine the effect of dealing with multiple, rather than single alien species, on the outcomes of introductions and the management actions taken.

KEY PUBLICATIONS

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Bull JW, KB Suttle, A Gordon, NJ Singh and EJ Milner-Gulland (2013) Biodiversity offsets in theory and practice. *Oryx* 47:369-380

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Theme A
Case Study

COLLABORATION CAN REDUCE CONSERVATION COSTS IN TACKLING THE MOVING-TARGET PROBLEM

Using biodiversity offsets to capture moving conservation targets

By Joseph Bull (Imperial College London, UK)

How do we conserve something when it won't stand still? It's a question we are only just beginning to grapple with in conservation science. Fixed protected areas are an example of a classic conservation tool, but traditional interventions like these can be ineffective for 'moving targets': for instance, a species that is so mobile that it doesn't stay within a reserve. Biodiversity offsets, despite the suspicion they are often treated with by conservationists, may provide some answers to this question, as discussed in two new review papers resulting from CEED collaborations (Bull *et al*. 2013a; 2013b).

The moving-target problem that CEED researchers investigated comes in two forms. The first relates to mobile species and the second to species forced to move by a changing environment.

The problem with mobile species, such as migratory species, is that they are unlikely to be conserved by fixed protected areas that do not cover their entire range. The researchers, led by Joe Bull, reviewed potential alternatives to fixed protected areas and found that mobile or temporary protected areas that track species movements have both been proposed for many migratory species. These range from caribou to blue-fin tuna to leatherback turtles. However, apart from efforts made by the Soviet Union to conserve a certain antelope species, there is no evidence of these solutions having been implemented in practice (Bull *et al*. 2013a).

A second type of moving-target problem involves a threatened habitat that is being modified by environmental change, like climate change. As the habitat moves, the species it supports, even otherwise sedentary species, are forced to move unpredictably across the landscape. This type of moving-target problem is possibly more pernicious and intractable than planning for naturally mobile species because it involves multiple interactions and enormous uncertainty.

Extensive habitat modification can change ecological dynamics, affect species both directly and through their interactions with other species, and even modify the human behaviours causing biodiversity loss. Again, the researchers found that numerous solutions had been proposed for this kind of moving target including mobile protected areas and networks of protected areas that are specifically resilient to change. But, again, these proposals remain largely theoretical.

An imperative for contemporary conservation is to implement and thereby test more 'dynamic' interventions, such as those mentioned above. Biodiversity offsets are mechanisms that compensate for unavoidable ecological impacts of development. They potentially offer an excellent framework for testing interventions such as mobile protected areas. That's because, as the researchers argue in both papers, offsetting explicitly requires 'no net loss' of biodiversity occurs overall. Consequently, effective offsetting requires that a baseline for evaluating biodiversity losses and gains is specified, in turn forcing consideration of the uncertain and dynamic nature of conservation targets.

Of course, there are many technical challenges that still frustrate offsetters when attempting to determine what's being compensated (Bull *et al*. 2013b).

It turns out that in some proposed offset schemes, this no-net-loss requirement has led to the design of novel conservation interventions that consider the mobile nature of migratory species. Examples include offsets for white-tailed sea eagles impacted by wind farms in Norway, and seabirds caught as bycatch in commercial fisheries off the coast of Australia.

As yet, offsets that are specifically designed around the incorporation of migratory or highly mobile species have yet to be implemented. However, Australia can boast an example of an offsets scheme that takes account of the second type of moving target discussed in this article: habitats undergoing environmental change. Indeed, offsets have arguably been at their most effective in practice for native vegetation in Australian states, such as New South Wales, where they systematically take account of environmental trends.

Theme A
Case Study

(CONTINUED)

In this case, the downward trend in the condition of habitat is recognised, and habitat restoration/ protection schemes are designed to deliver no net loss against a relative baseline. The result is that the cost of clearing native vegetation goes up because to get approval for a site to be cleared, resources need to be invested at another location to compensate for the loss of natural values at the site being cleared. What happened in NSW as a result of this was a large reduction in clearing approvals for native vegetation.

What happens when you have both types of moving target problem – a mobile species and a changing environment? The researchrs explored this for a critically endangered and declining saiga antelope (Saiga tatarica). It's a migratory species and its habitat in northwest Uzbekistan is undergoing rapid change (this is the region that has witnessed the catastrophic decline of the Aral Sea from over extraction of water for irrigation).

In essence, what's been proposed is that compensation will be paid by oil and gas companies which are exploring and mining in this semi-arid saiga habitat. They're not compensating for direct saiga mortality, but for the miners' contribution towards desertification in the region. The compensation will ideally pay for habitat restoration and protection, but in areas that are strategically selected to then additionally ensure that the overall network of fixed and temporary protected areas benefit the saiga. Reserves will be strictly enforced where there are key semi-permanent saiga populations, and conservation effort will also target shifting saiga calving locations and migration corridors.

Further to this, the researchers suggest that efforts to reduce saiga poaching through changing socio-economic incentives and targeting illegal saiga horn trade routes might result in avoided additional losses. All of which will be necessary if we are to arrest and reverse the overall downwards trend for this critically endangered saiga population.

This Uzbek offset scheme is being designed as we speak. If implemented as conservation scientists have recommended, then it will hopefully provide useful insights into the practical challenges associated with dynamic conservation practices. It will represent another step towards recognising that, like the ecosystems we are trying to protect, our conservation interventions cannot stand still.

As the Russian saying to hunters goes: "не пуха не пера", which literally means: 'no fluff, no feathers' (which we might express as 'fingers crossed')!

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Theme A
Case Study

COLLABORATIVE POTENTIAL

The saiga population has declined by 95% since the fall of the Soviet Union (1991). The species is currently listed as Critically Endangered by the IUCN. Poaching represents the primary driver of this decline although environmental change and economic development across the species' range may also be responsible. The focus of our work is the isolated trans-boundary population inhabiting the Ustyurt Plateau, which spans the border between Kazakhstan (where the population summers) and Uzbekistan (where it migrates to during winter).

Saiga migration is driven by climate and forage availability, and saiga calving sites have shifted northward in recent decades in response to changes in both climate and forage. The IPCC projects that temperatures will rise considerably during this century, by as much as 6°C in Central Asia which would probably force further regional shifts in saiga habitat use. The combined impact of climate change and poaching on the distribution and migratory patterns of the Ustyurt saiga may be substantial.

A GROUP OF SAIGA ANTELOPE. (FROM BULL *ET AL*. 2013A; PHOTO BY NJ SINGH)

Theme B
Optimal Monitoring

JONATHAN RHODES, THEME LEADER

ABOUT THIS THEME

Our work on how to monitor efficiently and effectively is transforming optimal monitoring into a central pillar of environmental decision-making and prioritisation. Monitoring is crucial for providing information to make environmental decisions and CEED research focuses on identifying monitoring actions and strategies that provide the greatest environmental outcomes for the lowest cost.

THREATENED SPECIES

CEED researchers have shown for the first time that monitoring species' abundance and characterising the shape of the decline can be used to infer the type of threats driving a decline. This new approach provides a much needed 'short-cut' for interpreting species declines to inform management (Di Fonzo *et al*., 2013). Most conservation programmes also aim to conserve whole communities of species, but objective methods for selecting which species should be monitored to cost-effectively detect changes in ecosystems to inform management have been lacking (Tulloch *et al*., 2013). We used decision science to solve this problem by selecting the best suite of species to monitor to meet specific conservation objectives and applied the approach to a recovery programme for mammals in south-western Australia focussed on managing invasive foxes.

Determining whether a species has gone extinct or still persists is important for informing the allocation of conservation funding to that species. It not only helps avoid wasting scarce conservation resources on managing species that have already gone extinct, but also avoids the mistake of not managing a species when it is not yet extinct.

CEED researchers have presented a new method for estimating the chance that a species has gone extinct based on sighting records (Thomson *et al*., 2013). This method greatly simplifies and improves the problem of quantifying extinction, leading to better management of at risk species.

LINKING MONITORING WITH MANAGEMENT

For monitoring programmes to benefit biodiversity, clear links between monitoring outcomes and management actions are required. However, this essential link is rarely made, resulting in species extinctions, despite comprehensive data being obtained through monitoring (Lindenmayer *et al*., 2013). High profile examples of these include the West African black rhinoceros and the Christmas Island pipistrelle. We developed guidelines for monitoring that will have better conservation outcomes for species. These guidelines include: (1) clearly articulating links between monitoring information and management actions; (2) transparently specifying trigger points for management; and (3) quantifying the ability to detect change early.

ADAPTIVE MANAGEMENT

Adaptive management is an important framework because it establishes explicit links between monitoring and management. However, CEED researchers have revealed that adaptive management is rarely enacted in the real world (Westgate *et al*., 2013). Even when it is enacted, the extent to which key aspects of adaptive management, such as ongoing monitoring, are incorporated is highly variable. We suggest that, through better collaboration between managers and scientists, and by communicating potential risks of not adaptively managing, we can improve the uptake of adaptive management in real-world conservation.

RESEARCHERS

Dr Jonathan Rhodes, Theme Leader (UQ)

Dr Joe Bennett (UQ)

Dr Martina Di Fonzo (UQ)

Dr Gurutzeta Guillera-Arroita (UM)

Prof David Lindenmayer (ANU)

Dr Eve McDonald-Madden (UQ & CSIRO)

Prof Michael McCarthy (UM)

Prof EJ Milner-Gulland (Imperial College)

Dr Alana Moore (UM)

Dr James (Jim) Nichols (USGS)

Prof David Pannell (UWA)

Prof Hugh Possingham (UQ)

Dr Libby Rumpff (UM)

Dr Reid Tingley (UM)

Dr Peter Vesk (UM)

Dr Martin Westgate (ANU)

Dr Brendan Wintle (UM)

STUDENTS

Payal Bal (UQ)

Els Van Burm (UM)

Abbey Camaclang (UQ)

Kiran Danjal-Adams (UQ)

Darren Southwell (UM)

Ayesha Tulloch (UQ) now a postdoctoral research fellow

Theme B
Optimal Monitoring

LEADER PROFILE

DR JONATHAN RHODES

Jonathan Rhodes is a CEED CI and UQ node leader based in the School of Geography, Planning and Environmental Management at The University of Queensland. Jonathan's research is centred around three main research areas: the impact of landscape change and climate change on biodiversity and ecosystem services; the role of human social factors in conservation decision-making; and the value of information for conservation. He is particularly interested in how spatial ecological processes, human social processes and multiple threats interact to determine priorities for biodiversity conservation in human-modified landscapes. He is also interested in how to learn about these systems using optimal monitoring strategies and adaptive management. He addresses these questions by linking data and quantitative models with decision analysis.

PROFILES

DR EVE MCDONALD-MADDEN

Eve McDonald-Madden is a CEED CI and an ARC Early Career Research Fellow with the School of Geography, Planning and Environmental Management, at The University of Queensland. Her research on how we make decisions in conservation is at the cross-roads of statistical and mathematical analysis and ecology, and focuses on finding novel solutions to the complex problem of managing biodiversity. The foundation of her work is 'Decision Theory', a concept initially used to maximise the effectiveness of scarce military resources while dealing with the uncertainties always present in war. To aid better conservation decision-making, she uses a suite of analysis techniques for seeking optimal strategies that are largely novel to ecology and conservation, such as Artificial Intelligence (AI). In particular she is interested in decisions about when to invest in monitoring and adaptive management, what is the value of information for improving decisions, and how such adaptive processes can aid decision-making in the face of uncertainty about climate change.

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DR AYESHA TULLOCH, POSTDOCTORAL RESEARCH FELLOW (FORMERLY PHD STUDENT)

Ayesha Tulloch is a conservation biologist interested in monitoring and management of threats to biodiversity. She integrates disciplinary perspectives (economic, social, political and environmental) to evaluate approaches for prioritising conservation investments in places where there are multiple stakeholders. She has a particular interest in invasive and wide-ranging predators, network theory, cost-benefit analysis, migratory species and bird ecology.

Ayesha is currently working on tools and approaches for prioritising investment in adaptive management and monitoring of multiple species and threats, and on trans-boundary conservation issues such as collaboration, large-scale species movements and international policy. She is also interested in the use of decision theory to address human-wildlife conflict where there are many different players and values.

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THEME LEADER DR JONATHAN RHODES

DR AYESHA TULLOCH

DR EVE MCDONALD-MADDEN

Theme B
Optimal Monitoring

PLANS FOR 2014 AND BEYOND

This theme will focus on addressing four critical areas for monitoring:

1. How to prioritise monitoring and management investment in declining species to inform recovery planning: Currently, rates of species decline dominate decisions regarding investments in species recovery. However, there are no methods that explicitly account for costs and benefits of the information gained when prioritising monitoring investment in learning about these declines. Nor are there methods to determine how much to invest in monitoring activities versus recovery actions. Developing new methods to do this will form an important component of our future work.

2. Understanding the value of learning about population demographics for managing threatened species: An alternative approach to using information on population declines alone for prioritising investment in threatened species is to use demographic models to quantify species' responses to management. Such an approach is generally more data intensive than relying on decline data alone, but it is unclear when the value of gaining additional information is cost effective. We will address this issue by first exploring the value of monitoring to gain new information when developing demographic models to inform threatened species management.

3. Developing better methods for linking indicators of change to biodiversity responses and prioritising investment in these indicators: We will investigate effective monitoring of indicators of biodiversity when measuring outcomes directly is problematic (e.g., measuring habitat change as an indirect indicator of changes in species abundance). We will develop new methods that quantify links between indicators and biodiversity values, and protocols for deciding which indicators provide the greatest management benefits.

4. Approaches for allocating monitoring investment to learn about ecological and social systems: The field of environmental decisions increasingly recognises that decision tools must incorporate information about human social and economic processes. Optimal investment in learning about social and economic systems versus ecological systems is unclear. We will address this novel problem using ideas from optimal monitoring and decision theory.

KEY PUBLICATIONS

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Theme B

Case Study

THE VALUE OF MORE INFORMATION

Thinking like a multi-billion dollar mining magnate may help to preserve biodiversity

By Sean Maxwell (PhD Student, University of Queensland)

Koalas in south-east Queensland are in trouble. They are threatened by vehicles, dog attacks and disease. And these threats are growing as koala habitat is cleared to make way for new housing and industrial estates. The rate of decline is alarming, with the population crashing from an estimated 6000 individuals to fewer than 2000 in the space of 15 years. In response to appeals from koala managers, conservation scientists and the public to do something, the Queensland Government has allocated $26.5 million to managing koalas in south-east Queensland over the next four years. How should this $26.5 million be spent to maximise the chance of koalas persisting in South-East Queensland?

Most natural resource management budgets are typically allocated to either gaining new information about the species (or ecosystem) in question or to direct management action. In the case of the koala, there is uncertainty about the birth and death rates, and the effect of forest cover on these rates. Gaining new information that would reduce these uncertainties may lead to more effective management strategies. Alternatively, new information about these uncertainties may not change how we are currently managing the species, and a better investment could be to allocate funds to direct management action now.

These kinds of resource allocation problems are not restricted to natural resource management. They are common in health, economics, business management and the mining sector. Decision-makers in these fields have turned to analytical tools to help make good resource allocation decisions in the face of uncertainty. For example, imagine that you are Gina Rinehart and that you're reviewing a proposal for a potentially lucrative coal mining project. The project could bring in big returns, but the mining sector is competitive, and you don't want to blow millions on a project that isn't viable.

If you were in this position, the question you would ask yourself is: "should I fund geological studies, exploratory drilling and price forecasts to reduce my level of uncertainty about the site, and hopefully improve the long-term success of the proposed mining project?"

Instead of relying on gut feelings or expert opinion to answer this question, the smart approach is to use Value-of-Information analysis to help make this decision. It presents a way of evaluating the benefits of collecting additional information before making a decision. If after conducting the Value-of-Information analysis you see that the expected improvement in your profit margin from having additional information is not worth the cost of obtaining that information, then there's little point in making that investment.

Where a miner might think in terms of profit, environmental decision makers think in terms of conservation outcomes. Given limited funds to address the enormous challenge of arresting the decline in koala numbers, should we invest in learning more or just get on with the job?

Over the past year, I have been working with CEED researchers Eve McDonald-Madden, Jonathan Rhodes and Hugh Possingham in applying Value-of-Information analysis to evaluate the benefits of resolving uncertainty surrounding the declining koala population in South-East Queensland. We modelled the effectiveness of koala management using current levels of information and compared this to a situation where all uncertainty about birth and death rates, and the effect of forest cover on these rates, was resolved.

We found the optimal management strategies with and without new information on birth and death rates, and the effect of forest cover on these rates, to be very similar. This similarity suggests that resolving uncertainty will have negligible effects on management performance. Indeed, we found that a 0.034% improvement in the population growth rate is the best we could expect if uncertainty was resolved. When we converted values of information, in terms of population growth rate, into values of information in terms of dollars, we found that if resolving uncertainty costs more than 1.7% of the koala management budget, it would be more cost-effective to allocate that money to direct management action now.

Theme B
Case Study

(CONTINUED)

In the coming months, we intend to explore the value of resolving other sources of uncertainty surrounding the management of koalas in South-East Queensland. This future research may place more value on gaining new information, but the results of our analysis to date suggest that allocating resources to direct management action now will likely provide better returns on investment than gaining new information.

The low values of information illustrated in our koala case study have also been mirrored in case studies using other focal species. However, cases exist where gaining additional information has dramatically improved management performance.

These contrasting results from different Value-of-Information analyses show how uncertainty can have variable effects on our ability to achieve a management objective. They highlight the benefits and importance of a Value-of-Information analysis before making that all important investment decision.

KOALA, SOUTH-EAST QUEENSLAND.

Theme C

Socio/Ecological Analysis and Modelling for Environmental Decision–Making

SARAH BEKESSY, THEME LEADER

ABOUT THIS THEME

We build on techniques from a range of disciplines, and develop methods to analyse, model and integrate knowledge about socio-economic and ecological processes to improve environmental decision-making. This theme recognises that environmental management is, by definition, a social and political process, so responses to environmental problems must focus at least in part on human behaviour and social preferences.

The challenges of holistically managing social-ecological systems are typically complex, dynamic and multifaceted. CEED researchers produced foundational review papers in 2013 that emphasised these challenges and established new directions for multiple disciplinarity in conservation science (Pooley *et al*., 2013; Raymond and Knight 2013). These papers argue that conceptual and quantitative models are important for understanding and characterising social-ecological systems, and for predicting outcomes of management. However, this is largely uncharted scientific territory as modelling of social and ecological systems typically breaks down along disciplinary lines. Without more integrated models, a priori evaluations of environmental decisions will remain simplistic and continue to overlook key social or ecological processes that determine their success or failure.

CEED research in 2013 developed innovative methodologies for integrating social behaviours, social preferences, ecological processes and human-nature interactions in an environmental decision analysis framework. Numerous topics formed the basis of this work, two of which will be highlighted here.

COLLABORATION IN CONSERVATION

CEED research showed that collaboration between different participants contributes substantially to the outcomes of conservation planning. This research has spanned individual landowners, landscapes, countries, to entire countries. At the scale of landowners we discovered that collaboration strongly influences the outcome of attempts to control two invasive species (Coutts *et al*., 2013). Using the landscape-scale conservation collaboration Gondwana-Link as a case-study, we highlighted the value of social network analysis in conservation planning, warning that scale mismatches between conservation actions and ecological processes can seriously undermine conservation outcomes (Guerrero *et al*., 2013). Gondwana-Link is a rare example of individuals, NGOs and government agencies collaborating to conserve biodiversity; in most landscapes these participants will act independently. CEED researchers have explored the costs and benefits associated with groups collaborating in their conservation actions, given that objectives overlap to varying extents and that such collaboration can lead to time delays and additional administrative costs (Gordon *et al*., 2013). International collaboration is critical to tackling many environmental problems and can potentially reduce costs substantially. We have shown that collaboration between countries around the Mediterranean Sea could reduce costs of marine conservation by two thirds (Mazor *et al*., 2013) – see Theme A. While these factors may be enough to encourage some countries to collaborate, for others there are large cultural differences, political histories and language barriers that may be too difficult to overcome. To address this, we developed a framework for including collaborative potential into conservation planning (Levin *et al*., 2013) to identify countries that are more or less likely to work together successfully. These papers are examples of our cutting edge research on the importance of collaboration in conservation management.

SOCIAL DIMENSIONS TO PRIVATE LAND CONSERVATION

The effect of social and cultural contexts on the success of biodiversity conservation efforts on private land is likely to be pivotal. Understanding what drives landowner decision-making; values, beliefs, social norms; and how these decisions impact on biodiversity on privately owned land will improve environmental decision making. We provided the first example of modelling the social dimensions of habitat restoration, combined with ecological response models. This work demonstrated how Bayesian Networks can be used to integrate ecological and social data with expert opinion to model the cost-effectiveness of revegetation in agricultural landscapes (Jellinek *et al*., 2013).

The increasing use of novel policy instruments that are influenced by complex human responses, such as biodiversity markets, creates a particular need for socio-ecological analyses. CEED researchers have identified the relative importance of different drivers of participation in Victorian conservation tenders (Blackmore and Doole, 2013). Australia has been a world-leader in the application of market-based policy instruments in environmental programs. In order to work efficiently, these approaches need high participation rates. Counter to the assumptions underpinning market-based strategies we found that economic incentives for adoption may be less important than non-monetary drivers such as the administrative burden and relationships between agencies and landholders. This raised potential concerns about whether the programs are achieving conservation outcomes that are additional to what would have happened without the program.

Theme C

Socio/Ecological Analysis and Modelling for Environmental Decision–Making

RESEARCHERS

Dr Sarah Bekessy, Theme Leader (RMIT)

Dr Yvonne Buckley (UQ)

Dr Morteza Chalak (UWA)

Dr Shaun Coutts (UQ)

Dr Graeme Doole (UWA)

Dr Georgia Garrard (RMIT)

Dr Fiona Gibson (UWA)

Dr Ascelin Gordon (RMIT)

Dr Christopher Ives (RMIT)

Dr Salit Kark (UQ)

Dr Andrew Knight (Imperial College)

Dr Marit Kragt (UWA)

Dr Noam Levin (HUJ, Israel)

Dr Ramona Maggini (UQ)

Prof EJ Milner-Gulland (Imperial College)

Dr Emily Nicholson (UM)

Prof David Pannell (UWA)

Dr Maksym Polyakov (UWA)

Prof Hugh Possingham (UQ)

Dr Jonathan Rhodes (UQ)

Dr Libby Rumpff (UM)

Dr Ayesha Tulloch (UQ)

Dr Peter Vesk (UM)

Dr Jessie Wells (UQ)

Dr Kerrie Wilson (UQ)

Dr Brendan Wintle (UM)

STUDENTS

Ana Backstrom (RMIT)

Louise Blackmore (UWA)

Angela Guerrero-Gonzalez (UQ)

Mat Hardy (RMIT)

Alex Kusmanoff (RMIT)

Laura Mumaw (RMIT)

Fleur Maseyk (UQ)

Brigette Sommer (UQ)

Nooshin Torabi (RMIT)

Theme C

Socio/Ecological Analysis and Modelling for Environmental Decision–Making

LEADER PROFILE

DR SARAH BEKESSY

Dr Sarah Bekessy has been teaching and conducting research in environmental studies at RMIT University since 2004. Using her background in conservation biology and more recent experience in the social sciences, Sarah has established a successful research team that seeks to engage in high impact, interdisciplinary and collaborative research to find solutions to applied environmental problems (Interdisciplinary Conservation Science research group).

Sarah has published on technical and policy issues around biodiversity conservation, including planning for biodiversity in cities, the use of market-based instruments for biodiversity conservation, exploring synergies between carbon and biodiversity management, dynamic population modelling and exploring the role of genetics in conservation. She also publishes on institutional change for sustainability and sustainability education. Sarah runs a project funded by the Myer Foundation titled 'Reimagining the Australian Suburb: planning for biodiversity in the urban fringe'. In 2013, Sarah was awarded an ARC Future Fellowship titled 'Socio-ecological models for environmental decision making'.

PROFILES

DR MARIT KRAGT, ASSISTANT PROFESSOR

Dr Marit Kragt has a strong interdisciplinary background with a PhD in Environmental Economics and a Masters of Environmental Science. She is an expert in nonmarket valuation and integrated modelling. Her research focuses on integrating knowledge about socio-economic and biophysical systems, to improve environmental management decisions. Her main interests lie in (agricultural) land management practices, carbon sequestration, biodiversity conservation, and integrative research.

Recent studies have focused on understanding what drives farmers to adopt carbon farming practices, and on social willingness to pay for carbon offsets that have biodiversity co-benefits. Marit was a 2013 recipient of an Early Career Research Excellence awarded by the Modelling and Simulation Society of Australia and New Zealand. Marit has a joint position with the CSIRO Sustainable Agriculture Flagship.

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ANGELA GUERRERO-GONZALEZ, PHD STUDENT

Angela is interested in the human and socio-ecological aspects that affect nature conservation. Her recent research focuses on human-social networks and their role in the effectiveness of conservation actions. In particular her research looks at how networks of human relationships can be utilised for dealing with multi-scalar conservation issues.

Angela is also interested in the links between human and ecological systems, how they affect and can be accounted for in environmental decision making. Her current research focuses on developing methods for integrating social-ecological systems thinking into conservation planning. These methods aim to aid the identification of constraints and opportunities concealed within the social-ecological system dynamics, so that they can be used for the identification of priorities for action and the development of implementation strategies.

Guerrero AM, RRJ McAllister, J Corcoran and KA Wilson (2013) Scale Mismatches, Conservation Planning, and the Value of Social-Network Analyses. *Conservation Biology* 27:35-44

THEME LEADER DR SARAH BEKESSY

DR MARIT KRAGT

ANGELA GUERRERO-GONZALEZ

Theme C

Socio/Ecological Analysis and Modelling for Environmental Decision–Making

PLANS FOR 2014 AND BEYOND

Our research on socio/ecological analysis and modelling for environmental decision-making will expand by:

1. Integrating human responses to climate change into conservation planning: developing an integrated decision framework. Efforts to integrate climate change adaptation into conservation planning have failed to adequately account for human behavioural responses. We will address this issue from a decision theory perspective and, using real world case studies, developing an integrated decision framework.

2. Reconciling the triple bottom line of social equity, economic return, and environmental benefits in conservation decision making. We will further develop ideas focused on the relationship between equity and conservation success that were first presented by Halpern *et al*., (2013) in their publication in The Proceedings of the National Academy of Sciences (PNAS).

3. Modelling the social dimensions of market based instruments for biodiversity conservation: This workshop will explore the use of agent-based models to explore social responses to different conservation interventions.

4. Evaluating environmental research: There is increasing demand worldwide for research to be accountable to the public who fund it. We are working with one of the world experts in the economics of research, Prof Julian Alston from the University of California Davis to develop new methods for evaluating environmental research.

KEY PUBLICATIONS

Blackmore L and GJ Doole (2013) Drivers of landholder participation in tender programs for Australian biodiversity conservation. *Environmental Science & Policy* 33:143-153

Coutts SR, H Yokomizo and YM Buckley (2013) The behavior of multiple independent managers and ecological traits interact to determine prevalence of weeds. *Ecological Applications* 23:523-536

Gordon A, L Bastin, WT Langford, AM Lechner and SA Bekessy (2013) Simulating the value of collaboration in multi-actor conservation planning. *Ecological Modelling* 249:19-25

Guerrero AM, RRJ McAllister, J Corcoran and KA Wilson (2013) Scale Mismatches, Conservation Planning, and the Value of Social-Network Analyses. *Conservation Biology* 27:35-44

Halpern BS, CJ Klein, CJ Brown, M Beger, HS Grantham, S Mangubhai, M Ruckelshaus, VJ Tulloch, M Watts, C White and HP Possingham (2013) Achieving the triple bottom line in the face of inherent trade-offs among social equity, economic return, and conservation. *Proceedings of the National Academy of Sciences of the United States of America* 110(15):6229-6234

Jellinek S, L Rumpff, DA Driscoll, KM Parris and BA Wintle (in press). Modelling the benefits of habitat restoration in socio-ecological systems. *Biological Conservation* 169: 60-67

Levin N, AIT Tulloch, A Gordon, T Mazor, Bunnefeld and S Kark (2013) Incorporating Socioeconomic and Political Drivers of International Collaboration into Marine Conservation Planning. *Bioscience* 63(7):547-563

Mazor T, HP Possingham and S Kark (2013) Collaboration among countries in marine conservation can achieve substantial efficiencies. *Diversity and Distributions* 19:1380-1393

Pooley SP, JA Mendelsohn and EJ Milner-Gulland (2013) Hunting Down the Chimera of Multiple Disciplinarity in Conservation Science. *Conservation Biology* 28(1):22-32

Raymond, CM and AT Knight (2013) Applying Social Research Techniques to Improve the Effectiveness of Conservation Planning. *Bioscience* 63(5):320-321

Theme C
Case Study

WILL SELLING HORNS (LEGALLY) SAVE THE RHINO?

Tackling Africa's rhino poaching crisis

By Duan Biggs (Post Doctoral Fellow, University of Queensland)

'Use it or lose it' has been a controversial mantra put forward by some conservation biologists. Now, with an explosion in illegal poaching for rhino horn, we're suggesting legalising the trade might be the rhino's only chance of escaping extinction.

There are only 5,000 black rhinos and 20,000 white rhinos left, the vast majority of which are in South Africa and Namibia. The western black rhino, a subspecies of the black rhino, was declared extinct in 2011.

Back in 1994 the situation was even grimmer, with black rhino numbers down to 2,410. In South Africa and Namibia this population was built up to just over 5,000 through a dedicated conservation ethic and culture that saw the creation of financial incentives for land-holders to manage and protect rhinos. The rhinos brought in tourists (and white rhinos also brought in money from high-end commercial hunting).

In the remainder of Africa, however, rhino numbers have plummeted because of illegal poaching. And this curse is now threatening conservation efforts in South Africa and Namibia. Rhino poaching in South Africa has more than doubled on average every year since 2007, from 13 animals to 668 in 2012 (figure 1). If current rates of poaching continue to escalate, the rhino could be extinct in the wild in Africa within two decades.

This dramatic escalation in illegal poaching is being driven by the dramatic increase in the retail price of rhino horn. In 1993 rhino horn was worth around $4,700 per kilogram. In 2012 it sells for around $65,000 per kilogram! The price has risen to these stratospheric levels because of persistent and growing demand in the face of restricted supply due to a CITES trade ban in place since 1977 (CITES stands for Convention on the Trade of Endangered Species).

Rhino horn has been used in traditional Chinese medicine for over 2000 years. The recent tightening of restrictions on the domestic trade of rhino horn and export of trophies from legal commercial hunts has contributed to the upsurge in poaching. Rhino protection has become increasingly militarized and expensive in terms of both money and human lives. Despite this there has been very little success in reigning in the accelerating slaughter. What's more, the increased cost of protection has resulted in a reallocation of conservation resources and is negatively affecting other conservation actions.

Current management strategies are clearly failing. It's time to consider some alternatives. Together with Franck Courchamp, Rowan Martin and Hugh Possingham, I recently proposed in the journal Science a re-examination of the debate on the legal trade in rhino horn (Biggs *et al*. 2013). We argue that the most sensible way to conserve South Africa's rhino is through a carefully controlled legal trade in horn harvested from live animals.

Rhino horn is composed of keratin and regrows when cut. The persistent and growing demand for horn could therefore be met by the humane and renewable harvesting of horns from live white rhino. However, the CITES trade ban means that the only way the growing demand can be met is by the illegal killing of rhinos for their horns.

THE FIGHT AGAINST RHINO POACHING IS BECOMING INCREASINGLY MILITARIZED WITH THE FREQUENT USE OF HELICOPTERS. PHOTO BY DUAN BIGGS.

A WHITE RHINO IN SOUTH AFRICA'S KRUGER NATIONAL PARK. PHOTO BY DUAN BIGGS

Theme C
Case Study

(CONTINUED)

Sedating a rhino to shave its horn can be done for as little as $20. The annual horn production of one white rhino averages 0.9 kg per year and the current speculative demand for horn could be met by the white rhinos on private conservation land in South Africa alone. With current technology, the risks to a rhino from dehorning are minimal. Moreover, there is limited evidence of significant behavioural change following dehorning.

Evidence from studies of other wildlife products suggests that a legal trade in rhino horn is likely to succeed in three key ways. First, technology now exists to track wildlife product through the selling chain to the end consumer to minimise laundering and illegal trade. Second, the cost-effectiveness, reduced risk, and lower transaction costs associated with a legal trade are likely to attract buyers away from the illegal market. Third, if there is an increase in demand for horn following legalisation, this increase can be met by increasing the amount of land that white rhinos live on. The rhino therefore serves conservation as an umbrella species leading to broader conservation benefits and generates income for rural communities.

A Central Selling Organisation (CSO) is one option of a structure through which a carefully regulated legal trade can be managed. A CSO can be funded from a percentage of horn sales and would be accountable to white-rhino-range states and the CITES Convention of the Parties (CoP), which includes governments of demand countries. The CSO could ensure that proceeds from rhino horn are channelled towards the enforcement of the legal trade, that horn harvesting is humane and renewable, and that financial benefits are returned to communities and landholders where rhino occur.

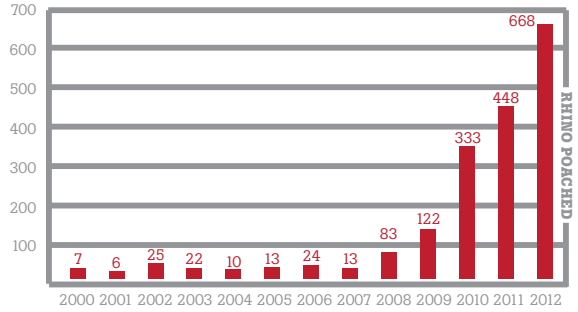

FIGURE 1: ANNUAL RHINO POACHING IN SOUTH AFRICA SINCE 2000.

Moreover, the CSO could take the lead in creating and implementing a system in which the harvesting of horn takes place from animals that live in their natural habitat so that the production of horn not only conserves rhino, but their natural habitat and associated species.

A CSO can be structured to manage the uncertainties and risks that may emerge from a legal trade in a number of ways. A CSO represents a short and closely-monitored market chain which reduces the risk of corruption because it will be difficult to circumvent the controls. The CSO should work in partnership with the governments of demand countries to ensure that strong penalties are enforced for any buyers who operate outside of the legal market. Importantly, the CSO should fund and lead the monitoring of a legal trade so that an understanding of the market can emerge and to support and enable the adaptive management of the trade.

A legal trade in rhino horn was first proposed to CITES two decades ago but was rejected as premature on the grounds that the problem lies with consumers and their insatiable demand. Yet attempts at stronger enforcement, education and awareness have clearly failed and the trade ban is now unintentionally accelerating the slaughter in the only part of Africa where healthy rhino populations still exist.

A carefully regulated legal trade in rhino horn may be morally repugnant to some, but it is probably the only feasible way to prevent the extinction of Africa's remaining rhino in the wild.

REFERENCE

Biggs D, F Courchamp, R Martin & HP Possingham (2013). Legal Trade of Africa's Rhino Horns. *Science* 339: 1038-1039 DOI: 10.1126/science.1229998

Theme D
Ecological Theory and Processes

PETER VESK, THEME LEADER

ABOUT THIS THEME

We tackle strategic, fundamental ecological science questions that are expected to inform environmental decisions. Ecology is the science of the patterns and processes determining species abundance and distribution and interactions between them and the environment. It would be foolish to advise managers and policy makers about how to manage ecosystems without understanding the critical features of those ecosystems that affect decision-making.

NOVEL ECOSYSTEMS

Substantial and exciting achievements have been made in this theme. The book Novel Ecosystems: Intervening in the new ecological order, edited by Richard Hobbs and colleagues, contains a host of contributions from CEED and other authors and recently received an honorable mention in the Biological Science category of The American Publishers Awards for Professional and Scholarly Excellence (The PROSE Awards). This book probes the science of ecological restoration in the context of widespread species invasions and changed environments.

Recognising that historical benchmarks are inappropriate brings the requirement to think hard about what is desirable and what is possible in restoration. The challenges for landscape-scale restoration are the focus of a paper in Science (Menz *et al*., 2013).

FRAGMENTED LANDSCAPES

Land use divides populations and habitats into patches embedded in a matrix. Despite years of research, how best to counter fragmentation effects remains unclear, with most attention on the patches. CEED research has clarified the conceptual domain of the 'matrix' in fragmented landscapes (Driscoll *et al*., 2013). This research highlights the importance of considering how the matrix affects movement and dispersal, resource availability and abiotic environment of patches.

DISTURBANCE

Genetic diversity is essential to viable populations and is a common aim of species conservation. CEED researcher Sam Banks led an important review of the effects of disturbance on genetic diversity. It illustrated the ways that disturbance can modify genetic diversity at various scales and how such understanding may influence management of disturbances such as fire (Banks *et al*., 2013).

RESEARCHERS

Dr Peter Vesk, Theme Leader (UM)
Dr Sam Banks (ANU)
Dr Philip Barton (ANU)
Dr Joe Bennett (UQ)
Dr Hawthorne Beyer (UQ)
Dr Yvonne Buckley (UQ)
Dr Nathalie Butt (UQ)
Dr Jane Catford (UM)
Dr Shaun Coutts (UQ)
Dr Don Driscoll (ANU)
Prof Richard Hobbs
Dr Karen Ikin (ANU)
Dr Luke Kelly (UM)
Prof David Lindenmayer (ANU)
Dr Melinda Moir (UWA)
Dr Jodie Price (UWA)
Dr Rachel Standish (UWA)
Dr Annabel Smith (ANU)
Dr Reid Tingley (UM)
Dr Leonie Valentine (UWA)

STUDENTS

James Camac (UM)
Dini Fardila (UM)
Michelle Freeman (UM)
Katherine Giljohann (UM)
Darren Le Roux (ANU)
Chrystal Mantyka-Pringle (UQ)
Will Morris (UM)
Estibaliz Palma (UM)
Michaela Plein (UM)
Keren Raiter (UWA)
Freya Thomas (UM)
Vivitskaia Tulloch (UQ)
Michael Wysong (UWA)

Theme D
Ecological Theory and Processes

LEADER PROFILE

DR PETER VESK

Peter Vesk is an ecologist whose research focuses on gathering and organising knowledge for ecological management of rural landscapes, on generalising ecological knowledge so as to facilitate its availability, and understanding interactions between plants and animals.

This research aims to bridge the gap between field ecology and modelling. One stream is more fundamental, concerning the functional traits of plants and other organisms that can be used to infer ecological responses of importance to management, including distribution and disturbance responses. Another stream is more applied, focused on measuring, projecting and optimizing the biodiversity benefits of ecosystem management activities in rural landscapes; understanding woody plant population dynamics to aid restoration and management decisions.

Vesk P (2013) How traits determine species responses to environmental gradients. *Journal of Vegetation Science* 24(6):977-978

PROFILES

DR ANNABEL SMITH,
POST-DOCTORAL RESEARCHER

Annabel conducts empirical research on ecological disturbance, often in the context of additional environmental pressures such as habitat loss, fragmentation and logging. Specifically, her research seeks to understand how fire affects ecosystems so that fire management decisions can be well informed and conserve biodiversity. She is currently investigating fire ecology in temperate grasslands, semi-arid woodlands and wet forests on a range of taxa including plants, invertebrates, reptiles, birds and mammals.

Following the 'Black Saturday' wildfires of 2009 in south-eastern Australia, Annabel and her colleagues set out to discover how the Mountain Ash (Eucalyptus regnans) forests regenerated under a range of fire severities and environmental conditions (Smith *et al*., in review). Fire was the key trigger initiating Mountain Ash seedling establishment in the first year after fire, with up to 1600 seedlings per square metre. Unexpectedly, fire severity had little influence on patterns of initial seedling establishment.

Annabel's research also showed that Mountain Ash regeneration was climate sensitive, highlighting the importance of incorporating cumulative effects of climate change and fire regime changes into forest management practices.

In another study, Annabel investigated how fire affected reptiles in semi-arid mallee woodlands of South Australia (Smith *et al*., 2013). Many reptile species were absent from a particular post-fire habitat stage, indicating that they may be at risk of extinction under inappropriate fire regimes. Furthermore, many of the ecological responses to fire were not previously detected with smaller, although substantial data sets, highlighting the massive survey effort required to study reptiles. In particular, Annabel's research suggested that there may be a large suite of reptile species that use long unburnt vegetation as their habitat. These species may become threatened if the amount of fire in the landscape increases, for example by implementing high prescribed burning targets such as 5% per annum.

Smith AL, CM Bull and DA Driscoll (2013) Successional specialization in a reptile community cautions against widespread planned burning and complete fire suppression. *Journal of Applied Ecology* 50(5):1178-1186

THEME LEADER DR PETER VESK

DR ANNABEL SMITH

DR LUKE KELLY

Theme D
Ecological Theory and Processes

DR LUKE KELLY, POST-DOCTORAL RESEARCHER

Luke's research at CEED combines fundamental ecology and applied ecology. He leads research on fire ecology, habitat fragmentation and island biogeography. This includes using novel quantitative techniques to analyse large-scale data from arid, temperate and tropical ecosystems. A common theme of Luke's work is using ecological knowledge to make better environmental decisions. Two priority topics are:

1. Fire regimes and biodiversity: Fire is used as a management tool for biodiversity conservation worldwide. A common objective is to avoid population extinctions due to inappropriate fire regimes. However, in many ecosystems, it is unclear what mix of fire histories will achieve this goal. With colleagues from CEED, Luke has developed a framework for determining the optimal fire history of a given area for biological conservation. This includes linking tools from three fields of research: species distribution modelling, composite indices of biodiversity and decision science. By clearly defining fire management objectives based on the habitat requirements of multiple species in a community, this approach could be used globally to maximize biodiversity in fire-prone ecosystems. The results of this research are being used by the Department of Environment and Primary Industries, Victoria to set appropriate fire management targets for biodiversity conservation, in major vegetation types across the state.

2. Island biogeography and connectivity: The theory of island biogeography revolutionised ecology. MacArthur and Wilson (1963, 1967) proposed that the number of species on islands is determined by island area and isolation.

With a team of collaborators from CEED, Luke is exploring how recent developments in quantitative ecology can be used to better understand the distribution of island fauna.

Specifically, the team is testing if better predictions of species richness on islands can be made by a) using connectivity measures that consider multiple sources of colonists, rather than the distance to a single source island or continent, and b) incorporating species traits such as dispersal ability into statistical models. The team has compiled an extensive spatial data set on the occurrence of birds on some 200 islands in Melanesia, and built predictive models of bird dispersal ability based on wing length, body size and diet. This work will advance one of the most influential theories in ecology.

Kelly LT, R Dayman, DG Nimmo, MF Clarke and AF Bennett (2013) Spatial and temporal drivers of small mammal distributions in a semi-arid environment: The role of rainfall, vegetation and life-history. *Austral Ecology* 38(7):786-797

PLANS FOR 2014 AND BEYOND

Our research will address these four major areas:

I. Population ecology, CEED researchers will pursue several lines: the definition of invasive species, the effects of urban development on populations and the study of general patterns in population dynamics.

2. Species traits, with community assembly and model validation as foci: how to model multiple species with joint species distribution models and trait-based multi-species models. Traits will be also addressed in a trait-based study of multi-trophic interactions in restored areas in 2014.

3. Multi-species interactions, will be addressed in workshops on the role of strongly interacting species in ecosystem management and in translocation.Moving a species that might strongly affect the environment in which it lives and other organisms is critically important. This area of research is critical to managing invasive species, and managing assisted colonisation in the face of climate change. Further research into multispecies models will occur in work on alpine vegetation dynamics under climate change, and on islands (sub-antarctic and tropical)

4. Ecosystem resilience and effective ecosystem interventions, will be pursued including a major meta-analysis on how resilience has been measured in ecological studies in a range of ecosystems worldwide. While resilience thinking is already finding its way into government policy, it is still unclear exactly how it should be measured.

Theme D
Ecological Theory and Processes

KEY PUBLICATIONS

Banks SC, GH Cary, AL Smith, ID Davies, DA Driscoll, AM Gill, DB Lindenmayer and R Peakall (2013) How does ecological disturbance influence genetic diversity? *Trends In Ecology & Evolution* 28(11):670-679

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Coutts SR, H Yokomizo and YM Buckley (2013) The behavior of multiple independent managers and ecological traits interact to determine prevalence of weeds. *Ecological Applications* 23:523-536

Driscoll DA, SC Banks, PS Barton, DB Lindenmayer and AL Smith (2013) Conceptual domain of the matrix in fragmented landscapes . *Trends In Ecology & Evolution* 28(10):605-613

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Mayfield MM, JM Dwyer, L Chalmandrier, JA Wells, SP Bonser, CP Catterall, F DeClerck, Y Ding, JM Fraterringo, DJ Metcalfe, C Queiroz, PA Vesk and JW Morgan (2013) Differences in forest plant functional trait distributions across land-use and productivity gradients. *American Journal of Botany* 100(7):1356-1368

Menz MHM, KW Dixon and RJ Hobbs (2013) Hurdles and Opportunities for Landscape-Scale Restoration. *Science* 399(6119):526-527

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Vesk P (2013) How traits determine species responses to environmental gradients. *Journal of Vegetation Science* 24(6):977-978

Theme D
Case Study

THE DETECTION OF SPECIES AND THEIR ABUNDANCE

What's the relationship between a species' abundance and an observer's chance of spotting it?

By Mick McCarthy (EDG, University of Melbourne)

Strange scenes were recently reported in Royal Park next to Melbourne Uni. People were spotted planting tiny native plants in seemingly random patterns in the grass. And nearby these same people were said to have been dropping five and ten cent pieces in the bush. But there was method in this madness. We were preparing an experiment that would help us understand the relationship between detectability and abundance.

How hard do we need to look to be sure a species is absent when it is not detected? Detectability lies at the heart of much ecology and environmental decision making. This question is relevant when determining the appropriate level of survey effort, when compiling lists of species, when determining the extinction or absence of species, and when developing surveillance strategies for invasive species.

Without sufficient survey effort, species are not detected perfectly. Imperfect detection arises because species may be temporarily absent, hidden from view, or simply require extra effort to find. The detectability of species can be defined by the rate at which individuals of a species (or groups of those individuals) are encountered.

All else being equal, detectability of species will increase with abundance.

The more individual specimens there are in an area you're searching, the more likely you will spot at least one of those individuals. But what is the nature of that relationship? It's important to understand the relationship between detectability and abundance because it can be used to determine an adequate survey effort. But the nature of this relationship has received relatively little attention in the detectability literature.

So, we set out to model the relationship between detectability and abundance, and then evaluated that model using field data. The time it takes to detect a species is equivalent to the time to detection of the first encountered individual of that species. Therefore, the model is based on the time it takes to encounter each individual at a site, and then finding the minimum of those times.

If individuals are encountered randomly, we show that the average time to detection of the species will be inversely proportional to abundance. This is equivalent to the rate of detection increasing proportionally with abundance. If the degree of clustering of individuals increases with abundance, then the detection rate will still increase with abundance but less than proportionally (McCarthy *et al*. 2013).

Therefore, we model the rate of detection as a power function of abundance (Fig. 1). The exponent for this function (b) will equal 1 if individuals are encountered independently of one another. When clustering of individuals increases with abundance, we expect this exponent to be less than 1, but greater than 0.

MICK MCCARTHY PLANTS A SPECIMEN IN A RANDOMIZED LOCATION WITHIN ONE OF THE NINE QUADRATS OF THE ROYAL PARK TRIAL.

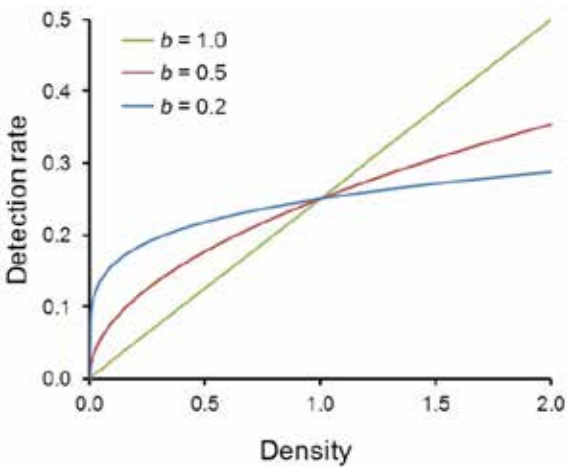


FIGURE 1: EXAMPLES OF THREE FUNCTIONS FOR HOW DETECTION RATE (LAMBDA; EXPECTED NUMBER INDIVIDUALS DETECTED PER UNIT TIME) VARIES WITH DENSITY (N). THE EXPONENT B CONTROLS THE STRENGTH OF THE RELATIONSHIP.

Theme D
Case Study

(CONTINUED)

As values for the scaling exponent approach 0, the detection rate becomes less sensitive to abundance (Fig. 1). Knowing how detection rate scales with abundance can assist when determining detection rates of rare species. This is important because detecting rare species is often important, yet estimates of detection rate are often most uncertain for these species. A scaling relationship would allow extrapolation of detection rates to cases when species are rare.

Our paper describes the development of our model of how detectability scales with abundance, and we used three field trials to estimate the scaling exponent using different measures of abundance. The results were consistent with our expectation that the scaling exponent would lie between 0 and 1. And, as expected, a value close to 1 was obtained in a study that was designed to conform to the assumption of a random distribution of individuals.

We tested the model's scaling relationship with empirical data from three independent field studies. The first study focused on detecting naturally occurring chenopod groundcover plants in a red gum remnant in Royal Park (near The University of Melbourne). Five- and ten-cent coins (19mm and 24mm in diameter respectively) were also placed haphazardly over the site. Because of the possibility that surveyors might misidentify species and the relatively high cover of some of the target species, the coins were used as a benchmark for which identification was certain and occurrence was low. The searchers were mainly masters students studying at The University of Melbourne.

The second study examined the time to detection of randomly planted species across an abundance gradient. Five native species were planted at known densities in nine quadrats in Royal Park. We used more masters students for this study, but we also had experienced field botanists, including some of Australia's most experienced. Planting occurred approximately two months prior to the search experiment so that disturbance due to planting was less obvious to searchers.

And the third study examined the relationship between the probability of detection of forest stream-dwelling frogs via audio recordings of frog calls, using abundance data measured by the number of individuals observed during nocturnal field surveys. These data were collected in the 1990s as part of Kirsten Parris' PhD on stream dwelling frogs of eastern Australia. The detection data were analysed using statistical models to estimate the scaling relationship and determine whether it conformed to the assumptions of the model.

PIN-POINTING THE RANDOMIZED LOCATION AT WHICH TO PLANT THE NATIVE LILY DIANELLA LONGIFOLIA, WITHIN A QUADRAT AT ROYAL PARK.

Our theoretical model places bounds on the abundance-detectability relationship, and provides a means of extrapolating detection probabilities to rare species with greater confidence. The model is useful when assessing the likelihood that non-detection represents a true or false negative, when allocating search effort to detect rare species, or when estimating abundance from detection time and search effort with greater precision.

Common field applications, such as threatened species surveys for development proposals, and eradication or control measures for invasive species would benefit from these applications. In these, detection of rare species is important, and this model helps determine what the detection rate of these species is likely to be if they are present.

REFERENCE

McCarthy MA, JL Moore, WK Morris, KM Parris, GE Garrard, PA Vesk, L Rumpff, KM Giljohann, JS Camac, SS Bau, T Friend, B Harrison & B Yue (2013). The influence of abundance on detectability. *Oikos*. 122(5):717-726

Theme E
Quantitative Tools and Approaches

DR MICHAEL BODE, THEME LEADER

ABOUT THIS THEME

Our activities are all quantitative, extending from fundamental research into mathematical approaches to ecological questions, through to training on-the-ground managers to use decision-support tools. For example, in 2013, CEED researchers developed novel quantitative approaches for modeling the detectability of species, applied new methods to management problems such as identifying threatened ecosystems, addressed mainstream issues through engagement with managers and policy makers by developing tools for project prioritisation and biodiversity offsetting.

DETECTABILITY MODELLING

The statistics of detection lies at the base of all environmental science. All ecologists know that wildlife surveys are almost never perfect. Individuals are often missed, and entire species remain undetected and unknown even in the world's most densely-inhabited regions. Our research has directly questioned the use and performance of species distribution models, a methodology that underpins decisions as diverse as the planning of national reserve systems, and environmental impact assessments (Guillera-Arroita *et al*., 2013).

AN IUCN RED LIST FOR THREATENED ECOSYSTEMS

Tropical rainforests are being cleared rapidly, while coral reefs are being degraded by coastal runoff, disease and bleaching – but are these ecosystems under threat? The newly-established IUCN Red List of Ecosystems provides for the first time a comprehensive set of quantitative criteria to assess threats to biodiversity at the ecosystem level. CEED researchers Dr Emily Nicholson and Dr Tracey Regan hosted workshops in collaboration with the IUCN, and state and federal conservation agencies to develop definitions and measurements of ecosystems and threat status. Like the IUCN's Red List for Threatened Species, the listing criteria for ecosystems will set standards for conservation NGOs and governments at all levels, and by doing so, will influence conservation actions, land-use patterns and macroeconomic planning across the globe. (See impact statement, page 48).

THE PROJECT PRIORITISATION PROTOCOL

The PPP scheme was developed by us late last decade to optimise threatened species management in New Zealand. It is increasingly the tool of choice for conservation asset management planning, particularly threatened species. CEED's ongoing engagement with multiple conservation agencies (governmental and NGO) is creating major shifts in the way actors distribute their resources. In 2013, an open letter to the US Secretary of the Interior from the Ecological Society of America demanded that the USA's Endangered Species Act – arguably the most important piece of conservation legislation on the planet – be enacted according to a PPP-style algorithm, citing CEED's New Zealand project as world's best practice. CEED researchers Dr Ayesha Tulloch and Dr Joseph Bennett worked throughout 2013 with Dr Liana Joseph, who first developed PPP in 2009, on extending PPP in novel directions, and helping governments around the world make more rational and efficient threatened species investment decisions. The next stage of the research will test the new criteria with models and a series of case studies from around the world (see impact statement, page 50).

MARXAN

Marxan is the primary tool used by conservation organisations and governments to plan systematic reserve networks – both on land and at sea. In 2013, CEED revolutionised Marxan's software engine and user-interface; trained hundreds of new students and practitioner in its use; helped conservation groups plan reserve networks in the south Pacific; and freely distributed the program to thousands of new conservation scientists. In terms of its impact on conservation thinking and practical outcomes, Marxan is one of CEED's most important outputs (see our Theme E Case Study, page 43).

Theme E
Quantitative Tools and Approaches

RESEARCHERS

Dr Michael Bode, Theme Leader (UM)

Dr Hawthorne Beyer (UQ)

Dr Martina Di Fonzo (UQ)

Dr Gurutzeta Guillera-Arroita (UM)

Dr Carissa Klein (UQ)

Prof Michael McCarthy (UM)

Dr Emily Nicholson (UM)

Prof Hugh Possingham (UQ)

Dr Reid Tingley (UM)

Dr Ayesha Tulloch (UQ)

Dr Jessie Wells (UQ)

Dr Kerrie Wilson (UQ)

STUDENTS

Nancy Auerbach (UQ)

Chris Baker (UM)

Abbey Camaclang (UQ)

Katrina Davis (UWA)

Kiran Dhanjal-Adams (UQ)

Chris Hallam (UM)

Bill La Marca (UM)

Tal Polak (UQ)

Rebecca Runting (UQ)

Gerard Ryan (UM)

Darren Southwell (UM)

Vivitskaia Tulloch (UQ)

Theme E
Quantitative Tools and Approaches

LEADER PROFILE

DR MICHAEL BODE

Dr Michael Bode is an applied mathematician and he is preoccupied with conservation decisions being made according to quantitative methodologies. This means enumeration and quantification (How much do the different options cost? Which species will benefit?); it requires statistics and it acknowledges uncertainty (How much do we know about an ecosystem? How sure are we that management will work?); finally, it delivers transparency and explicit logic.

His research specifically deals with conservation fences, which are built across Australia and New Zealand to keep threatened species protected from invasive predators like foxes. He has developed tools to help decide on their design, their size and geometry, and their location in the broader conservation landscape. Michael is also involved in bioeconomic analyses of coral reef fisheries. His recent work studies interactions between community management and fish population dynamics. The relative scales of these two processes can either support or undermine cooperation between different stakeholders, and therefore the outcomes of fisheries management.

PROFILES

DR REID TINGLEY, POST-DOCTORAL RESEARCHER

Reid's research focuses on understanding how species' traits and human activities influence the dual processes of invasion and extinctions, and how we can use this information to inform management decisions. In 2013, Reid worked closely with a variety of stakeholders to develop novel tools to monitor and manage the spread of invasive aquatic vertebrates. In suburban Melbourne, Reid conducted a study to assess the sensitivity and cost-efficiency of a new survey technique based on the detection of species-specific DNA for monitoring the spread of a recently established non-native amphibian: the European smooth newt (Lissotriton vulgaris).

Meanwhile, in Western Australia, Reid and his colleagues used metapopulation models to explore optimal strategies for halting the spread of a more familiar amphibian invader: the notorious cane toad (Rhinella marina). Reid's research showed that excluding cane toads from just 100 artificial waterbodies along a narrow corridor linking the Kimberley to the Pilbara could prevent toads from occupying 268,000 square kilometres of their potential range in WA; an area of land larger than the State of Victoria!

Tingley R, BL Phillips, *et al* (2013) Identifying optimal barriers to halt the invasion of cane toads (Rhinella marina) in arid Australia. Journal of Applied Ecology 50(1):129-137

Tingley R, *et al* (2013) Life-history traits and extrinsic threats determine extinction risk in New Zealand lizards. Biological Conservation 165:62-68

DR EMILY NICHOLSON, POST-DOCTORAL RESEARCH FELLOW

Emily is a Centenary Fellow who focuses on structured decision-making for conservation and environmental management, using quantitative methods where the goals and uncertainties are made explicit. Applications include threat assessment, scenario modelling, conservation planning, modelling social-ecological systems, and making decisions under uncertainty. Since 2007, her research has focused on biodiversity risk assessments at the ecosystem level, including the developing the new criteria for the IUCN Red List of Ecosystems, published in 2013. This promises to become a key tool in biodiversity assessment and monitoring worldwide. Another focus is conservation planning, including integrating viability models for multiple species into planning tools. She also works on global biodiversity indicators, and is particularly interested in evaluating the performance of indicators to test whether they can reliably reflect trends in biodiversity – information that is critically important for global policy. She organised a CEED workshop on global biodiversity indicators in May 2013, which has given rise to several pieces of on-going research.

Keith DA, *et al* (2013) Scientific Foundations for an IUCN Red List of Ecosystems. *PLoS ONE* 8(5):e62111

Nicholson E, *et al* (2013) Testing the focal species approach to making conservation decisions for species persistence. *Diversity and Distributions* 19:530-540

THEME LEADER DR MICHAEL BODE

DR REID TINGLEY

DR EMILY NICHOLSON

Theme E
Quantitative Tools and Approaches

PLANS FOR 2014 AND BEYOND

Researchers from Theme E will continue to tackle problems that range from the theory of quantitative ecology, through to the implementation of quantitative tools to support management practice and policy. Our researchers will develop cutting-edge quantitative tools, collaborate directly with managers, and hold workshops that bring stakeholders together around a shared problem.

Prioritisation methods are essential tools in modern conservation decision-making, helping managers decide which conservation actions offer the greatest benefit, and when and where they should be undertaken. CEED will push the methodological boundaries of the field, with workshops that will assess and rank the most valuable information in spatial conservation decisions. PPP will continue to be a focus of CEED, with the development of new techniques that make the method more flexible, sophisticated, and broadly applicable.

Structured decision-making is the process of making environmental decisions based on quantitative management objectives, and an understanding of the goals, constraints and uncertainties of organisations and managers. Many of the highlights of 2014 for CEED will revolve around structured decision-making, including a workshop being held in Broome on halting the southward spread of cane toads in Western Australia. Led by CEED researcher Dr Reid Tingley, this workshop will build on his widely-reported 2013 article that identified "choke-points" between the Kimberley and the Pilbara where the invasion could be halted. The workshop will bring multiple NGOs, state and federal government departments, graziers and indigenous ranger groups to Broome, to discuss the feasibility and logistics of the plan.

CEED researchers will also start to ask some bigger and broader questions to do with fundamental conservation dichotomies such as: should we expand or better manage our protected area system. We will work on formulating the models that can underpin these basic dichotomous decisions during 2014.

KEY PUBLICATIONS

Addison PFE, L Rumpff, S Sana Bau, JM Carey, YE Chee, FC Jarrad, MF McBride and MA Burgman (2013) Practical solutions for making models indispensable in conservation decision-making. *Diversity and Distributions* 19:490-502

Bode M, KEC Brennan, K Helmstedt, A Desmond, R Smia and D Algar (2013) Interior fences can reduce cost and uncertainty when eradicating invasive species from large islands. *Methods In Ecology and Evolution* 4:819-827

Brown CJ, MI Saunders, HP Possingham and AJ Richardson (2013) Managing for Interactions between Local and Global Stressors of Ecosystems. *PLoS One* 8(6):e65765

Cook CN, HP Possingham and RA Fuller (2013) Contribution of Systematic Reviews to Management Decisions. *Conservation Biology* 27(5):902-915

Game ET, P Kareiva and HP Possingham (2013) Six Common Mistakes in Conservation Priority Setting. *Conservation Biology* 27(3):480-485

Guisan A, R Tingley, JB Baumgartner, I Naujokaitis-Lewis, PR Sutcliffe, AIT Tulloch, TJ Regan, L Brotons, E McDonald-Madden, C Mantyka-Pringle, TG Martin, JR Rhodes, R Maggini, SA Setterfield, J Elith, MW Schwartz, BA Wintle, O Broennimann, M Austin, S Ferrier, MR Kearney, HP Possingham and YM Buckley (2013) Predicting species distributions for conservation decisions. *Ecology Letters* 16(12):1424-1435

Lahoz-Monfort JJ, G Guillera-Arroita and BA Wintle (in press) Imperfect detection impacts the performance of species distribution models. *Global Ecology and Biogeography* 23(4):504-515

Salomon Y, MA McCarthy, P Taylor and BA Wintle (2013) Incorporating Uncertainty of Management Costs in Sensitivity Analyses of Matrix Population Models. *Conservation Biology* 27(1):134-144

Theme E
Case Study

MARXAN
conservation solutions

QUANTITATIVE TOOLS AND APPROACHES

Marxan is the primary tool used by conservation organisations and governments to plan systematic reserve networks – both on land and at sea. In 2013, CEED revolutionised Marxan's software engine and user-interface; trained hundreds of new students and practitioner in its use; helped conservation groups plan reserve networks in the south Pacific; and freely distributed the program to thousands of new conservation scientists. In terms of its impact on conservation thinking and practical outcomes, Marxan is one of CEED's most important outputs.

SOFTWARE DEVELOPMENT

CEED collaborated with the Queensland Cyber Infrastructure Foundation (QCIF) to develop Marxan.net, a migration of the Marxan software the Cloud. The transfer allows users around the world to rely on Australia's computational and data-storage advantages to run enormous reserve network design problems from any internet-connected computer. Marxan.net comes with online tutorials, a user guide, sample datasets and source code. It liberates conservation managers, students and scientists in developing countries from infrastructure limitations.

TRAINING COURSES & NEW USERS

In the last two years, Marxan was downloaded by more than 10,000 users, across 141 different countries. As well as freely downloading the software, these users took advantage of tutorials and user manuals. They were also introduced to an active online community of conservation scientists, who are continually road-testing the software and adapting it to the ever-changing conservation landscape.

CEED researchers also took an active role in training students and practitioners how to use Marxan, holding 9 courses in 2013 that taught 165 participants from 85 different organisations. As well as introducing these scientists to the use and underlying theory behind Marxan, CEED instructors provided support and advice to participants who brought along their own planning problems and data.

To extend their reach even further, 2013 saw the "Train the trainer" courses continue, where experts from CEED taught experienced Marxan users the skills to train others.

CONSERVATION OUTCOMES

CEED researchers were deeply involved in two applications of Marxan in 2013, both within the Coral Triangle biodiversity hotspot.

FIJI: In collaboration with the Wildlife Conservation Society, CEED worked with Fiji's National Protected Area Committee to re-prioritise the government's investement in terrestrial protected areas. When Marxan outputs showed that some vegetation types were under-protected, particularly on Vanua Levu, the Protected Area Committee added new forests to their list of highest conservation priorities. This is the first time that a terrestrial protected area network was systematically designed to minimise run-off impacts on the marine environment.

MALAYSIA: The Tun Mustapha Park (TMP) in Malaysia will soon protect more than 1 million hectares of marine and coastal areas, with the triple goal of poverty reduction, sustainable development, and biodiversity conservation. To balance the park's competing uses, a collaboration between Sabah Parks, WWF-Malaysia, CEED and TMP stakeholders applied Marxan with zones to decide what configuration of conservation and fishing zones would satisfy each of the park's objectives.

IMPACT ON POLICY AND SOCIETY

It's easy to point to outputs (meetings, workshops, *Science* papers etc) but being able to say something led to an outcome (change in policy, new approach to management, the introduction of transparency to decision making etc), that's something special. CEED, and its antecedents, have been at the forefront of environmental decision science for many years and many of our outputs are now beginning to be put to use. In 2013 it was pleasing to see that several of our research efforts are resulting in significant outcomes. Here we highlight several of these and describe the impact they are having now, and are expected to have in the future.

Impact on Policy and Society

IPBES: shaping a new international approach to biodiversity conservation

CEED researchers in collaboration with the International Branch of the Commonwealth Department of Environment have made significant contributions to the development of the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES). Fifteen researchers comprising CEED CIs, post-docs and students have provided input into the IPBES process. Part of this contribution involved CEED PhD student Ms Jane McDonald joining the Australian government delegation in Turkey to provide input to a work plan and deliberations of the panel in Dec 2013.

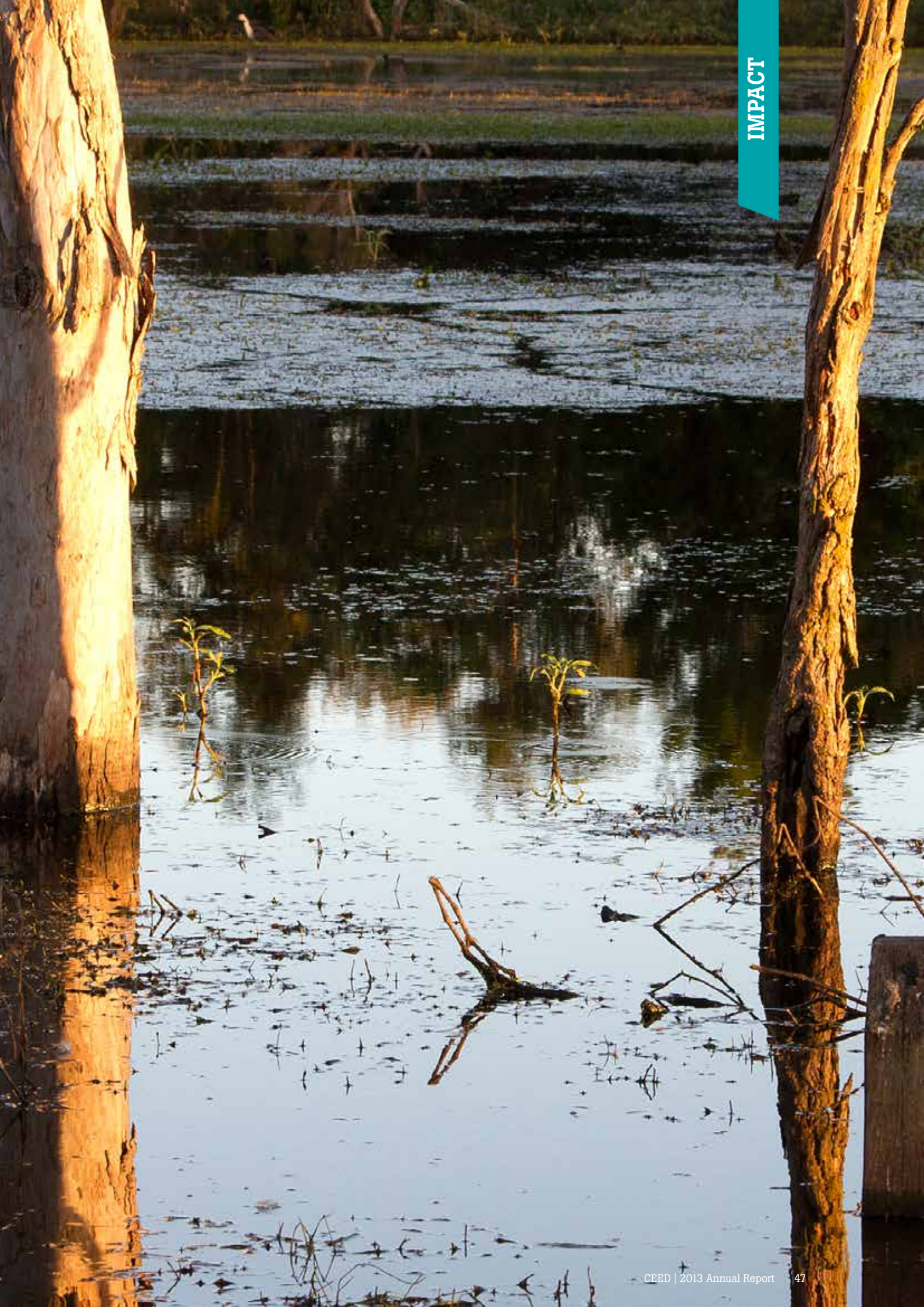
The IPBES is an important international initiative that aims to provide assessment of threats to, and trends in biodiversity and ecosystem services at global and regional levels. The need for the IPBES was a consensus decision from the stakeholders involved in the Millennium Ecosystem Assessment (MEA) (CEED CI Kerrie Wilson was a Millennium Ecosystem Assessment Fellow in 2003 while completing her PhD). The IPBES was then established in 2012 as an independent intergovernmental body open to all member of the United Nations. Including Australia, there are now 117 member countries signed up to IPBES.

The aim of this platform is to assess and critically evaluate the state of the planet's biodiversity, its ecosystems and the services provided by ecosystems to society. Its core purpose is to provide and interpret scientifically credible and independent information that takes into account the complex relationships between biodiversity, ecosystem services, and people to inform policy decisions at all levels. IPBES has the potential to be highly influential in global conservation efforts by the signatory nations.

The success of the IPBES will rely on a credible group of experts to conduct assessments of information and knowledge in a transparent way and CEED researchers have been involved in this process since the MEA. CEED's contribution to the IPBES in the lead up to the plenary meeting was to provide critical feedback on key inter-sessional scoping documents including (a) the recommended conceptual framework for the IPBES; (b) valuation and accounting of biodiversity and ecosystem services; and (c) scenarios and modelling for biodiversity and ecosystem services.

CEED is in a unique position to influence IPBES methodology and implementation through contributions to scenario modelling and policy evaluation. CEED researchers have also been nominated for these roles through the Australian government as expert members of upcoming task forces and fast track assessments. In 2014 and beyond, CEED will be seeking to be involved in future writing of IPBES documents, chapters and peer-reviewed publications. We will continue to work closely with the Department of Environment delegation to provide technical expertise to build the scientific evidence base for the IPBES.

CEED RESEARCHER JANE MCDONALD, SECOND FROM THE LEFT, WITH THE AUSTRALIAN DELEGATION AT THE SECOND PLENARY MEETING OF THE IPBES IN TURKEY IN DEC 2013.



Impact on Policy and Society

A new list to frame biodiversity conservation

Much of the debate on declining biodiversity has been framed around disappearing species. A new IUCN Red List promises to enlarge this debate to take ecosystems into account. CEED researchers have made several important contributions to developing the criteria for assessing ecosystem status.

The status of threatened species is but one facet of the conservation problem of declining biodiversity. Scientists have become increasingly concerned that the habitats of species and the ecological processes that influence the relationships between species are not adequately considered. A Red List of Ecosystems has long been needed, and last year the IUCN delivered one. It's a risk assessment framework for ecosystems that lets the IUCN rank ecosystems as endangered, vulnerable or not threatened according to the risks they face.

Defining, measuring and comparing ecosystems is a much tougher proposition than defining, measuring and comparing the status of threatened species (which is challenging enough in itself). It's easy to observe that the Aral Sea is a collapsed ecosystem; the sea itself has largely disappeared and with it many of its native animals and plants – never to return. In terms of area, composition and function, this ecosystem is gone. But what about the Coorong or the Great Barrier Reef? They're under tremendous pressure, and certain environmental indicators (such as shorebird numbers and coral cover) are in rapid decline, but at what point should they be considered vulnerable as opposed to endangered?

Attempting to classify the threat level to ecosystems is a truly daunting task given the range of factors involved and things that could be measured. The Red List of Ecosystems assesses an ecosystem against multiple criteria: how rapidly is it declining and what is its current extent? How rapidly and how extensively are its physical and biological components degrading? And what is the nature of the multiple threats it faces and how are these threats interacting?

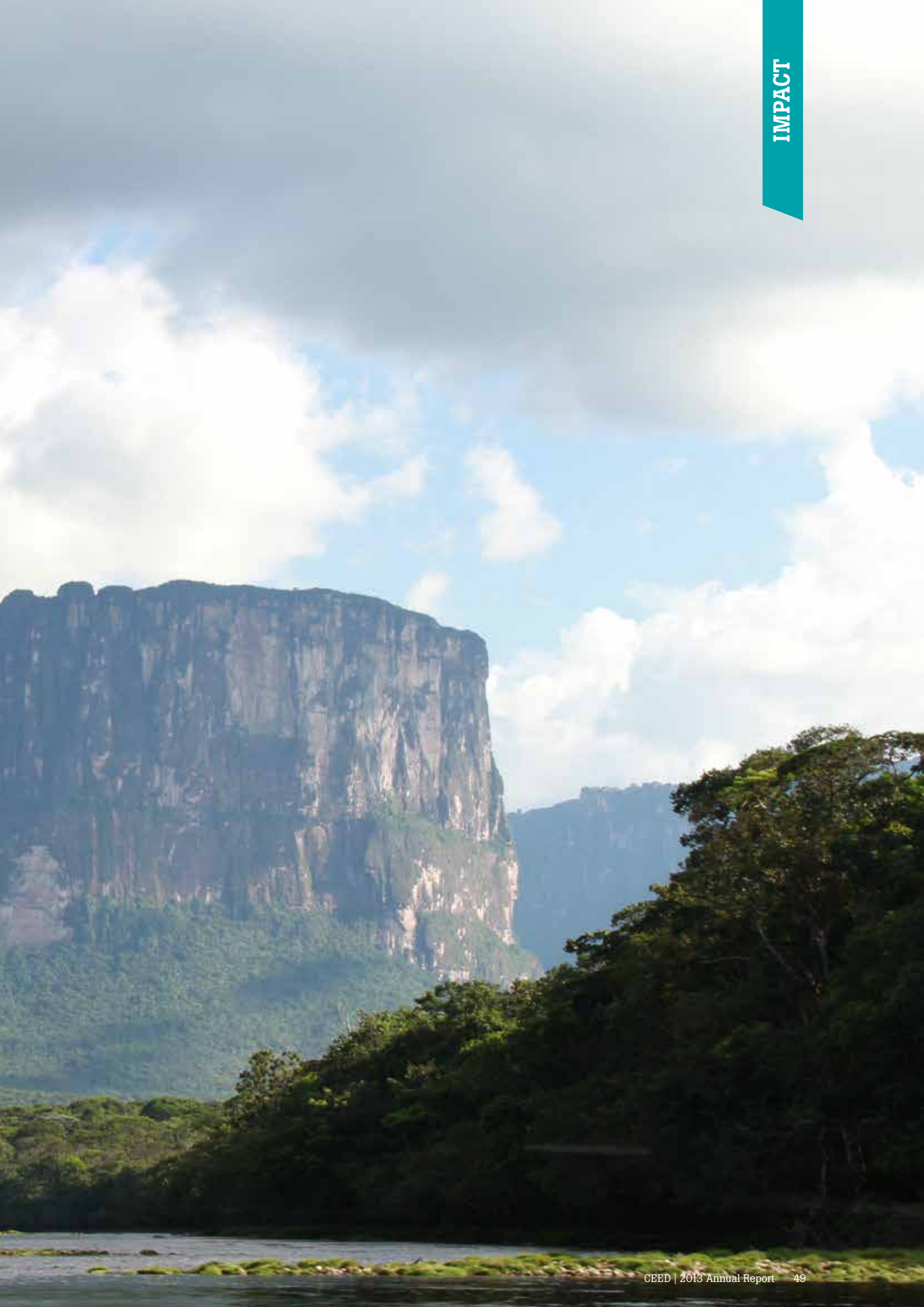
The ecosystems framework that has been released by the IUCN is the product of many discussions and workshops between scientists. CEED researchers Dr Emily Nicholson and Dr Tracey Regan spent 2013 hosting workshops and collaborating with state and federal conservation agencies and the IUCN to develop definitions and measurements of ecosystems and threat status.

They were recently part of an analysis that sought to test the framework's criteria against 20 illustrative case studies from around the world. Of the ecosystems they compared, the remote mountain ecosystems of the Venezuelan Tepui are among those at least risk of collapse. These systems are showing little evidence of decline in distribution or function in the past or near future. At the other extreme is the Aral Sea, which collapsed during the 1980s and 1990s.

The Aral Sea assessment underscores the importance of healthy ecosystems. Not only were a host of species lost forever as the sea became hypersaline and dried up. This ecosystem collapse led to a socio-economic disaster, with closure of regional fisheries and major continuing impacts on human health. As an early warning system, the Red List of Ecosystems will help governments, industries and communities avoid ecosystem collapse and the associated socio-economic impacts by informing better environmental decisions.

The Aral Sea has been transformed from a large and thriving ecosystem to a dry and toxic wasteland. If it was a 'species' it would be a good example of what 'extinction' looks like because this ecosystem is not coming back. It's lost forever. However, while ecosystem collapse might be obvious (especially when viewed in hindsight), what does an endangered ecosystem look like? And how do you distinguish between 'endangered' and 'vulnerable' ecosystems. The IUCN Red List of Ecosystems, with assistance from CEED, is grappling with these questions.

THE TEPUI SHRUBLANDS OF SOUTHERN VENEZUELA OCCUR ON TEPUI SUMMITS, PICTURED HERE, AND ARE CHARACTERISED BY A HIGH DEGREE OF PLANT ENDEMISM. THEY WERE ASSESSED AS LEAST CONCERN UNDER THE IUCN RED LIST CRITERIA, HOWEVER LONGTERM THREATS INCLUDE DAMAGE FROM TOURISM AND CLIMATE CHANGE. PHOTO BY TRACEY REGAN.



Impact on Policy and Society

The Project Prioritisation Protocol

The Project Prioritisation Protocol, or PPP, was first developed in 2009 as a tool to help optimise threatened species management in New Zealand. It is increasingly the tool of choice for conservation asset management planning, particularly involving threatened species lists.

Prof Hugh Possingham's consistent and persuasive arguments about rational conservation asset prioritisation, and CEED's ongoing engagement with multiple conservation agencies (governmental and NGO) is creating tectonic shifts in the way conservation managers distribute their resources. In 2013 an open letter to the US Secretary of the Interior from the Ecological Society of America demanded that the USA's Endangered Species Act – arguably the most important piece of conservation legislation on the planet – be enacted according to a PPP-style algorithm. This cited the application of PPP in New Zealand as World's best practice.

The approaches developed in PPP are now underpinning the way several state governments in Australia approach conservation triage, most recently in NSW with their Save our Species plan announced late in 2013.

CEED researchers, Dr Ayesha Tulloch and Dr Joseph Bennett, worked throughout 2013 with Dr Liana Joseph, who first developed PPP in 2009 developing the protocol and associated software. They also helped governments around the world to engage with the process, thereby making more rational and efficient threatened species investment decisions.

IMAGE: GREEN TURTLE HATCHLING

Impact on Policy and Society

Contributing to threatened species management

In 2012 the Australian Senate asked the Environment and Communications References Committee to set up an inquiry titled the Effectiveness of threatened species and ecological communities' protection in Australia. CEED, being one of the key research centres working in this area, made a formal submission to this inquiry. A team from CEED including two CIs, three CEED post-docs, two collaborators and a CEED PhD student (Jane McDonald) synthesised relevant CEED-researched solutions in a written submission and Prof Michael McCarthy accepted an invitation to appear at the inquiry to give verbal support to the submission and answer further questions from senators.

The Senate Inquiry released a report in Aug 2013, summarizing the key points of the submissions and outlined recommendations. The report included over thirty references to the CEED submission, Prof McCarthy's Senate appearance and three major recommendations based on CEED's contributions. These recommendations are intended to guide further policy developments and reforms.

The authors of the CEED submission have also converted the submission into a paper for publication in a peer reviewed journal to communicate it to the scientific community. During the development of this paper the CEED authors worked closely with CSIRO and staff from the Department of the Environment. CEED will seek to contribute to future parliamentary inquiries relevant to CEED research and work closely with the Department of the Environment to formulate effective policy solutions for conservation problems.

IMAGE: ENDANGERED ORANGE BELLIED PARROT

Impact on Policy and Society

Calculating biodiversity offsets

Biodiversity offsetting aims to compensate damage to the environment in one place (usually arising from development) with improvements in other places. Although applied by governments and industry worldwide, how to calculate losses in biodiversity and compare them to gains elsewhere is poorly understood. CEED researchers across Australia and in the UK are leading the world in developing this understanding, and improving the way that offsets are implemented. One study, led by Joseph Bull at the Imperial College in London, defined offsets and reviewed their implementation. This study led CEED members being invited to participate in expert consultations at the Royal Society of London and the UK Parliament to help guide the UK's offset policy.

Back in Australia, the Australian Government recently created an offsets policy that redefines key elements of the Environment Protection and Biodiversity Conservation (EPBC) Act, and CEED researchers helped to create an "offset calculator", a tool that will provide government managers with transparent and quantitative support for some of the most frequently made and important decisions in Australian conservation.

Offsetting biodiversity loss is a challenging process. The work of CEED researchers has helped frame what needs to be done to do it appropriately, and we have also worked to understand and communicate its limitations. When done with rigor, biodiversity offsetting can reduce the chance that declines will become steeper, and it can also reveal to us the replacement cost of biodiversity. CEED's input into offsets policy in Australia has placed our country at the leading edge of this emerging field.

HOW MANY YOUNG TREES DO YOU NEED TO PLANT TO OFFSET THE CLEARING OF A SINGLE OLD HABITAT TREE? THE ANSWER TO THIS AND ANY OFFSETTING PROPOSAL IS NEVER STRAIGHTFORWARD. THE DEVELOPMENT OF A SCIENTIFICALLY ROBUST CALCULATOR IS HELPING POLICY MAKERS AND MANAGERS TO UNDERSTAND THE MANY COSTS INVOLVED IN DEVELOPMENT THAT NEGATIVELY IMPACTS ON BIODIVERSITY.

Impact on Policy and Society

New frames for hot debates

Through their publications, public debates and discussion, some conservation scientists rise above the science itself to help clarify and even create new frames and approaches for tackling some of our biggest conservation challenges. CEED CI Prof Richard Hobbs has been one of these players and in 2013 he made important contributions to two (overlapping) hot-button issues – novel ecosystems and the management of non-native species.

Perhaps no issue in conservation spawns as much emotional debate as the issue of managing non-native species. Depending on the context and perspective, non-native species may be villains, heroes, victims, or organisms just trying to survive. Calling them pests and weeds, however, is too simplistic because many non-natives never create any problems to agriculture or conservation whereas some natives do go on to become serious problems. However, this issue of a species origin – native vs non-native – and how we prioritise our management of them has always stirred up emotions. Prof Hobbs made an important contribution to this debate by examining different non-native species management goals and options, and then developing a framework that incorporates different approaches for new occurrences and introductions of non-native species versus established non-native and invasive species populations.

Moving beyond species, the idea of novel ecosystems has also generated considerable heat and discussion. Land conversion, climate change and species invasions are contributing to the widespread emergence of novel ecosystems. Dealing with them demands a shift in how we think about traditional approaches to conservation, restoration and environmental management. Once again, Prof Hobbs has played a pivotal role in this debate. Last year he led the production of a book titled Novel Ecosystems. The text, a collection of peer-reviewed chapters, is the first comprehensive volume to look at the ecological, social, cultural, ethical and policy dimensions of novel ecosystems. The authors argue these altered systems are overdue for careful analysis and that we need to figure out how to intervene in them responsibly.

Prof Hobbs' contribution to these debates (which have included public addresses and briefings to the Commonwealth Department of the Environment) has had an enormous impact on policy, management and society. In acknowledgement of his contribution, he was recently awarded a Special Recognition Award by the Society of Ecological Restoration.

IMAGE: THE NON-NATIVE, HIGHLY INVASIVE PRICKLY PEAR CACTUS

TRAINING AND MENTORING

CEED puts a high priority on the career development of the next generation of conservation researchers. We have a multi-pronged approach to facilitating the development of this next generation through a focus on training both our CEED early career researchers and through the development of programs to ensure our legacy extends beyond our walls to reach early career researchers from all parts of the globe.

Training and Mentoring

EARLY CAREER RESEARCHER CAREER DEVELOPMENT PROGRAM

In 2013 we initiated an Early Career Researcher (ECR) Training program to have a coordinated approach to the training needs of our up and coming members of CEED. Following consultation with these members of our group, we ran three training courses focused on Facilitation Skills, Species Distribution Modelling and an Introduction to Bayesian Belief Networks.

In March 2013, fifteen ECRs from The University of Queensland, The University of Melbourne and The University of Western Australia took part in a two day course on Facilitation Skills for Environmental Decisions run for CEED by Mary Maher and Associates. The aim of the course was to improve the understanding and development of competences in working with groups in challenging situations of natural resource management.

In June 2013 we contracted Dr Carl Smith from University of Queensland to run an Introduction to Bayesian Networks (BN). Bayesians Networks are fast becoming the new tool of choice for conservation management due to their ability to utilise a variety of information and data and to intuitively integrate variables of cause and effect. In this course 22 ECRs from The University of Queensland, The University of Melbourne and The University of Western Australia and RMIT University learnt the fundamentals of using BNs in natural resource management putting them on the front foot of this burgeoning method in conservation science.

In October 2013, 34 researchers from all nodes attended a course run by CEED on Species Distribution Modelling (SDM). SDM is a key approach to modelling how species utilise the landscape and how species distributions might be affected in the future by management or climate change. It is one of the most popular modelling methods of the last decade and is an essential skill for the career development of our current cohort of CEED researchers. Due to popular demand, we are looking to rerun this course in 2014.

In 2014 we will be expanding our training program to run two more courses (SDM and Australian Environmental Policy) and a training week for CEED ECR focussing on core skills for being a successful conservation scientist (Facilitation, Grant writing, Stakeholder engagement, Media training and Structured Decision-making).

ECR TRAVEL GRANT SCHEME

The development of researchers and their productivity early in their career is enhanced substantially through international interaction. The CEED Early Career Researcher Travel Scheme is designed to enable PhD students and postdoctoral researchers less than five years out of their PhD to come to Australia or travel overseas to collaborate and build networks. Grants are available for CEED members to spend 1–6 months visiting overseas research groups or for non-CEED researchers to visit Australia to spend 3-6 months visiting two or more of the four Australian CEED hubs. This scheme is funded separately to the core funding allocated to ARC CEED.

The scheme has been very successful in facilitating training and raising the profile of our centre internationally. For example, the scheme is instrumental in developing lasting benefits through the mentoring of CEED ECRs from leaders in the field outside of CEED and establishing strong connections with the institutions that they visit. This scheme will leave a lasting legacy through building capacity in environmental decision science. The scheme as has also allowed CEED to develop new links with other institutions through the mentoring of incoming ECRs. This provides impact well beyond CEED and opportunities for new opportunities across the globe.

Grant recipients in 2013 that epitomise the success of the scheme include Lucie Bland, Dr Örjan Bodin and Dr Jessie Wells.

The incoming visitor funding allowed Lucie Bland, a PhD student from the Institute of Zoology and Imperial College London, to visit The University of Melbourne and The University of Queensland between January and May 2014 2014. During her visit, she worked with CEED researchers to develop an additional chapter for her thesis on using machine learning methods to assess risks faced by species classified as Data Deficient by the IUCN. Specifically, the research determines how to optimally allocate effort between using machine learning methods to assess risks, and assessing risks using standard IUCN methods. Two publications are expected to emerge from the visit.

Training and Mentoring

Between December 2012 and February 2013, Dr Örjan Bodin, from Stockholm University, visited RMIT University and University of Queensland nodes to work with CEED CIs on decision making in socio-ecological systems. This has facilitated links to the social sciences and the development of skills in this area within CEED. It has also resulted in two successful grant applications and two papers currently in preparation.

ARC funding was also provided for outgoing recipients, who had the opportunity to travel overseas to further their research. Jessie Wells, a Post-Doctoral Research Fellow from The University of Queensland, visited Indonesia and Spain through this grant. In March 2013, Dr Wells travelled to Indonesia to design a project on hydrological ecosystem services in relation to land use change in Borneo and visit government agencies involved in river basin planning; to continue studies of local perceptions of ecosystem services with CEED affiliate with Erik Meijaard, and to discuss ideas for research with colleagues at the Center for International Forestry Research. An ARC Linkage proposal has emerged from this interaction. She then joined CEED PhD student Rebecca Runting as participants in the inaugural International Spring University in Ecosystem Services Modelling at the Basque Centre for Climate Change Research (Bilbao, Spain), learning about and contributing to the development of the ARIES platform for modelling the flows of services from ecosystems to people.

EXTERNAL TRAINING DELIVERED BY CEED

Since CEED's inception we have placed a high value on providing training to researchers and environmental managers external to CEED.

For several years, we've been engaged in teaching people how to use the conservation planning software Marxan, and the concepts of systematic conservation planning that underpin it. We've developed teaching material, and run courses around the world. In 2013, CEED researchers' ran nine Marxan courses in Australia with a total of 165 students and 85 organisations involved. Our training endeavours are truly global with Marxan courses also being taught in 2013 in Germany and Chile.

During our Student Conference on Conservation Science (see page 69) we conducted short workshop courses in a range of software programs, decision theory, effective presentations and generalised linear modelling. We trained over 100 students from the pacific and beyond during this conference.

2014 CEED CONSERVATION LEADERSHIP TRAINING

As the importance of sound environmental decisions increases in today's world, so does the need for well-prepared and skilled leaders. In 2014, CEED will be developing an environmental conservation leadership training series for its research students and staff. The potential value of this type of training has been revealed by expressions of interest from our staff and students and the success of our leadership-focussed training sessions to date. At the 2013 CEED conference a small working group convened to commence scoping of the training series. A CEED leadership training program presents an opportunity to empower our graduates for high level or high impact positions within and beyond academia. We envisage that the training series will be introduced by a general module on leadership and will likely comprise up to four modules over a year, covering a diversity of topics such as meeting facilitation, public speaking, and negotiation skills. Participants will self-nominate for the training program and will be selected based on established criteria.

At a higher level, CEED is also seeking to foster the leadership skills of current and potential future leaders in the "business" of conservation, within and beyond our Centre. In 2014 we will begin to scope the content and structure of a high-level and collaborative conservation leadership training program that extends beyond academic modules and will be an important legacy of CEED. We envisage that this program will run as a joint program with an international academic institution with representation from developed and developing nations spanning the global North and South, and with partnerships from the corporate and philanthropic sectors. The program will also include a conservation mentoring program, engaging leaders in conservation from all sectors and reflecting gender and cultural diversity.

DR JESSIE WELLS, ARC ECR TRAVEL GRANT SCHEME RECIPIENT IN INDONESIA

Training and Mentoring

WORKSHOPS

One of the most productive ways we can engage with other researchers and with end users of our science is through workshops. These can vary from perhaps half a dozen people up to 30 people, for a day or two, or for a full week. The choice of invitees, number of invitees and length are determined by the topic. As well as creating closer working relationships with those that use our work, our workshops frequently produce collaborations, result in peer-reviewed journal articles, Decision Point stories, and even media releases.

Toward the end of 2012, nominations for workshops to be held in 2013 were called for from all CEED researchers, targeting in particular post-graduate students. The result was an increase in the number of workshops overall in 2013 compared to 2012 and 2011, and an increase in the number of international attendees to these workshops, as can be seen in Figure 1.

We were delighted to have participants from over 38 countries (see Figure 2) attend our workshops, demonstrating the international significance of our research, and CEED's emphasis on international outreach programs.

The workshop proposal process was repeated in 2013, with 21 proposals being accepted for workshops in 2014.

In 2013, it was also exciting to see the proportion of workshops that were led by Early Career Researchers (ECR) (Figure 3 below), demonstrating that personal mentoring, and opening up research opportunities, such as workshops and national and international travel, meant a greater number of ECR stepped up and led new programs of research.

Further to this, 52% of our workshops were collaborations across CEED nodes. These statistics are clear demonstrations of the strength of our work in and commitment to outreach through workshops. This also demonstrates our ongoing commitment to scientists in their early career years, across the many scientific disciplines our various nodes engage in. A full list of our workshops in 2013 is across in Table 1 on page 65.

OTHER EVENTS

Aside from workshops, CEED has an annual conference that brought us together in the one place (see CEED Biennial Conference on page 68). As well as having presentations by the researchers about their work, three training courses: Decision Theory, Marxan and INFFER software, and two workshops on giving effective presentations and using social methods in conservation science were offered. Julian Cribb, from Julian Cribb and Associates, also gave a presentation on science and the media.

In early 2013, CEED sponsored the Student Conference on Conservation Science (SCCS 2013), held at the University of Queensland. This conference brought over 100 students from the Asia/Pacific region together to learn, share and to form collegiate groups. Many of these students received a scholarship to attend, without which, they would never have been able to have this sort of experience. Full details can be found on page 69 of this report.

Our researchers also conducted a number of training courses, including Marxan Introduction and Train-The-Trainer, Bayesian networks introduction, Species Distribution Modelling and Structured Decision Making. These were open to all CEED researchers, and were conducted in number of places, including one in Chile. A full list of our other events for 2013 is in Table 2 on page 66.

Altogether, our workshops, conferences and training courses brought 763 researchers, decision makers and policy makers together throughout 2013. Countless collaborations were created, early career scientists were inspired, and over 100 enthusiastic students were empowered at the Student Conference for Conservation Science (page 69).

Training and Mentoring

FIGURE 1: NUMBER OF ATTENDEES AT WORKSHOPS

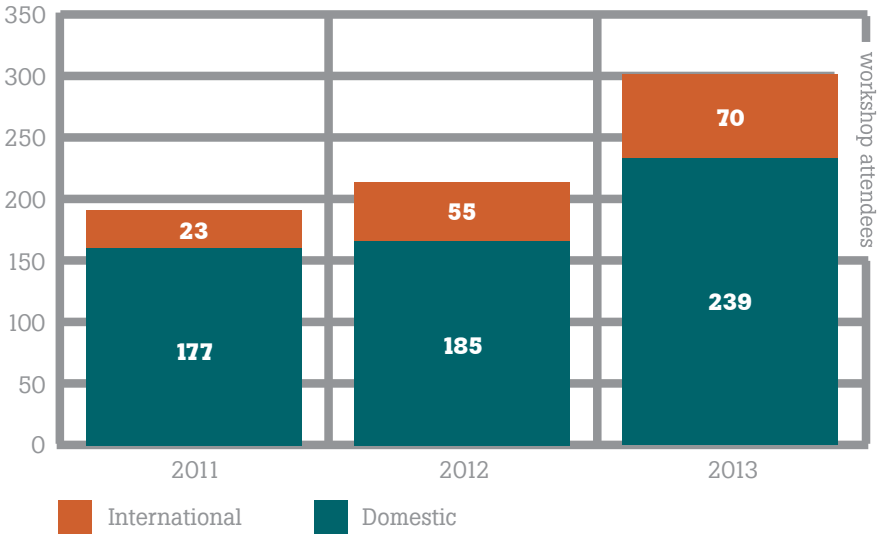
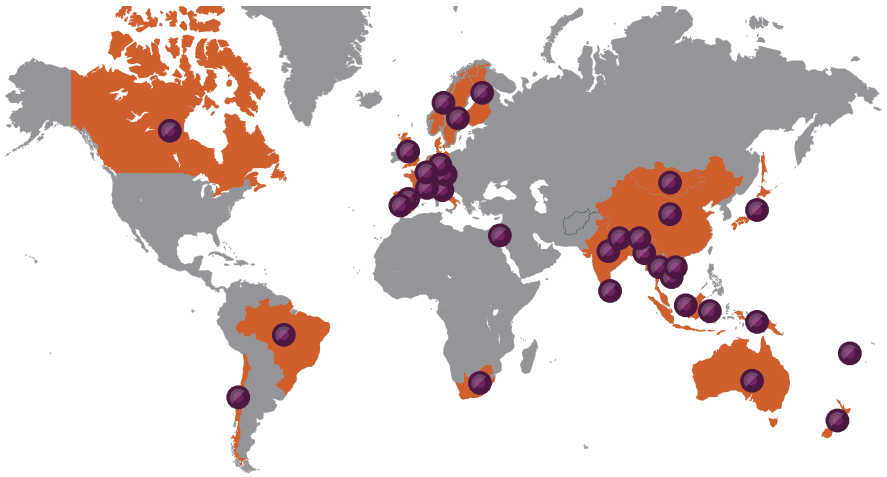


FIGURE 2: COUNTRIES OF ORIGIN OF INTERNATIONAL PARTICIPANTS AT CEED WORKSHOPS IN 2013



Training and Mentoring

FIGURE 3: WORKSHOPS LEAD BY CEED EARLY CAREER RESEARCHER

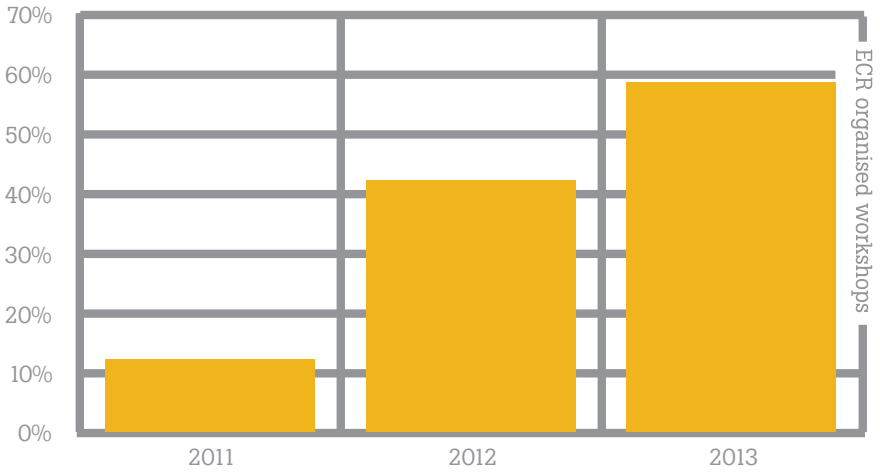
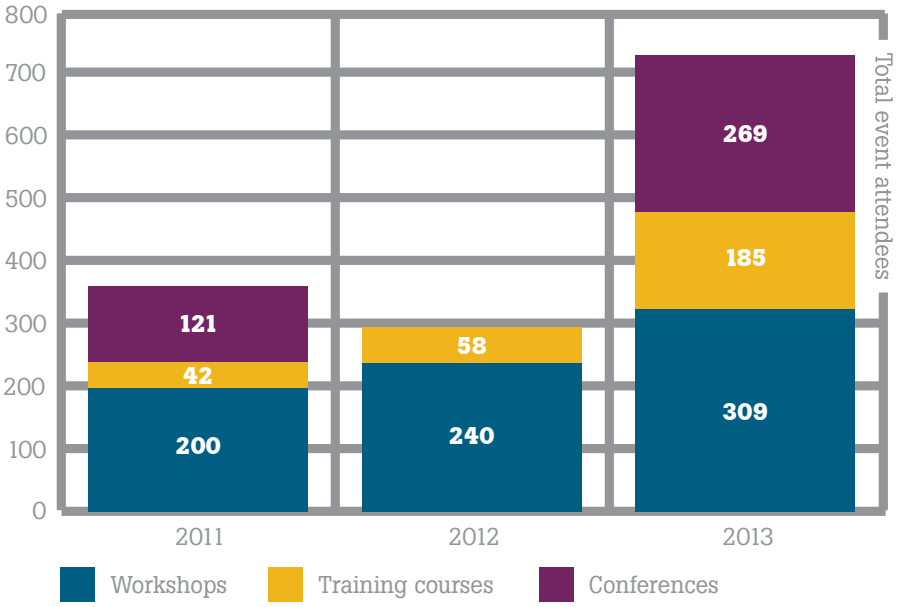


FIGURE 4: THE TOTAL NUMBER OF ATTENDEES AT CEED EVENTS IN 2013, BROKEN DOWN BY TYPE



Training and Mentoring

TABLE 1: CEED WORKSHOPS HELD DURING 2013

RESEARCH TOPIC	DATE
Taxonomic sufficiency in aquatic environmental assessment	4th-5th Feb
Evaluation and prioritisation of environmental research	27th Feb-5th Mar
Distribution and economics of restoring brigalow systems	2nd-5th Apr
Antarctic/arctic environmental challenges: commonalities, differences and shared lessons	7th-8th Feb
Incorporating social networks into conservation planning	13th Feb
The effectiveness of threatened species and ecological communities' protection in Australia	6th-10th Mar
Urban ecology workshop	15th-17th Apr
From conservation priority to opportunity	23rd-26th Apr
Reformulating the minimum viable population debate using decision theory	30th Apr
Indicators workshop	23rd Apr-3rd May
Critical review of indicators	6-9 May
International comparative evaluation of agri-environmental policies	7th June
Conservation decision making on private land	11th-14th June
International comparative evaluation of agri-environmental policies (2)	28th June
Extinction risks of frogs under climate change	1st-5th July
Reef resilience investment strategy expert workshop	3rd-4th July
Urban ecology workshop	9th July
Linking social networks to conservation decision making	21st July
USGS Patuxent lab visit and working group	29th July
Decision-making for the assisted migration of scrub jays on California islands	26th-28th Sep
Cumulative impact of stressors on Posidonia oceanica food web	2nd-4th Oct
Adaptation pathways for the Great Barrier Reef	9th Oct
CEED/Imperial College - ecological, social and economic factors for conservation decision-making: what should we learn about and when?	16th-18th Oct
Systematic conservation planning - spatial explicit incorporation of evolutionary processes	16th-18th Oct
Expert elicitation for cost effective flatback turtle conservation	28th Oct
Urban ecology workshop	31st Oct
Integrating bottom-up social processes into science-based conservation strategies	18th-21st Nov
Expert elicitation for cost effective flatback turtle conservation (2)	21st Nov
Trade-offs between the (co)-benefits of carbon farming	21st-22nd Nov
Marxan calibration workshop	27th Nov
Technical workshop on zoning with Marxan with Zones for Tun Mustapha Park	2nd-5th Dec
Meta-analysis of experimental tests of resilience to disturbance	9th-12th Dec
Borneo futures project workshop	10th-12th Dec

Training and Mentoring

TABLE 2: OTHER FORMALLY ORGANISED CEED EVENTS CONDUCTED IN 2013

EVENT TITLE	EVENT TYPE	CONDUCTED ON
Student conference on conservation science (see a detailed write up on this event on page 69 of this report)	Conference	21st Jan-1st Feb
EDG facilitation course	Training course	13th-15th Mar
Introduction to Bayesian networks short course	Training course	25th-27th June
Marxan train the trainer course	Training course	24th June
Introduction to Marxan course	Training course	25th-26th June
Marxan training course	Training course	29th-30th Aug
CEED Conference 2013	Conference	2nd-6th Sep
CEED training course on species distribution modelling	Training course	30th Sep-4th Oct
Training workshop on structured decision making	Training course	11th-15th Nov
Introduction to Marxan course	Training course	18th-20th Nov
Marxan train the trainer course	Training course	19th-20th Nov
Introduction to Marxan	Training course	16th-17th Dec

IMAGE DR ALVIN VAN NIEKERK

Training and Mentoring

TRADE-OFFS BETWEEN CARBON FARMING AND BIODIVERSITY - A CEED WORKSHOP (UNIVERSITY OF WESTERN AUSTRALIA, NOVEMBER 2013)

By Marit Kragt (UWA), Fleur Maseyk (UQ), Louise Blackmore (UWA)

Under the Carbon Farming Futures Programme, rural landholders have the potential to generate carbon credits through activities such as agroforestry, re-vegetation of land or changed agricultural practices. Each of these activities may have positive or negative effects beyond their intended mitigation of climate change (externalities or co-benefits).

For example, tree belts can have a positive impact on crop productivity in neighbouring fields, or native tree plantations can increase the availability of native habitat.

If carbon farming proposals are evaluated only on their carbon mitigation potential, there is a risk that management creates 'perverse' outcomes (eg, by supporting activities that have negative impacts on biodiversity). There are many, and often complex, costs and co-benefits that should be taken into account when assessing different carbon farming mitigation options. If we are looking to achieve multifunctional landscapes, we need to assess the carbon mitigation as well as the co-benefits of carbon farming. Unfortunately, there are still many gaps in our understanding about carbon sequestration, the co-benefits provided by carbon farming activities, and the tradeoffs between different impacts.

This workshop, set in the leafy grounds of the University of Western Australia, brought together various players working on this issue from around Australia. We aimed to create valuable collaborations and produce useful research outputs.

The workshop drew together ecologists, economists, social scientists, modellers, foresters, policy officers and carbon consultants; all sharing their insights on how farming for carbon and farming for biodiversity can be understood, measured and traded off.

The two days involved brief research presentations and stimulating discussions between the participants. The main themes that emerged from the discussions included the spatial mapping of co-benefits; appropriate mechanisms to incentivise biodiverse carbon farming; an examination of what we've learned from the various multispecies planting experiments across Australia; drivers and barriers of participating in carbon farming; the willingness to pay for the multiple benefits of carbon farming practices; defining metrics for measuring biodiversity and carbon values; avoided deforestation as a method to meet national carbon sequestration goals; and the potential role of insurance providers as important players in the voluntary carbon offset market.

Responding to these themes is challenging, not least because they require inter-disciplinary collaboration. Workshops like these are helpful to increase mutual understanding, and can help to develop a shared language required to progress inter-disciplinary research. We formed a number of multi-disciplinary teams that will each work on a theme.

Plans were drawn up on how each topic would be tackled over the coming months. In March 2014, there will be a follow-up workshop in Brisbane to further exchange ideas and enable the various projects to be written up.

A BREAK-OUT GROUP DISCUSSION DURING THE TRADE-OFFS BETWEEN CARBON FARMING AND BIODIVERSITY WORKSHOP. IMAGE BY JANE CAMPBELL

Training and Mentoring

CEED BIENNIAL CONFERENCE

Conference reflections - Dr Jonathan Rhodes (University of Queensland)

Unlike most conferences, where participants run from session to session to seek out the best talks, CEED's Biennial Conferences focus on the sharing of ideas as a group – ideas for future CEED work and innovative new ways of doing decision science. These opportunities to come together, share and reflect are crucial for generating interaction and links between all CEED members, both in Australia and overseas. Over 150 people attended the 2013 conference and the emphasis was on interaction and networking in an informal setting. Of course, we did have talks, but the emphasis was very much on creating a forum for sharing and discussion.

Two successful components of the conference were speed symposia and working groups. The speed symposia were clusters of three minute talks (focussed on a theme) followed by panel discussions. There was a distinct social science and economics flavour to many of the symposia, emphasising the strong multi-disciplinary nature of the environmental decision problems we work on.

The working groups were self-organising discussion groups on topics driven organically by the conference participants. They raised some excellent topics and we made progress in some really important areas, including: re-designing the CEED themes, how to be entrepreneurial, how to evaluate the value of a workshop, developing CEED communication strategies and discussions on a wide range of decision science topics.

We also had excellent plenary talks from Mark Burgman (The University of Melbourne), Martin Drechsler (Helmholtz Centre for Environmental Research) and Hugh Possingham (The University of Queensland). Mark explained how to make research work for government, Martin described a new approach for managing grasslands and Hugh told us that to be successful and have impact, we need to be bold and steal ideas from other disciplines.

The formal part of the conference was capped off by dinner at the Plough Inn and a fun debate about the merits, or not, of hunting and grazing in national parks. As you can imagine, this was a controversial topic.

The final two days were devoted to skills training and a field trip. Training workshops ranged from 'how to give a good presentation' to 'how to use social science in biodiversity conservation', a talk from science journalist Julian Cribb on mass media communication, and sessions on INFFER, Marxan and decision theory.

The field trip to Lamington National Park capped off the conference giving visiting researchers a firsthand view of the local biodiversity.

HUGH POSSINGHAM PRESENTS TO THE CEED BIENNIAL CONFERENCE

Training and Mentoring

STUDENT CONFERENCE ON CONSERVATION SCIENCE

Training the next generation of conservation scientists is imperative if we want to slow and hopefully halt current rates of decline in biodiversity. A network of Student Conferences on Conservation Science (SCCS) has been running in the Northern Hemisphere over the last 14 years with the aim of helping young conservation scientists gain experience, learn new ideas and make contacts that will be valuable for their future careers. Conferences have been run in England, China, USA and India.

We estimate that our region, from Burma to Fiji, contains one third of the world's terrestrial biodiversity and some of the most species rich oceans on the planet. The students of this region will be essential for generating the science to support the management of such a unique and fragile environment. However, many of the countries in Asia-Pacific have limited capacity to do the conservation research that is needed.

In Jan 2013, CEED, along with substantial financial support from The Thomas Foundation, ran the inaugural SCCS at the University of Queensland (http://www.sccs-aus.org/).

More than 100 students from 30 countries throughout the Asia-Pacific region travelled to Brisbane and over eleven days received training in ecology, conservation, decision science, GIS, communication and conservation economics, as well as having the opportunity to present at a conference. Perhaps even more importantly, they were given a platform to create a network of like-minded young researchers who will be their colleagues, peers and supporters in the future.

In Jan 2015 we plan to run this important event again and to support another group of up-and-coming scientists to continue the legacy of excellence in conservation science in this region. This will mean substantial planning and organisation in 2014.

The SCCS provided the added bonus of enabling more than twenty of our own CEED students to participate in several intensive workshops (see Table 3 below), and engage in the trials and tribulations of running a small international conference.

TABLE 3: TRAINING PROVIDED DURING THE 2013 STUDENT CONFERENCE ON CONSERVATION SCIENCE (SCCS)

SCCS WORKSHOPS	
1.	Basic R (Will Morris and John Baumgartner, The University of Melbourne)
2.	Bayesian Statistics (Prof Michael McCarthy & Prof Brendan Wintle, The University of Melbourne)
3.	Decision Theory (Dr Terry Walshe, The University of Melbourne)
4.	Designing Poster Presentations (Arthur Riedel, The University of Queensland)
5.	Effective talks and presentations (David Salt, Editor, Decision Point Magazine)
6.	Generalised Linear Models (Dr Yvonne Buckley, The University of Queensland)
7.	Introduction to GIS [Geographic Information Systems] (Dr Hawthorne Beyer, The University of Queensland)
8.	Marxan (Matt Watts, The University of Queensland)
9.	Media Skills (Caroline McFarlane, Wentworth Group of Concerned Scientists)
10.	Role of Scientist in Society (Max Bourke, The Thomas Foundation)
11.	Scientific writing (Dr Patrick O'Connor, The University of Adelaide)
12.	Spatial Conservation Planning (Dr Carissa Klein, The University of Queensland)
13.	Stakeholder Engagement (Dr Eddie Game, The Nature Conservancy)
14.	Using Socioeconomic Information (Dr Josie Carwardine, CSIRO Ecosystem Sciences)
15.	Writing Grant Proposals (Dr Hugh Possingham, The University of Queensland)

Training and Mentoring

A SUMMER CAMP WITH EDGE - REFLECTIONS ON THE 2013 SCCS EXPERIENCE

By Michelle Venter (James Cook University attendee)

Can you imagine a hundred keen post graduate students from 30 countries gathered in one place for ten days of talks, workshops and exchange forums? To me, it was reminiscent of a pleasant summer camp experience, a bubble in time where you learn new skills, form lasting friendships and grow as a person. By the end, you find yourself exhausted and happy to return home, but still wishing it could have lasted a bit longer.

So far in my PhD, I have participated in a half dozen conservation and ecology conferences. Unlike the rest, the Student Conference on Conservation Science hosted by UQ in Brisbane in Jan 2013 was the first one designed specifically "for post-graduate students only". With this in mind, I honestly didn't know what to expect.

Shortly after arriving I discovered, to my surprise, more than a dozen other students at the conference were working on very similar topics to mine. These young experts from all over the South East Asia and the Pacific were actively involved with REDD+, a policy mechanism that aims to providing incentives for reducing emission from forest loss while improving forestry practice, conservation and local livelihoods.

The students working on REDD+ issues came from Myanmar, Cambodia, Nepal, Indonesia, Philippines, Fiji, Papua New Guinea and Canada; with bachelors ranging from ecology, forestry, law and biology. Although we came from different places and backgrounds, we soon discovered that we had many things in common.

All of us had spent some time working in remote resource-dependent communities and all of our projects were necessarily interdisciplinary, encompassing elements of conservation science, policy, landholder values and forest management.

Nearing the conference's close, in a session called 'Birds of a Feather', delegates aggregated into groups to discuss a topic of their choice. We quickly formed a REDD+ group as a formal way for us to share our experiences of common barriers in our work, of which we soon discovered there were many. However, early in the discussion things moved from doom-and-gloom to a focus on constructive opportunities for REDD+. We shared lessons learnt, our future work plans and our common interests.

We came to a consensus that in the long run, REDD+ has potential to achieve important climate and conservation outcomes. We also agreed that for these global objective to be met, a holistic approach to REDD+ was the key, whereby meeting the objective of local communities engaged in sustainable resource management. Our discussions revitalised us and I left with greater confidence about my research goals.

These ten days at the University of Queensland were more than just a conference. In the second week, we enjoyed four days of workshops in which we had the opportunity to choose from sixteen skills-based tutorials lead by experts in a variety of fields. Some of the workshops were on different forms of communication including scientific writing, oral presentations and media skills. Others were more focussed on science skills and environmental decision.

SCCS CONFERENCE PARTICIPANTS, MICHELLE VENTER 2ND FROM LEFT

Training and Mentoring

A WIN FOR REGIONAL BIODIVERSITY CONSERVATION

By Prof Hugh Possingham, Convenor of the 2013 SCCS

The SCCS exceeded my expectations. We brought together students from throughout the region and I know that among their ranks will be some of tomorrow's heavy hitters in the arena of conservation science. I hope that when some of these high achievers look back over their career paths that they will see this student conference as having been an important stepping stone.

It was also a special event because, while we used a template that has been tested in other places like Cambridge University, this is the first time such an operation has been run in the southern hemisphere. That it worked so well is testament to almost 60 enthusiastic volunteers and organisers mainly based here at the University of Queensland (with considerable input from members of CEED).

We're proud of what we've achieved and I think Australia as a nation should acknowledge the importance of events such as these. Australia needs to shoulder its responsibility more when it comes to biodiversity conservation in the region (much as we rightly shoulder regional responsibilities with respect to human rights and health). I estimate that somewhere between Burma and Fiji, taking in Brisbane on the way, there are about a third of all terrestrial species on the planet packed into 10% of the world's land. And if we dive into the marine realm, the Coral Triangle, which lies the middle of that broad transect, has no parallel on the land in terms of the richness of its marine biodiversity. Yet many of the countries in our region have limited capacity to do the conservation research they need to. Training and skills in ecology, conservation, GIS, communication and conservation economics is absent or limited. The SCCS is one small action we can take as a nation to help redress this situation, but it's only a start.

So, well done Team SCCS – organisers and participants. May this be the first step in a longer journey that sees our region's best and brightest students working more effectively together to tackle the enormous challenges of conserving our precious biodiversity.

SCCS PARTICIPANTS WALKING AT LAMINGTON NATIONAL PARK

HUGH POSSINGHAM PRESENTING AWARDS FOR STUDENT TALKS

OUTREACH AND COMMUNICATION

CEED acknowledges that meaningful conservation outcomes require real engagement between our research and a broad range of stakeholders. These stakeholders include other conservation scientists, policy makers, NGOs, graduate students and the general public. Consequently, CEED puts considerable effort into its outreach activities. Building relationships with each of our stakeholder groups has involved multiple and overlapping strategies that include media releases, a dedicated general access research magazine (Decision Point), public talks, workshops, training courses, a major international conference, scientific publications, a functional and flexible web site (upgraded in 2013) and numerous meetings with end users.

Outreach and Communication

MEDIA

In 2013 we continued to engage with the general public via a highly successful media strategy. During the year we coordinated 10 media releases on CEED's emerging research. The uptake from these releases was excellent, resulting in 930 unique media stories. A few examples are highlighted below. This coverage was magnified through syndication, where a single unique story is re-printed or re-broadcast multiple times on subsidiary networks (eg repeated across ABC Radio networks). We therefore had a total of 2,400 reports across print, radio, internet and television throughout 2013. As can be seen in Figure 1 below, our total reports have increased substantially in 2013 due to a large increase in articles reported on the internet.

HEADLINE STORIES

RHINO CONSERVATION

Two media releases in Mar 2013 "Scientists call for legal trade in Rhino Horn", and "Could legally trading horn save the Rhino?", based on research published in *Science* by CEED Post Doctoral fellow, Dr Duan Biggs, generated a massive media response, particularly in the international press. This topic generated 351 separate media stories and over 400 reports world wide, with a potential audience of 730,854 people in 2013, and continues to do so into 2014, particularly through internet media.

Dr Biggs, a CEED early career researcher, followed up on the press release with many public talks about the topic. One of these was filmed and broadcast on our CEED YouTube channel, and was instrumental in him being invited to present in London at The Big Earthwatch Debate 2013: Bone of Contention (http://au.earthwatch.org/events/2013/09/30/the-big-earthwatch-debate-2013-bone-of-contention).

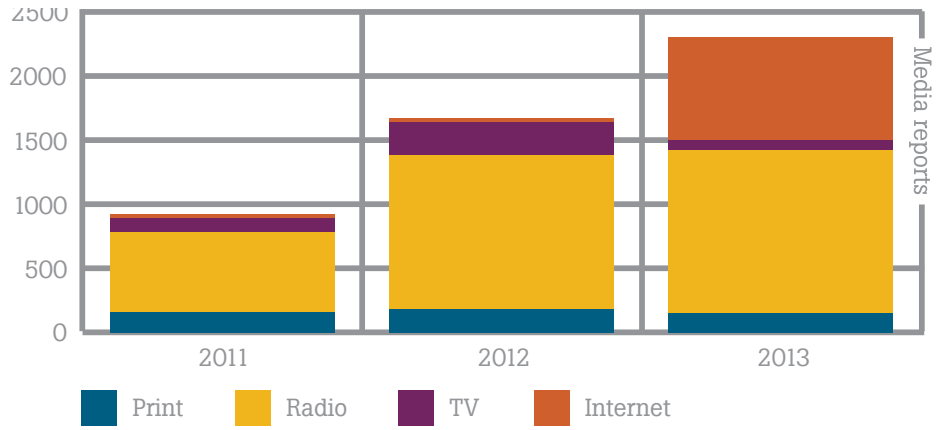
The true potential audience for this research is immense, and demonstrates the international significance of CEED research, and the immense and varied audience our media is reaching.

CLOSING THE GAP BETWEEN CONSERVATION AND COMMUNITIES

CEED Post Doctoral Research Fellow and early career researcher, Dr Carissa Klein put out a media release about a methodology she helped develop that enables governments to balance the needs of society and industry with conservation.

This generated 222 media articles, with a potential audience of 298,573 through print media, and further tens of thousands of listeners through broadcasting on 75 radio stations across Australia.

FIGURE 1: CEED MEDIA COVERAGE BY MEDIA TYPE



Outreach and Communication

MEDIA STORIES: A FEW EXAMPLES OF THE VARIETY OF STORIES AND MEDIA ENTITIES INTERESTED IN OUR WORK.

King Island Courier, Monitoring endangered species to death, 27 Nov 2013, Brendan Wintle, audience circulation - 1200.

China.org.cn, Fossil fuel's double whammy' to wildlife, 25 Oct 2013, Hugh Possingham.

The Business Spectator, Managing Australia's animal migration, 12 Oct 2013, Eve McDonald-Madden.

The Australian, Seagrass may slow climate change, 25 Sep 2013, Megan Saunders, audience circulation – 116,655.

ABC Radio, Ecologists have suggested that churches are pivotal in getting the message out about trying to preserve remnant ecology, 5 Sep 2013, Hugh Possingham, AM Radio.

Australasian science, Grieving for the Past, Hoping for the Future, 1 Sep 2013, Richard Hobbs, audience circulation – 9,000.

Scoop, ASPIRE winner balances ocean conservation and socioeconomics, 2 July 2013, Carissa Klein, online.

Science Alert, New tool helps plan greener cities, 29 April 2013, Jessica Sushinsky, online with 5,157,643 followers.

Science Alert, Smart plans for sustainable development, 27 Mar 2013, Carissa Klein, online with 5,157,643 followers.

ABC Radio, Australia's coastal wetlands 'need room to move', 15 Jan 2013, Jonathan Rhodes.

WEB PAGE

In the last quarter of 2013, the CEED web site underwent a total redesign to improve navigation, functionality and the aesthetic appeal of the site. In addition to improving the main CEED website, separate websites were established for our magazine Decision Point and the Student Conference on Conservation Science (SCCS), run in January of 2013. This was done for simplicity and longevity (as Decision Point and the SCCS are also connected to other collaborators) however these activities were still strongly linked to CEED.

The CEED Publications Directory was substantially upgraded, allowing better access and search facilities for CEED, and other relevant, publications.

And, finally, a CEED twitter account was created in 2013, and a twitter feed added to the web site. Several CEED researchers (including Hugh Possingham and Michael McCarthy) have been experimenting with social media over the past year and have become regular tweeters (well over 1000 followers each).

DECISION POINT

Decision Point continues to be our key tool in communicating our science to consultants, other scientists, policy makers, environmental managers, NGOs and members of the general public. Ten issues of Decision Point were published between Feb and Nov 2013. There are now over 5300 subscribers to Decision Point, an increase of a further 1000 subscribers since 2012. The Decision Point web site had 71,416 hits, an increase of 40% above 2012.

Twenty six percent of our readership continues to be from outside Australia giving both CEED and environmental decision science in general an international presence. We have had several enquiries from institutions overseas about how we produce Decision Point but, to the best of our knowledge, no-one has yet been able to produce a research magazine on environmental decision science of similar quality or reach. We are currently investigating the production of a Spanish language issue.

Outreach and Communication

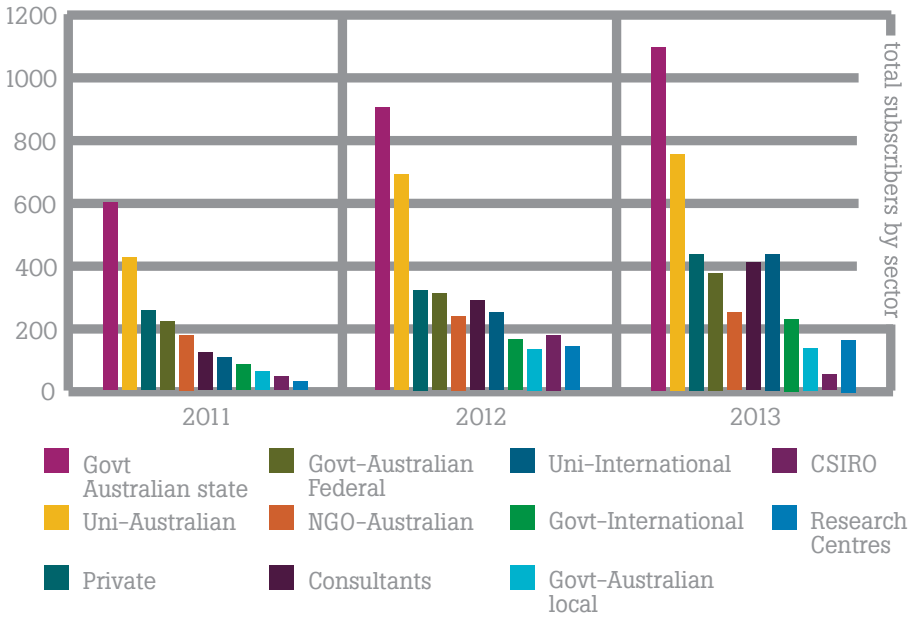
SUBSCRIBERS BY SECTOR

The number of subscribers to Decision Point in every sector has grown in 2013, with particularly strong growth in subscribers from overseas universities reflecting CEED's broadening reach. Figure 2 below shows the growth in each sector across the two and a half years CEED has been operational.

FUTURE DEVELOPMENTS

In 2014, a new format for presenting Decision Point stories will be trialled – a blog where every story will be a new entry. This should provide easier access for readers with mobile devices and also provide a way for readers to enter into dialogue about each story.

FIGURE 2: DECISION POINT SUBSCRIBERS, BY SECTOR.



Outreach and Communication

COMMENTARY ABOUT DECISION POINT - 2013

"I want to pass on how much myself and the team enjoy reading Decision Point. We find it not only useful as apply information to get on-ground outcomes (environmental rehabilitation and restoration projects) but also feel inspired by the dedicated research occurring that keeps knowledge up to date."

Mia, Dragonfly Environmental

"Thanks for consistently filling your publication with interesting, frank and creative discussions. The reading material is appreciated."

Jenni, BAAM Ecological Consultants

"I always find time to read D-Point when it arrives (or shortly thereafter) and this one will be no exception."

Judy, Community Solutions, Sydney

"I had a read of the draft decision point newsletter last night. Some super interesting stuff around species traits which we need to look into further."

Tim, Species Information Section, DSEWPAC

"I've been intending to contact you for some time to say how much my colleagues and I at ACT Conservation Planning and Research enjoy Decision Point. In particular the series of articles by Brendan Wintle summarising some of the fundamental conservation tools was read avidly by our group. It's great to have the considerations underpinning some of our core conservation tools outlined clearly in one place. As I'm sure you are aware, Agency staff rarely have time to conduct extensive reviews of the current literature relating to all our conservation planning and management activities. Consequently it's of great befit being able to tap into the current best practice approaches and ideas emerging from academia."

Julian, Senior Ecologist, Environment and Sustainable Development, ACT Government

"I'm just emailing to say your article in the latest Decision Point was forwarded to me and it's absolutely fantastic! The underlying theme of all my research is reconnecting conservation to ecological processes (which we often seem to have forgotten about), so of course I loved it, but it was so elegantly written and to the point."

Veronica, Senior Research Scientist, CSIRO Ecosystem Sciences

"I just read your article in Decision Point, and will forward it to our fire management staff in western NSW. Thank you for such a well written article that provides some sensible management options. Improving knowledge in this field is always valuable."

Belinda, Fire Science Interpretation Officer, NSW National Parks & Wildlife Service

DECISION POINT
Connecting conservation policy makers, researchers and practitioners

OUTPUTS AND OUTCOMES

Outputs and Outcomes

PUBLICATIONS

Publications are part of our permanent legacy to advance global knowledge. Publishing in publicly indexed outlets (mainly journals and books) of high quality is core business. The number of publications produced by CEED increased substantially in 2013, from 120 to 182. This compares favourably with similar ARC Centres of Excellence after equivalent years of operation, especially given our relative amount of funding.

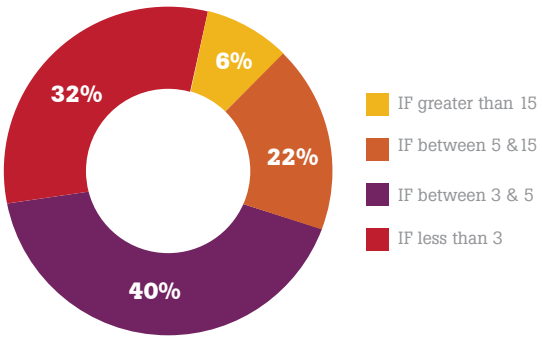
Interaction is the key to our success and we are glad to report that one-fifth of papers were co-authored by researchers from more than one node, a fraction we hope to grow. Equally important is our interactions with the global research community and our overseas partner investigators. Of all 182 publications, 54% were co-authored by researchers with an overseas address.

The impact factor (IF) of an academic journal is a measure reflecting the average number of citations to recent articles published in the journal. Figure 7 below shows the distribution of CEED papers across four IF categories. Notably, of 40 "Biodiversity Conservation" journals in the world only 7.5% have an impact factor over 5, and of 136 "Ecology" journals only 12% had an impact factor over 5 compared to the fact that over a quarter of our papers were published in these high impact journals.

When our publication output, including impact factor category, is compared across years (Figure 8 below), it is evident that we are not only increasing the number of publications per year, but we are continuing to publish in high impact journals.

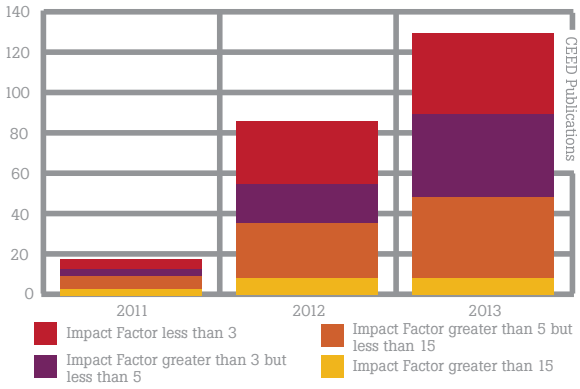
Whilst publications are key to making our research available for use by scientists and conservation managers, they are also important to the professional development of our Early Career Researchers (ECRs) and promote networking across our research institutions. We are pleased that 49% of our publications include ECRs, including 85 journal articles. Of the 85 journal articles published in 2013 involving ECRs, 61% (52/82) were led by ECRs. Of these journal article publications led by ECRs, 25% (13/52) have an impact factor of greater than 5. This demonstrates that not only is CEED publishing well, but that our brightest and best early career scientists are producing leading world class outputs.

FIGURE 7: PUBLICATIONS BY IMPACT FACTOR (IF) CATEGORY.



10% of all publications are marked as N/A as Thomson Reuters Web of Science has not yet assigned an impact factor. Further, books and book chapters are also not allocated an IF, so are not included.

FIGURE 8: CEED PUBLICATIONS BY IMPACT FACTOR*



**Note that books, book chapters, conference proceedings, reports and some journals do not have an impact factor and are not included in these figures.*

Outputs and Outcomes

LIST OF PUBLICATIONS

BOOKS (1)

1. Hobbs RJ, ES Higgs and C Hall (Eds.) (2013) Novel Ecosystems: Intervening in the New Ecological World Order. John Wiley & Sons, USA. 380pp.

BOOK CHAPTER (12)

2. Hallett LM, RJ Standish, KB Hulvey, MR Gardener, KN Suding, BM Starzomski, SD Murphy, JA Harris and CR Nelson (2013) Towards a conceptual framework for the management of novel ecosystems. In: RJ Hobbs, ES Higgs and CM Hall (Eds.) *Novel Ecosystems: Intervening in the new ecological world order*. Wiley-Blackwell, UK
3. Harvie BA and RJ Hobbs (2013) Case Study: Shale "bings" in Central Scotland: from ugly blots on the landscape to cultural and biological heritage Pp. 286-289 in: RJ Hobbs, ES Higgs & CM Hall (Eds.) *Novel Ecosystems: Intervening in the new ecological world order*. Wiley, Oxford.
4. Hobbs RJ, ES Higgs and CM Hall (2013) Defining novel ecosystems. p58-60 in: Hobbs, R.J., Higgs, E.S. & Hall, C.M. (Eds.) *Novel Ecosystems: Intervening in the new ecological world order*. Wiley, Oxford
5. Hobbs RJ, ES Higgs and CM Hall (2013) Introduction: why novel ecosystems? Pp. 3-8 In: RJ Hobbs, ES Higgs, CM Hall (Eds.) *Novel Ecosystems: Intervening in the new ecological world order*. Wiley, Oxford.
6. Hobbs RJ, ES Higgs and CM Hall (2013) What do we know about, and what do we do about, novel ecosystems? Pp. 353-360 in: RJ Hobbs, ES Higgs & CM Hall (Eds.) *Novel Ecosystems: Intervening in the new ecological world order*. Wiley, Oxford.
7. Hulvey KB, RJ Standish, LM Hallett, BM Starzomski, KN Suding, SD Murphy, CR Nelson, MR Gardener, P Kennedy and T Seastedt (2013) Incorporating novel ecosystems into management frameworks. In: *Novel Ecosystems: Intervening in the new ecological world order*. RJ Hobbs, ES Higgs and CM Hall (Eds.). Wiley-Blackwell, UK
8. Kennedy PL, L Lach, AE Lugo and RJ Hobbs (2013) Fauna and novel ecosystems. p. 148-122 in: RJ Hobbs, ES Higgs and CM Hall (Eds.) *Novel Ecosystems: Intervening in the new ecological world order*. Wiley, Oxford
9. Knight AT, ASL Rodrigues, N Strange, T Tew and KA Wilson (2013) Designing effective solutions to conservation planning problems. Pages 362-383 in DW MacDonald and Katherine J Willis, Eds. *key Topics in Conservation Biology 2*. John Wiley & Sons. Ltd
10. Mackey B, HP Possingham and S Ferrier (2013) Connectivity conservation principles for Australia's National Wildlife Corridors. *Linking Australia's Landscapes: Lessons and Opportunities From Large-Scale Conservation Networks* 233-243
11. McCarthy MA and HP Possingham (2013) Population Viability Analysis IN: SEl-Shaarawi AH and W Piegorsch (Eds.), *Encyclopedia of Environmetrics*, John Wiley & Sons Ltd. Chichester UK
12. Perring MP, P Manning, RJ Hobbs, AE Lugo, CE Ramalho and RJ Standish (2013) Novel urban ecosystems and ecosystem services. Pp. 310-325 in: RJ Hobbs, ES Higgs & CM Hall (Eds.) *Novel Ecosystems: Intervening in the new ecological world order*. Wiley, Oxford.
13. Standish RJ, A Thompson, ES Higgs and SD Murphy (2013) Concerns about novel ecosystems. In: RJ Hobbs, ES Higgs & CM Hall (Eds.) *Novel Ecosystems: Intervening in the new ecological world order*. Wiley-Blackwell, UK

JOURNAL ARTICLE (160)

Impact Factor greater than 15 (8)

14. Banks SC, GH Cary, AL Smith, ID Davies, DA Driscoll, AM Gill, DB Lindenmayer and R Peakall (2013) How does ecological disturbance influence genetic diversity? *Trends In Ecology & Evolution* 28(11):670-679
15. Biggs D, F Courchamp, R Martin and HP Possingham (2013) Legal Trade of Africa's Rhino Horns. *Science* 399(6123):1038-1039
16. Biggs D, F Courchamp, R Martin and HP Possingham (2013) Rhino Poaching: Apply Conservation Psychology Response. *Science* 340(6137):1168-1169
17. Butt N, HL Beyer, JR Bennett, D Biggs, R Maggini, M Mills, AR Renwick, LM Seabrook and HP Possingham (2013) Biodiversity Risks from Fossil Fuel Extraction. *Science* 342:425-426

Outputs and Outcomes

18. Driscoll DA, SC Banks, PS Barton, DB Lindenmayer and AL Smith (2013) Conceptual domain of the matrix in fragmented landscapes . *Trends In Ecology & Evolution* 28(10):605-613

19. Guisan A, R Tingley, JB Baumgartner, I Naujokaitis-Lewis, PR Sutcliffe, AIT Tulloch, TJ Regan, L Brotons, E McDonald-Madden, C Mantyka-Pringle, TG Martin, JR Rhodes, R Maggini, SA Setterfield, J Elith, MW Schwartz , BA Wintle, O Broennimann, M Austin, S Ferrier, MR Kearney, HP Possingham and YM Buckley (2013) Predicting species distributions for conservation decisions. *Ecology Letters* 16(12):1424-1435

20. Lindenmayer DB and HP Possingham (2013) No Excuse for Habitat Destruction. *Science* 340(6133):680-680

21. Menz MHM, KW Dixon and RJ Hobbs (2013) Hurdles and Opportunities for Landscape-Scale Restoration. *Science* 399(6119):526-527

Impact Factor greater than 5 but less than 15 (28)

22. Addison PFE, L Rumpff, S Sana Bau, JM Carey, YE Chee, FC Jarrad, MF McBride and MA Burgman (2013) Practical solutions for making models indispensable in conservation decision-making. *Diversity and Distributions* 19:490-502

23. Almany GR, RJ Hamilton, M Bode, M Matawai, T Potuku, P Saenz-Agudelo, S Planes, ML Berumen, KL Rhodes, SR Thorrold, GR Russ and GP Jones (2013) Dispersal of Grouper Larvae Drives Local Resource Sharing in a Coral Reef Fishery. *Current biology* 23:626-630

24. Bennett JR (2014) Comparison of native and exotic distribution and richness models across scales reveals essential conservation lessons. *Ecography* 37(2):120-129

25. Beyer HL, J Morales, D Murray and MJ Fortin (2013) The effectiveness of Bayesian state-space models for estimating behavioural states from movement paths. *Methods In Ecology and Evolution* 4(5):433-441

26. Bode M, KEC Brennan, K Helmstedt, A Desmond, R Smia and D Algar (2013) Interior fences can reduce cost and uncertainty when eradicating invasive species from large islands. *Methods In Ecology and Evolution* 4:819-827

27. Bull JW, KB Suttle, NJ Singh and EJ Milner-Gulland (2013) Conservation when nothing stands still: moving targets and biodiversity offsets. *Frontiers In Ecology and the Environment* 11:203-210

28. Crase B, A Liedloff, PA Vesk, MA Burgman and BA Wintle (2013) Hydroperiod is the main driver of the spatial pattern of dominance in mangrove communities. *Global Ecology and Biogeography* 22(7):806-817

29. Cunningham RB , DB Lindenmayer, M Crane, DR Michael, PS Barton, P Gibbons, S Okada, K Ikin and JAR Stein (2013) The law of diminishing returns: woodland birds respond to native vegetation cover at multiple spatial scales and over time. *Diversity and Distributions* 20:59-71

30. Dudaniec RY, JR Rhodes, J Worthington Wilmer, KE Lee, M Lyons, F Carrick and CA McAlpine (2013) Using multi-level models to identify drivers of landscape genetic structure among management areas. *Molecular Ecology* 22(14):3752-3765

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33. Heard GW, MA McCarthy, MP Scroggie, JB Baumgartner and KM Parris (2013) A Bayesian model of metapopulation viability, with application to an endangered amphibian. *Diversity and Distributions* 19(5-6):555-566

34. Hester SM, OJ Cacho, FD Panetta and CE Hauser (2013) Economic aspects of post-border weed risk management. *Diversity and Distributions* 19 (5-6):580-589

Outputs and Outcomes

35. Hulvey KB, RJ Hobbs, RJ Standish, DB Lindenmayer, L Lach and MP Perring (2013) Benefits of tree-mixes in carbon plantings. *Nature Climate Change* 3:869-874

36. Iwamura T, A Guisan, KA Wilson and HP Possingham (2013) How robust are global conservation priorities to climate change? *Global Environmental Change-Human and Policy Dimensions* 23(5):1277-1284

37. Iwamura T, HP Possingham, I ChadÞs, C Minton, NJ Murray, DI Rogers, EA Treml and RA Fuller (2013) Migratory connectivity magnifies the consequences of habitat loss from sea-level rise for shorebird populations. *Proceedings of the Royal Society B-Biological Sciences* 280(1761)

38. Lindenmayer DB, MP Piggott and BA Wintle (2013) Counting the books while the library burns: why conservation monitoring programs need a plan for action. *Frontiers In Ecology and the Environment* 11:549-555

39. Mazor T, HP Possingham and S Kark (2013) Collaboration among countries in marine conservation can achieve substantial efficiencies. *Diversity and Distributions* 19:1380-1393

40. Murray KA, LDV Arregoitia, A Davidson, M Marco and MMI Di Fonzo (2013) Threat to the point: improving the value of comparative extinction risk analysis for conservation action. *Global Change Biology* 20(2):483-494

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44. Seabloom EW, ET Borer, Y Buckley, EE Cleland, K Davies, J Firn, WW Harpole, Y Hautier, E Lind, A Macdougall, JL Orrock, SM Prober, P Adler, J Alberti, TM Anderson, JD Bakker, LA Biederman, D Blumenthal, CS Brown, LA Brudvig, M Caldeira,C Chu, MJ Crawley, P Daleo,, EI Damschen, CM D'Antonio, NM Decrappeo, CR Dickman, G Du, PA Fay, P Frater, DS Gruner, N Hagenah, A Hector, A Helm, H Hillebrand, KS Hofmockel, HC Humphries, O Iribarne, VL Jin, A Kay, KP Kirkman, JA Klein, JMH Knops, KJ La Pierre, LM Ladwig, JG Lambrinos, ADB Leakey, Q Li, W Li, R Mcculley, B Melbourne, CE Mitchell, JL Moore, J Morgan, B Mortensen, LR O'Halloran, M Paertel, J Pascual, DA Pyke, AC Risch, R Salguero-Gomez, M Sankaran, M Schuetz, A Simonsen, M Smith, X Stevens, L Sullivan, GM Wardle, EM Wolkovich, PD Wragg, J Wright, L Yang (2013) Predicting invasion in grassland ecosystems: is exotic dominance the real embarrassment of richness? *Global Change Biology* 19(12):3677-3687

45. Sushinsky J, JR Rhodes, HP Possingham, TK Gill and RA Fuller (2013) How should we grow cities to minimize their biodiversity impacts? *Global Change Biology* 19(2):401-410

46. Sutcliffe PR, C Mellin, CR Pitcher, HP Possingham and MJ Caley (2013) Regional-scale patterns and predictors of species richness and abundance across twelve major tropical inter-reef taxa. *Ecography* 37(2):162-171

47. van Rensburg BJ, S Hugo, N Levin and S Kark (2013) Are environmental transitions more prone to biological invasions? *Diversity and Distributions* 19(3):341-351

48. Watson J, T Iwamura and N Butt (2013) Mapping vulnerability and conservation adaptation strategies under climate change. *Nature Climate Change* 3:989-994

49. Wintle BC, F Fidler, PA Vesk and JL Moore (2013) Improving visual estimation through active feedback . *Methods In Ecology and Evolution* 4:53-62

Impact Factor greater than 3 but less than 5 (61)

50. Beyer HL, R Ung, DL Murray and MJ Fortin (2013) Functional responses, seasonal variation and thresholds in behavioural responses of moose to road density. *Journal of Applied Ecology* 50(2):286-294

Outputs and Outcomes

51. Brown CJ, MI Saunders, HP Possingham and AJ Richardson (2013) Managing for Interactions between Local and Global Stressors of Ecosystems. *PLoS One* 8(6):e65765

52. Bruton MJ, CA McAlpine and M Maron (2013) Regrowth woodlands are valuable habitat for reptile communities. *Biological Conservation* 165:95-103

53. Burgess S, M Bode and D Marshall (2013) Costs of dispersal alter optimal offspring size in patchy habitats: combining theory and data for a marine invertebrate. *Functional Ecology* 27(3):757-765

54. Butt N, E Slade, J Thompson, Y Malhi and T Riutta (2013) Quantifying the sampling error in tree census measurements by volunteers and its effect on carbon stock estimates. *Ecological Applications* 23(4):936-943

55. Canessa S and K Parris (2013) Multi-scale, direct and indirect effects of the urban stream syndrome on amphibian communities in streams. *PLoS One* DOI: 10.1371/journal.pone.0070262

56. Caplat C, PO Cheptou J Diez, A Guisan, BMH Larson, AS Macdougall, DA Peltzer, DM Richardson, K Shea, M van Kleunen, R Zhang and YM Buckley (2013) Movement, impacts and management of plant distributions in response to climate change: insights from invasions. *Oikos* 122 (9):1265-1274

57. Catford JA, RJ Naiman, LE Chambers, J Roberts, M Douglas and P Davies (2013) Predicting Novel Riparian Ecosystems in a Changing Climate. *Ecosystems* 16(3):382-400

58. Cook CN, HP Possingham, RA Fuller (2013) Contribution of Systematic Reviews to Management Decisions. *Conservation Biology* 27(5):902-915

59. Cook CN, MB Mascia, MW Schwarts, HP Possingham and RA Fuller (2013) Achieving Conservation Science that Bridges the Knowledge–Action Boundary. *Conservation Biology* 27(4):669-678

60. Coutts SR, H Yokomizo and YM Buckley (2013) The behavior of multiple independent managers and ecological traits interact to determine prevalence of weeds. *Ecological Applications* 23:523-536

61. Craft ME, HL Beyer and DT Haydon (2013) Estimating the Probability of a Major Outbreak from the Timing of Early Cases: An Indeterminate Problem? *PLoS One* 8(3):e57878

62. Cvitanovic C, SK Wilson, CJ Fulton, GR Almany, P erson, RC Babcock, NC Ban, RJ Beeden, M Beger, J Cinner, K Dobbs, LS Evans, A Farnham, KJ Friedman, K Gale, W Gladstone, Q Grafton, NAJ Graham, S Gudge, PL Harrison, TH Holmes, N Johnstone, GP Jones, A Jordan, AJ Kendrick, CJ Klein, LR Little, HA Malcolm, D Morris, HP Possingham, J Prescott, RL Pressey, GA Skilleter, C Simpson, K Waples, D Wilson and DH Williamson (2013) Critical research needs for managing coral reef marine protected areas: Perspectives of academics and managers. *Journal of Environmental Management* 114:84-91

63. Davis JT, K Mengersen, NK Abram, M Ancrenaz, JA Wells and E Meijaard (2013) It's Not Just Conflict That Motivates Killing of Orangutans. *PLoS One* 8(10):0075373

64. Duncan DH and PA Vesk (2013) Examining change over time in habitat attributes using Bayesian reinterpretation of categorical assessments. *Ecological Applications* 23:1277-1287

65. Game ET, E Meijaard, D Sheil and E McDonald-Madden (2013) Conservation in a wicked complex world; challenges and solutions. *Conservation Letters* DOI: 10.1111/conl.12050

66. Game ET, JA Fitzsimons, G Lipsett-Moore and E McDonald-Madden (2013) Subjective risk assessment for planning conservation projects. *Environmental Research Letters* 8(4):045027

67. Game ET, P Kareiva and HP Possingham (2013) Six Common Mistakes in Conservation Priority Setting. *Conservation Biology* 27(3):480-485

68. Giakoumi S, M Sini, V Gerovasileiou, T Mazor, J Beher, HP Possingham, A Abdulla, ME Çinar, P Dendrinos, AC Gucu, AA Karamanlidis, P Rodic, P Panayotidis, E Taskin, A Jaklin, E Voultsiadou, C Webster, A Zenetos and S Katsanevakis (2013) Ecoregion-Based Conservation Planning in the Mediterranean: Dealing with Large-Scale Heterogeneity. *PLoS One* DOI:10.1371/journal.pone.0076449

Outputs and Outcomes

69. Guerrero AM, RRJ McAllister, J Corcoran and KA Wilson (2013) Scale Mismatches, Conservation Planning, and the Value of Social-Network Analyses. *Conservation Biology* 27:35-44

70. Hornoy B, A Atlan, V Roussel, Y, Buckley and M Tarayre (2013) Two colonisation stages generate two different patterns of genetic diversity within native and invasive ranges of Ulex europaeus. *Heredity* 111(5):355-363

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72. Kent R, O Levanoni, E Banker, G Pe'er and S Kark (2013) Comparing the Response of Birds and Butterflies to Vegetation-Based Mountain Ecotones Using Boundary Detection Approaches. *PLoS One* 8(6):0058229-

73. Klein CJ, VJ Tulloch, BS Halpern, KA Selkoe, ME Watts, C Steinback, A Scholz and HP Possingham (2013) Tradeoffs in marine reserve design:habitat condition, representation, and socioeconomic costs. *Conservation Letters* 6(5):324-332

74. Kragt ME, BJ Robson and CJA MacLeod (2013) Modellers' roles in structuring integrative research projects. *Environmental Modelling & Software* 39(1):322-330

75. Levin N, AIT Tulloch, A Gordon, T Mazor, Bunnefeld and S Kark (2013) Incorporating Socioeconomic and Political Drivers of International Collaboration into Marine Conservation Planning. *Bioscience* 63(7):547-563

76. Levina N, JEM Watson, LN Joseph, HS Grantham, L Hadare, N Apele, A Perevolotsky, N DeMalachg, HP Possingham and S Kark (2013) A framework for systematic onservation planning and management of Mediterranean landscapes. *Biological Conservation* 158:371-383

77. Lindenmayer DB, W Blanchard, L McBurney, D Blair, SC Banks, D Driscoll, AL Smith and AM Gill (2013) Fire severity and landscape context effects on arboreal marsupials. *Biological Conservation* 167:137-148

78. Lukoschek V, M Beger, D Ceccarelli, Z Richards and M Pratchett (2013) Enigmatic declines of Australia's sea snakes from a biodiversity hotspot. *Biological Conservation* 166:191-202

79. Lunt ID, M Byrne, JJ Hellmann, NJ Mitchell, ST Garnett, MW Hayward, TG Martin, E McDonald-Madden, SE Williams and KK Zander (2013) Using assisted colonisation to conserve biodiversity and restore ecosystem function under climate change. *Biological Conservation* 157:172-177

80. Makino A, CJ Klein, M Beger, SD Jupiter and HP Possingham (2013) Incorporating Conservation Zone Effectiveness for Protecting Biodiversity in Marine Planning. *PLoS One* 8(11):0078986

81. Makino A, M Beger, CJ Klein, SD Jupiter and HP Possingham (2013) Integrated planning for land-sea ecosystem connectivity to protect coral reefs. *Biological Conservation* 165:35-42

82. Maron M, JR Rhodes and P Gibbons (2013) Calculating the benefit of conservation actions. *Conservation Letters* 2013(6):359-367

83. Marshall D, M Bode and C White (2013) Estimating physiological tolerances - a comparison of traditional approaches to nonlinear regression techniques. *Journal of Experimental Biology* 216:2176-2182

84. Mazor T, N Levin, HP Possingham, Y Levy, D Rocchini, AJ Richardson and S Kark (2013) Can satellite-based night lights be used for conservation? The case of nesting sea turtles in the Mediterranean. *Biological Conservation* 159:63-72

85. Mazor T, S Giakoumi, S Kark and HP Possingham (2013) Large-scale conservation planning in a multinational marine environment: cost matters. *Ecological Applications* DOI: 10.1890/13-1249.1

86. McCarthy MA, JL Moore, WK Morris, KM Parris, GE Garrard, PA Vesk, L Rumpff, KM Giljohann, JS Camac, SS Bau, T Friend, B Harrison and B Yue (2013) The influence of abundance on detectability. *Oikos* 122(5):717-726

Outputs and Outcomes

87. Meijaard E, NK Abram, JA Wells, AS Pellier, M Ancrenaz, DLA Gaveau, RK Runting and K Mengersen (2013) People's Perceptions about the Importance of Forests on Borneo. *PLoS One* 8(9):0073008

88. Micheli F, N Levin, S Giakoumi, S Katsanevakis, A Abdulla, M Coll, S Fraschetti, S Kark, D Koutsoubas, P Mackelworth, L Maiorano and HP Possingham (2013) Setting Priorities for Regional Conservation Planning in the Mediterranean Sea. *PLoS One* 8(4):e59038-doi:10.1371/journal.pone.0059038

89. PA Fleming, Anderson H, Prendergast A, Bretz M, Valentine LE, Hardy G (2013) Is the loss of Australian digging mammals contributing to deteriorating ecosystem functioning? *Mammal Review* 44(2):94-108

90. Parris KM and MA McCarthy (2013) Predicting the Effect of Urban Noise on the Active Space of Avian Vocal Signals. *American Naturalist* 182 (4):452-464

91. Pe'er G, YG Matsinos, K Johst, KW Franz, C Turlure, V Radchuk,AH Malinowska, JMR Curtis, I Naujokaitis-Lewis, BA Wintle and K Henle (2013) A Protocol for Better Design, Application, and Communication of Population Viability Analyses. *Conservation Biology* 27(4):644-656

92. Pooley SP, JA Mendelsohn and EJ Milner-Gulland (2013) Hunting Down the Chimera of Multiple Disciplinarity in Conservation Science. *Conservation Biology* 28(1):22-32

93. Raymond, CM and AT Knight (2013) Applying Social Research Techniques to Improve the Effectiveness of Conservation Planning. *Bioscience* 63 (5):320-321

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95. Rout TM, E McDonald-Madden, TG Martin, NJ Mitchell, HP Possingham and DP Armstrong (2013) How to decide whether to move species threatened by climate change. *PLoS One* 0075814

96. Salomon Y, MA McCarthy, P Taylor and BA Wintle (2013) Incorporating Uncertainty of Management Costs in Sensitivity Analyses of Matrix Population Models. *Conservation Biology* 27(1):134-144

97. Sato CF, JT Wood and DB Lindenmayer (2013) The Effects of Winter Recreation on Alpine and Subalpine Fauna: A Systematic Review and Meta-Analysis. *PLoS One* 0064282

98. Sato CF, JT Wood, M Schroder, K Green, WS Osborne, DR Michael and DB Lindenmayer (2013) An experiment to test key hypotheses of the drivers of reptile distribution in disturbed subalpine ski resorts. *Journal of Applied Ecology* 51:13-22

99. Schwartz M and TG Martin (2013) Translocation of imperiled species under changing climates. *Annals of the New York Academy of Sciences* 1286:15-28

100. Smith AL, CM Bull and DA Driscoll (2013) Successional specialization in a reptile community cautions against widespread planned burning and complete fire suppression. *Journal of Applied Ecology* 50(5):1178-1186

101. Smith AL, D Blair, L McBurney, SC Banks, PS Barton, W Blanchard, DA Driscoll, AM Gill and DB Lindenmayer (2013) Dominant Drivers of Seedling Establishment in a Fire-Dependent Obligate Seeder: Climate or Fire Regimes? *Ecosystems* 17(2):258-270

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Outputs and Outcomes

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Impact Factor less than 3 (44)

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Outputs and Outcomes

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No Impact Factor currently registered with ISI Web of Science (19)

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172. Smith AL, CM Bull and DA Driscoll (2013) Skeletochronological analysis of age in three "fire-specialist" lizard species. *The South Australian Naturalist*

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REPORT (2)

174. Ryan G (2013) Is the extirpation of Irrawaddy dolphins (Orcaella brevirostris) in Laos imminent: an assessment of status and recommendations for conservation. *Presented to the International Whaling Commission Scientific Committee.*

175. Wells JA, E Meijaard, NK Abram and SA Wich (2013) Forests, Floods, People and Wildlife on Borneo. *United Nations Environment Program, Nairobi, Kenya*. 54 pages.

CONFERENCE PAPER (6)

176. Chalak M and D Pannell (2013) Climate change, threshold and uncertainty. *57th Annual Conference of the Australian Agricultural and Resource Economics Society*, Sydney 5-8 Feb 2013

177. Davis K, D Pannell, M Kragt, S Schilizzi and S Gelcich (2013) Optimising for abundance using marine reserves and property rights. *57th Annual Conference of the Australian Agricultural and Resource Economics Society*, Sydney 5-8 Feb 2013

178. Kragt ME (2013) Comparing models of preference heterogeneity for environmental management. *57th annual conference of the Australian Agricultural and Resource Economics Society*, Sydney, 4-8 February 2013.

179. Massam G, M Kragt and M Burton (2013) Public preferences for the co-benefits of carbon farming. *57th Annual Conference of the Australian Agricultural and Resource Economics Society*, Sydney 5-8 Feb 2013

180. Polyakov M, R Pandit, D Pannell, G Park and S Tapsuwan (2013) Capitalized amenity value of native vegetation in a multifunctional rural landscape: a spatial hedonic analysis. *57th Annual Conference of the Australian Agricultural and Resource Economics Society*, Sydney 5-8 Feb 2013

181. Rogers R, E Petersen, F Gibson, M Kragt, D Pannell and M Burton (2013) Non-market valuation: praise, protest and performance in environmental policy. *57th Annual Conference of the Australian Agricultural and Resource Economics Society*, Sydney 5-8 Feb 2013

Outputs and Outcomes

INTERNATIONAL VISITORS

During 2013 CEED had a total of 131 international visitors to Australia, attending workshops and visiting our researchers, often in more than one node. In total 20 stayed for more than 10 days, and 111 had shorter stays of less than 10 days.

Listed below are those that vistited our CEED researchers and their country of origin, excluding workshop attendees.

Argentina
- Juan Morales

Borneo
- Erik Meijaard

Brazil
- Tiago Shizen

Canada
- Peter Boxall
- Carol Hall
- Eric Higgins
- Jon Smol
- Brian Starzomski

Chile
- Juan Armesto

France
- Nathalie Peyrard
- Regis Sannadin

Germany
- Enno Auferheide
- Jitendra Gaikwad
- Jurgen Geist
- Roland Gerstmeier
- Peter Haase
- Annette Menzel
- Ralph Rollrian
- Gert Worheide
- Pieter Zuidema
- Ulrich Zeller

Indonesia
- Prof Saefuddin
- Elfi Yuliati Yovi

Israel
- Ran Nathan

Japan
- Takehiro Sasaki

Malaysia
- Augustine Binson
- Sofia Johari
- Robecca Jumin
- Sikula Magupin

New Zealand
- Todd Dennis
- Ronny Groentmann
- Rebecca Jarvis
- Graeme Taylor

Papua New Guinea
- Ross Sinclair

Poland
- Magdalena Lenda

Portugal
- Silvia Carvahallo

South Africa
- Linda Harris
- Donavan Kruger

Sweden
- Örjan Bodin
- Mats Dynesius
- Ulrika Sahlin

United Kingdom
- Luci Bland
- Christopher Clements
- Ben Collen
- Michael Harfoot
- Jenny Hays
- Lochran Traill
- Josephine Walker

USA
- Julian Alston
- Loretta Battagilia
- Brandon Bestelmeyer
- Elizabeth Borer
- Virgina Dale
- Eliezer Gurarie
- Lauren Hallett
- Jim Haw
- Bob Holt
- Liana Joseph
- Keith Kline
- Mark Lindberg
- Bruce McCann
- Karthik Ram
- Eric Seabloom

Vietnam
- Klaus Schmitt

Outputs and Outcome

AWARDS AND RECOGNITION

Dr Sarah Bekessy, Chief Investigator, RMIT University
Awarded ARC Future Fellowship
http://rmit.net.au/browse;ID=ozribjxkm8mn

Awarded RMIT Deans Research Award

Dr Hawthorne Beyer, Post Doctoral Research Fellow, UQ
Awarded ARC Discovery Early Career Research Award
http://researchers.uq.edu.au/researcher/2719

Dr Yvonne Buckley, Chief Investigator, UQ
Appointed Chair of Zoology at Trinity College Dublin
https://www.tcd.ie/Zoology/

Prof Richard Hobbs, Chief Investigator, UWA
Awarded the Society for Ecological Restoration "Special Recognition Award" at the International Restoration Ecology Conference in Madison, Wisconsin
http://www.ser.org/programs/ser-awards/past-recipients

Honourable Mention in The PROSE awards (The American Publishers Awards for Profession and Scholarly Excellence) for *Novel Ecosystems: Intervening in the New Ecological World Order*, Edited by Richard J. Hobbs, Eric S. Higgs, and Carol M. Hall, Wiley Publishing

http://www.proseawards.com/current-winners.html

Dr Carissa Klein, Post Doctoral Research Fellow, UQ
Awarded APEC Science Prize for Innovation, Research and Education (ASPIRE)
http://www.apec.org/Press/News-Releases/2013/0702_aspire.aspx

Dr Andrew Knight, Partner Investigator, Imperial College, London
Appointed Editor-in-Chief of Conservation Letters
http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1755-263X

Dr Marit Kragt, UWA
Awarded Modelling and Simulation Society of Australia and New Zealand Early Career Research Excellence Award
http://www.mssanz.org.au/awards/ecre.html

Awarded International Choice Modelling Conference Best Paper Prize
http://www.icmconference.org.uk/index.php/icmc/ICMC2013

Awarded the Agricultural Economics Society Prize Essay
http://www.news.uwa.edu.au/201303275511/awards-and-prizes/uwa-scoops-prestigious-international-prize-again

Prof David Lindenmayer, Chief Investigator, ANU
Awarded ARC Laureate Fellowship
http://www.arc.gov.au/pdf/FL12/DAVID%20LINDENMAYER.pdf

Finalist Prime Minister's Environmentalist of the Year Award
http://www.unaavictoria.org.au/awards-programs/world-environment-day-awards/

Awarded Jim Pojar Award for the book "Salvage Logging and its Ecological Consequences"
http://islandpress.org/ip/books/book/islandpress/S/bo8015228.html

Dr Eve McDonald-Madden, Chief Investigator, UQ

Awarded University of Queensland Early Career Researcher Award
http://www.science.uq.edu.au/research-news

Awarded European Union Erasmus Mundas Fellowship to visit University of Copenhagen

Prof E.J. Milner-Gulland, Partner Investigator, Imperial College, London

Made Director of Imperial College's Grand Challenges in Ecosysterms and Environment Initiative
www3.imperial.ac.uk/ecosystemsandenvironment

Outputs and Outcome

Dr James (Jim) Nichols, Partner Investigator, USGS

Awarded Wetland Conservation Achievement Award, Research/Technical, Ducks Unlimited
http://huntinglife.com/dr-james-d-nichols-honored-at-2013-wetland-conservation-achievement-awards-ceremony/

Award of Excellence, Biometrics Working Group of The Wildlife Society
http://wildlife.org/biometrics/PastRecipients#Excellence

Prof Hugh Possingham, Director, UQ

Awarded ARC Laureate Fellowship
http://www.arc.gov.au/pdf/FL13/Bios/POSSINGHAM

Elected Fellow of the Ecological Society of America (only Australian who is a fellow)
http://www.esa.org/esa/?page_id=7167

Dr Rachel Standish, UWA

Awarded Best Publication by a Staff Member of the School of Plant Biology, UWA
http://scholar.google.com.au/citations?view_op=view_citation&hl=en&user=JlmF5ZQAAAAJ&citation_for_view=JlmF5ZQAAAAJ:9ZlFYXVOiuMC

Dr Ayesha Tulloch, Post Doctoral Research Fellow, UQ

Awarded Editors Choice for Biology of Conservation paper "Realising the full potential of citizen science monitoring programs"
http://www.journals.elsevier.com/biological-conservation/editors-choice/realising-the-full-potential-of-citizen-science-monitoring/

Dr James Watson, Adjunct Assoc. Professor, UQ

Awarded Early Career Conservationist with the Society of Conservation Biology
http://www.ceed.edu.au/ceed-news/137-news-ecc-award.html

Elected Global President of the SCB
http://www.conbio.org/publications/scb-news-blog/scb-welcomes-new-board-members

Dr Kerrie Wilson, Chief Investigator, UQ

Awarded Eureka Prize for Outstanding Young Researcher
http://www.uq.edu.au/news/article/2013/09/uq-conservation-scientist-wins-eureka-prize

UQ Foundation Research Excellence Award
http://www.uq.edu.au/news/article/2013/09/awards-recognise-uq%E2%80%99s-rising-stars-of-research

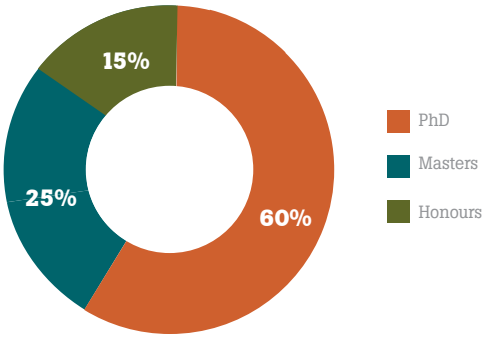
DR KERRIE WILSON RECIEVING HER EUREKA AWARD

Outputs and Outcomes

GRADUATIONS

In 2013 CEED was proud to graduate some 23 research students across all nodes. Figure 9 shows the breakdown of these graduations by research degree type.

FIGURE 9: CEED 2013 GRADUATIONS



STUDENT (ALPHABETICAL)	RESEARCH DEGREE	NODE
Scott Anderson	Masters (Research)	University of Queensland
Megan Barnes	PhD	University of Queensland
Sarah Butler	PhD	University of Queensland
Lorenzo Cattarino	PhD	University of Queensland
Yi Ling Chang	Masters (Research, 6 months)	University of Queensland
Ben Cooke	PhD	RMIT University
Sarah Devries	Masters (Research)	University of Melbourne
Madeleine Gorsuch	Masters (Research, 6 months)	University of Melbourne
Kate Grarock	PhD	The Australian National University
Kendall Jones	Honours	University of Queensland
Meera Joyce	Honours	University of Queensland
Kristylee Marr	Honours	University of Queensland
Karen McGregor	Masters (Research)	University of Melbourne
Adjie Pamungkas	PhD	RMIT University
William Probert	PhD	University of Queensland
Lucinda Robinson	PhD	University of Queensland
Zuraidah Said	Masters (Research, 6 months)	University of Melbourne
Andrew Smith	PhD	University of Queensland
Paing Soe	Masters (Research, 6 months)	University of Melbourne
Patricia Sutcliffe	PhD	University of Queensland
Ayesha Tulloch	PhD	University of Queensland
Jessie Wells	PhD	University of Queensland
Martin Westgate	PhD	The Australian National University

Outputs and Outcomes

COMMERCIALISATION

We are a public good centre so there is unlikely to be commercialisation of any of our products. The products that appear closest to commercial products are the software packages researchers in CEED have been involved in developing to facilitate environmental decision-making. The success of these software programs indicates that there is a real need to be able to make decisions taking into account a multitude of factors and variables. All of these packages are made freely available and there is no intention to commercialise these activities. They already bring new grants and significant reputation to CEED, as well as assisting outcomes in policy and management.

Some of the advances and innovations from 2013, most of which are available from our web site, include:

1. MARXAN.NET - A CLOUD MIGRATION OF THE MARXAN SOFTWARE

Marxan is the most widely used decision support software for conservation planning globally. Almost every country in the world has someone using Marxan to design systems of marine and terrestrial protected areas. Previously, users were required to download and install complex software packages. Centre researchers have, over a considerable period of time, developed and refined an easy to use method for researchers to utilise supercomputing resources to applying the Marxan software, and share analysis, data and results between stakeholders in conservation planning exercises worldwide. The software improves the ability for us to inform conservation planning globally and increases the utility of Marxan.

2. V-TRACK ANALYSIS AND VISUALISATION R PACKAGE FOR ANIMAL TRACKING

V-Track is an application programming interface for analysing and visualising data generated from the VEMCO suite of passive acoustic receivers that track individual animals. Centre researchers developed it in collaboration with members of the UQ Eco-Lab. It enables the storage, analysis and visualisation of detection data from the VEMCO suite of receivers and transmitters. This data and analysis is then integrated into the R-Project scientific data analysis system which makes it useful and accessible to many scientists and species management agencies around the world.

3. OZTRACK.ORG WEB BASED ANALYSIS AND VISUALISATION PLATFORM FOR ANIMAL TRACKING

OzTrack is a web portal that stores and analysis GIS-based animal tracking data. The initial concept was initiated inputs from the UQ Eco-Lab and then expanded with the collaboration of members of the UQ Eco-Lab and the UQ eResearch Lab to develop the web portal. It enables scientists and species management agencies around the world to store, analyse, and share animal tracking data.

4. INFFER – INVESTMENT FRAMEWORK FOR ENVIRONMENTAL RESOURCES

During 2013, the IP for INFFER (the Investment Framework for Environmental Resources), owned by The University of Western Australia, was licensed to a new company, Natural Decisions Pty Ltd. INFFER was developed prior to CEED, and has been used in various pieces of research within CEED. In Natural Decisions Pty Ltd, it is being used in a variety of contexts to support more rational and evidence-based decision making about the environment and natural resources. Work includes analysis of projects to promote reductions in sediment and nutrient pollution to the Great Barrier Reef, a project to protect Corner Inlet in eastern Victoria, and the use of prescribed burning to reduce bushfire risks in Victoria.

Outputs and Outcomes
Key Performance Indicators

PERFORMANCE INDICATORS

Performance indicators are a measure of how well the Centre is functioning relative to pre-determined targets.

RESEARCH FINDINGS

INDICATOR	TARGET 2013	OUTCOME 2013
Number of peer-reviewed publications	70	181
Number of plenary talks delivered at international conferences [1]	7	9
Number of international workshops and conferences attended	30	79
Number and nature of commentaries about the Centre's achievements [2]	4	20

RESEARCH TRAINING AND PROFESSIONAL EDUCATION

INDICATOR	TARGET 2013	OUTCOME 2013
Number of attended professional training courses for Centre staff and students [3]	18	70
Number of Centre attendees at all professional training courses	60	111
Number of new postgraduate students working on core Centre research – supervised by Centre staff	14	40
Number of new postdoctoral researchers recruited to the Centre and working on core Centre research	6	10
Number of new Honours students working on core Centre research and supervised by Centre staff	10	4
Number of postgraduate completions and working on core Centre research	15	19
Number of Early Career Researchers working on core Centre research	15	31
Number of students mentored	50	460
Number of mentoring programs	1	1

INTERNATIONAL, NATIONAL AND REGIONAL LINKS AND NETWORKS

INDICATOR	TARGET 2013	OUTCOME 2013
Number of international visitors and visiting fellows (for 10 days or more)	10	20
Number of other international visitors and visiting fellows (less than 10 days)	20	44 visits to CI's plus 67 international workshop attendees
Number of national and international workshops held/organised by the Centre	10	45
Visits to overseas facilities/collaborators for 10 days or more	15	31
Visits to overseas facilities/collaborators (less than 10 days)	30	76

Outputs and Outcomes
Key Performance Indicators

END-USER LINKS

INDICATOR	TARGET 2013	OUTCOME 2013
Indicator	Target 2013	Outcome 2013
Membership of national and international boards and advisory committees	20	72
Number of government, industry and business community briefings	20	129
Number of website hits	50,000	288,504
Number of public talks given by Centre staff	80	109
Internally produced Magazine issues	10	12
Separate media stories [4]	10	930
Media outputs, articles, radio [5]	100	2317

INDICATOR	TARGET 2013	OUTCOME 2013
Annual cash contributions from collaborating institutions	$834,037	$834,361
Annual in-kind contributions from collaborating institutions	$930,135	$2,595,886
Annual in-kind contributions from Partner organisations	$154,015	$154,015
Other ARC grants (Discovery, Linkage & Fellowships) income for 2013	$1,000,000	$3,840,716

Notes:

1. An international plenary talk is defined as a talk at an international conference where no one else is speaking. We are working towards a more nuanced allocation of talks to categories. The original KPI was about keynote talks which is not a well defined concept.

2. Commentaries about the Centre are described as independent comments made by reputable organisations or leading scientists relating to work or research carried out by the Centre and/or its staff. This KPI is not included in media stories.

3. This data includes attendance at conferences.

4. Separate media stories where each headline is unique, even if they spring from the same original media release.

5. Media outputs are syndicated stories - the same story relayed many times eg an ABC Radio interview (a separate media story) replayed across all ABC local radio stations.

FINANCE

Finance

INCOME

ARC CENTRE OF EXCELLENCE INCOME

In 2013, the Centre received $1,862,205 from the Australian Research Council in terms of the Funding Agreement with the ARC. In addition to the ARC funding, the University contributions (from the University of Queensland, Melbourne, Western Australia, the Australian National University, and the RMIT University) amounted to $834,361 in 2013 (Figure 1). The universities also made an in-kind contribution of $2,595,886 in 2013.

ARC GRANTS AND FELLOWSHIPS

Centre staff has been very successful in obtaining grants and fellowships. During 2013, the income from ARC grants and fellowships amounted to $3,693,907. The types and value of the grants are shown in Figure 3.

ADDITIONAL INCOME

The Centre has been successful in attracting additional income in the form of sponsorships and the co-funding of appointments. Below we discuss some of these additional funds, including the most important additional funding source, a centre grant from the federal Department of the Environment.

CENTRE FUNDING FROM THE DEPARTMENT OF THE ENVIRONMENT

The Department of the Environment has provided substantial funding through its National Environmental Research Program (NERP). The NERP Environmental Decisions (NERP ED) Hub is headquartered at the University of Queensland and has nodes at The Australian National University, The University of Melbourne, RMIT University and the University of Western Australia. The NERP ED Hub also collaborates with CSIRO and the National Herbarium in Victoria. In 2013, the NERP ED Hub received $3.149 million dollars and will receive $2.845 million in 2014. Many of the research programs run under the auspices of the NERP ED Hub also make a substantial contribution to CEED research. NERP funding ends early in 2015.

The universities, which host the respective hubs, make a financial contribution of $557,390 to the NERP program each year.

CO-FUNDED APPOINTMENTS

A number of co-funded appointments were made with various organisations. These organisations include:

The Wildlife Conservation Society has agreed to commit $136,362 over three years towards the appointment of a Postdoctoral Fellow. CEED will contribute $150,000 over three years towards this salary.

CSIRO has provided an amount of $40,000 per annum for two years towards a project being conducted by a CEED Postdoctoral Fellow. CEED will contribute $108,047 towards this project.

The Australian Antarctic Division has contributed $138,420 over three years towards the appointment of a Postdoctoral Fellow. CEED will contribute $116,677 towards this position in 2015.

The Queensland Cyber Infrastructure Foundation has committed to a grant of $50,000 over two years towards the Marxan program development. CEED will contribute $50,000 towards a salary related to this project in 2015

FUNDS FROM PHILANTHROPY

In 2013, a generous amount of $50,000 was received from The Thomas Foundation to host the first Student Conference on Conservation Science at the University of Queensland. A second conference is being planned for 2015 and negotiations are currently under way to finalise additional sponsorship.

ADDITIONAL FUNDING FROM UNIVERSITIES

Apart from the considerable in-kind contributions made by all the collaborating universities, additional funding is made available for DECRA (Discovery Early Career Researcher awards) top-ups and Fellowship top-ups. In 2013, The University of Melbourne made an additional amount of $50,650 available for DECRA top-ups as well as $5,750 towards a Future Fellowship. In addition, The University of Melbourne has committed to making $75,000 available for a Centenary Fellowship in 2014, and will support a Victorian Postdoctoral Research Fellowship valued at $75,000. CEED funding will provide a top-up of $21,000 to these two these Fellowships.

EXPENDITURE

The expenditure represented in Figure 4 (page 102) relates to income from the ARC Centre of Excellence funding, Grants and Fellowships plus the University contribution. Salaries constitute approximately 68% of the total expenditure.

FUTURE INCOME AND EXPENDITURE:

Predicted future income from a variety of sources is shown in Figure 5.

There is little doubt that the Centre's profile will allow it to attract additional funding. Importantly, there are a large number of other non-ARC grants to CIs that do not overlap CEED activities, but certainly complement CEED work; these will be assembled in full for the 2014 Annual Report.

Finance

FIGURE 1: CEED 2013 INCOME

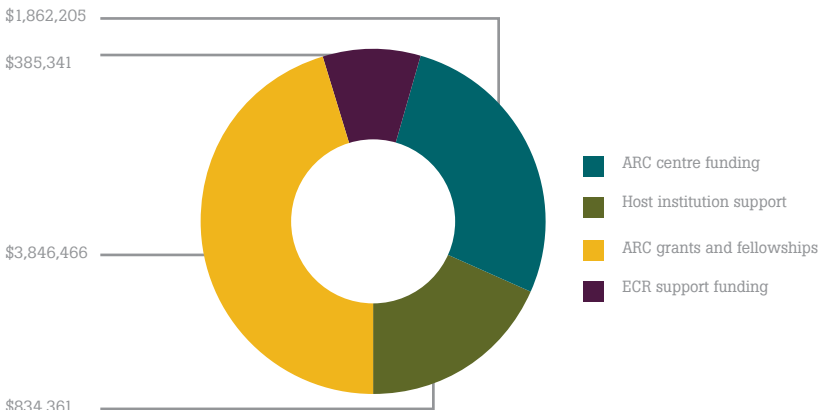


FIGURE 2: CEED 2014 PREDICTED INCOME

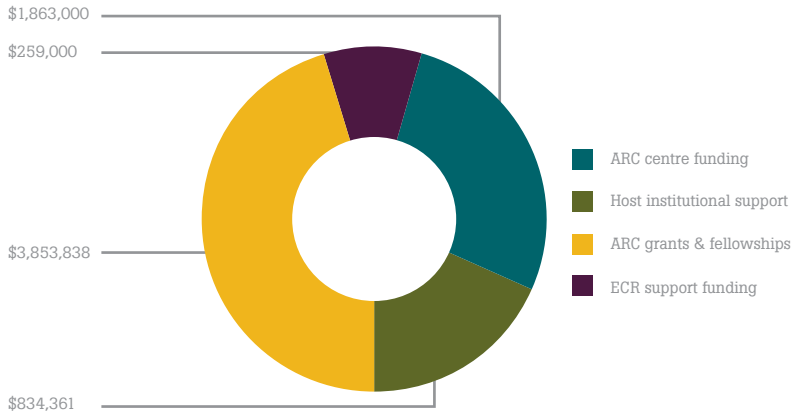
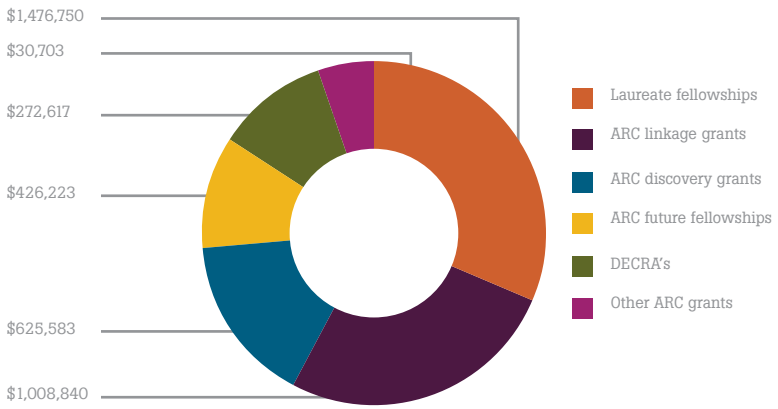


FIGURE 3: CEED 2013 INCOME FROM ARC GRANTS AND FELLOWSHIPS



Finance

FIGURE 4: CEED 2013 EXPENDITURE

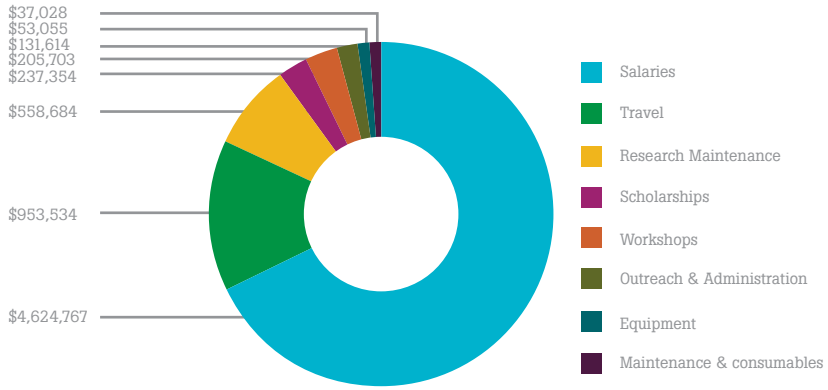
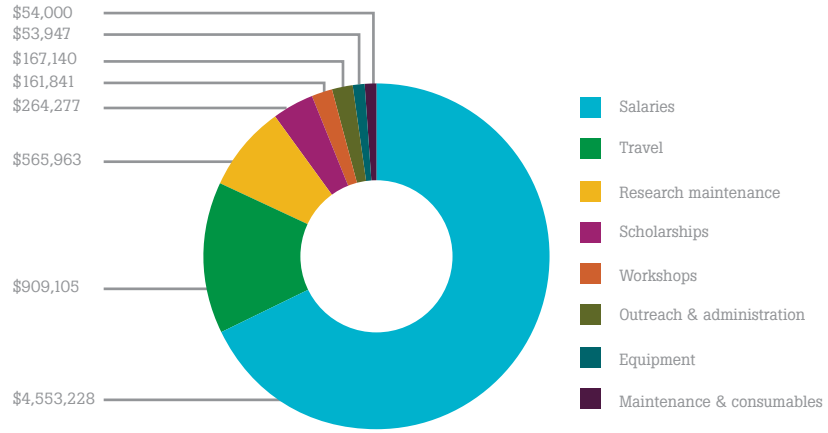


FIGURE 5: CEED 2014 PREDICTED EXPENDITURE



CEED's Partners

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