ARC ceed
Centre of Excellence for Environmental Decisions

2017 Annual Report

ARC ceed

ARC Centre of Excellence for Environmental Decisions

Room 532, Goddard Building 8
The University of Queensland
St Lucia, QLD 4072, Australia

P (+61 7) 3365 6907
F (+61 7) 3365 1692

www.ceed.edu.au

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Director's Report

Our natural environment is changing at a rapid rate. The year of 2017 saw a second mass coral bleaching event, multiple bouts of record-breaking weather, and political debate over land clearing and water use.

In such a climate, the role of robust environmental decision science has an even more important role to play. The vision that we set forth for CEED was to become the world's leading research centre for solving environmental management problems and for evaluating the outcomes of environmental actions. How have we fared?

In terms of outputs, CEED has been a stellar performer at producing scientific publications and delivering cutting-edge research. Our science is widely cited by researchers around the globe, but also in primary government reference materials such as the State of the Environment Report. You'll see several examples of this world leading research on display in this Annual Report. Indeed, CEED's contribution to the environmental sciences has made a major contribution to Australia's high standing in this field.

The QS World University Rankings (www.topuniversities.com/university-rankings/university-subject-rankings/2017/environmental-studies), sets out which universities around the world are excelling in different areas. Under 'environmental sciences' in 2017 Australia's top university is The University of Queensland coming in at number 9. The University of Melbourne sits at number 18 with the ANU close behind at number 23. Not bad in a list of the world's top 200 universities. And it's no coincidence that these top three Aussie unis happen to also be CEED nodes.

But, as I am sure you have heard on multiple occasions, an output is only the first part of an outcome, and defining and measuring outcomes is a very challenging thing to do. It's also an important part of environmental decision science and environmental policy. An important technical contribution from CEED has been an improved understanding of how you robustly define and measure the outcomes and impacts of environmental policy and management.

With this background we are also well placed to examine the impact of environmental research and research networks in Australia. In this past year we have initiated an effort to evaluate the impact of our Centre of Excellence. We now have evidence that CEED has achieved more impact in environmental decision making than would have been possible by the sum of all the individual, smaller research groups that make up CEED. This is due to the networks and collaborations that have been possible as a result of the significant investment from the Australian government. As such, our evaluation also captures how CEED has contributed to training the next generation of research leaders and improving research communication and outreach.

One of CEED's greatest legacies will be its people. CEED commenced in 2011 and has now generated a well-connected alumni network that spans the globe. These incredibly capable researchers are receiving national and international recognition for their achievements. They are securing coveted positions in the academy, and taking up leadership roles in governmental and non-governmental organisations. We are profiling a selection of this community in the fold out of this annual report and delight in promoting their achievements.

At international conferences in the environmental sciences, the breadth and reach of CEED's researchers becomes strikingly apparent. This is from both the sheer number of individuals that are associated with CEED (take our representation at the International Congress for Conservation Biology in Colombia as one example) and from our researchers' active engagement in cognate international and national societies and scientific bodies. This benefits the discipline more broadly and further enhances our Centre's impact.

Our Centre

The Centre of Excellence for Environmental Decisions (CEED) commenced in 2011 with funding from the Australian Research Council (ARC). ARC Centres of Excellence are world class, internationally competitive research teams investigating, and finding solutions to, challenging and important Australian and international problems. Since 2011, CEED has been pushing the frontiers of environmental decision science.

Our research magazine, *Decision Point*, is a fine example of CEED's communication and outreach. 2017 saw the production of our 100th issue of *Decision Point* and the 3rd edition of a Spanish version (*Decision Point en Español*). These are considerable milestones, but they also represent a significant investment made by CEED in communicating our research in an attractive, engaging and ongoing manner for the benefit of the wider community. The feedback we get on *Decision Point* has been uniformly praising and, along with our other communication and outreach activities, *Decision Point* has made a significant contribution to a cultural shift in policy formulation in Australian governments at all levels; a shift away from ad hoc, opaque decision making (in regards to policy relating to nature, environment and threatened species management) towards more transparent, accountable, systematic and adaptive decision-making. Over the life of our Centre, the field of environmental decision science has grown from a little utilised academic pursuit to become a cornerstone of environmental policy. Our sustained efforts at research outreach and communication have been fundamental for this achievement.

The evaluation of CEED's impact will continue, but our findings so far suggest CEED has a strong story to tell as is further evidenced in this Annual Report. Our development and trialing of an approach to evaluate a Centre of Excellence will be yet another legacy of the Australian government's investment in the Centre of Excellence program. A program like none other in the world, and the foundation of Australia's academic leadership in the biological sciences.

Professor Kerrie Wilson

CEED Director

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.

Our Research

Our research is integrated across five key themes:

Research Theme A:
Environmental Policy & Management Evaluation

Leader: Assoc. Prof. Salit Kark, UQ

Theme A focuses on the needs of environmental policy makers and managers at all scales across national and international boundaries. We study and evaluate the effectiveness of environmental management actions such as establishing protected areas, habitat and ecosystem restoration on a landscape scale and through protected area zoning. Our work ranges in scale from the global and continental to local. Working across these scales, we explore the implications of policy and management options for biodiversity and other ecosystem and environmental processes. Research in this area is expected to contribute to the Intergovernmental Platform on Biodiversity and Ecosystem Services.

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

1. Fundamental and novel policy options
2. Environmental policy performance
3. Invasive species management.

Research Theme B:
Optimal Monitoring

Leader: Assoc. Prof. Jonathan Rhodes, UQ

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

This theme focuses on addressing four critical areas for monitoring:

1. How to prioritise monitoring and management investment in declining species to inform recovery planning
2. Understanding the value of learning about population demographics for managing threatened species
3. Developing better methods for linking indicators of change to biodiversity responses and prioritising investment in these indicators
4. Approaches for allocating monitoring investment to learn about ecological and social systems.

Research Theme C:
Socio-ecological Analysis & Modelling for Environmental Decision-making

Leader: Prof. Sarah Bekessy, RMIT

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.

Our researchers build on techniques from a range of disciplines and develop methods to analyse, model and integrate knowledge about socioeconomic and ecological processes to improve environmental decision-making.

Our research will encompass:

1. Integrating human responses to climate change into conservation planning, developing an integrated decision framework
2. Reconciling the triple bottom line of social equity, economic return, and environmental benefits in conservation decision-making
3. Modelling the social dimensions of market based instruments for biodiversity conservation
4. Evaluating environmental research and its accountability.

Research Theme D:
Ecological Theory & Processes

Leader: Assoc. Prof. Peter Vesk, University of Melbourne

Theme D focuses on the ecology of novel ecosystems, fragmented landscapes, and disturbances by looking at various patterns and processes for determining species abundance and distribution, and the interactions between species and the environment.

The theme's research provides a critical understanding for managers and policymakers who are involved in the decision-making process.

Our research addresses four major areas:

1. Population ecology, including 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
3. Multi-species interactions, particularly in relation to invasive species and assisted colonisation management in the face of climate change
4. Ecosystem resilience and effective ecosystem interventions.

Research Theme E:
Quantitative Tools and Approaches

Leader: Assoc. Prof. Jane Elith, University of Melbourne

Theme E focuses on quantitative tools and approaches that extend from fundamental research into mathematical approaches to ecological questions through to training on-the-ground managers to use decision-support tools. Key elements include:

1. Statistical techniques such as detectability modelling
2. Tools aimed at implementing policy, such as the IUCN's threatened ecosystems Red List
3. Methods for deciding on conservation priorities, including the project prioritisation protocol scheme, structured decision-making and Marxan.

Our researchers deliver cutting edge quantitative tools; they collaborate with managers to make sure these tools tackle important questions, and offer comprehensive and comprehensible recommendations.

Researchers at CEED also use quantitative methods to ask broader questions about fundamental conservation dilemmas. The outputs of this research are not tools, they are mathematical frameworks that allow us to clarify the biggest strategic questions in conservation. For example, why are there so many conservation organisations? Should we expand our protected area system, or better manage the reserves we already have?

Governance and Management

CEED is a partnership between The University of Queensland (UQ), The University of Melbourne (UM), The Australian National University,(ANU), RMIT University (RMIT) and The University of Western Australia (UWA) and six partner organisations, CSIRO, Trinity College Dublin (TCD), Imperial College London (ICL), Oxford University (OU), Hebrew University of Jerusalem Israel (HUJI) and the US Geological Survey (USGS). Its operations are managed from The University of Queensland in Brisbane.

Our researchers are recognised as global leaders in fundamental environmental science and we put a high priority on the career development of the next generation of conservation researchers. Our complement of over 150 researchers — Chief Investigators, Partner Investigators, Senior Researchers, PhD and Masters students — collaborate extensively across node and disciplines. This collaborative culture has been the key to our success.

Further information on the Centre and activities can be found at our website **www.ceed.edu.au**.

The Centre's governance structure reflects the emphasis on strategy, research, and communication and outreach in planning and implementing the work programs. Figure 1 illustrates the governance and operating structure of the Centre.

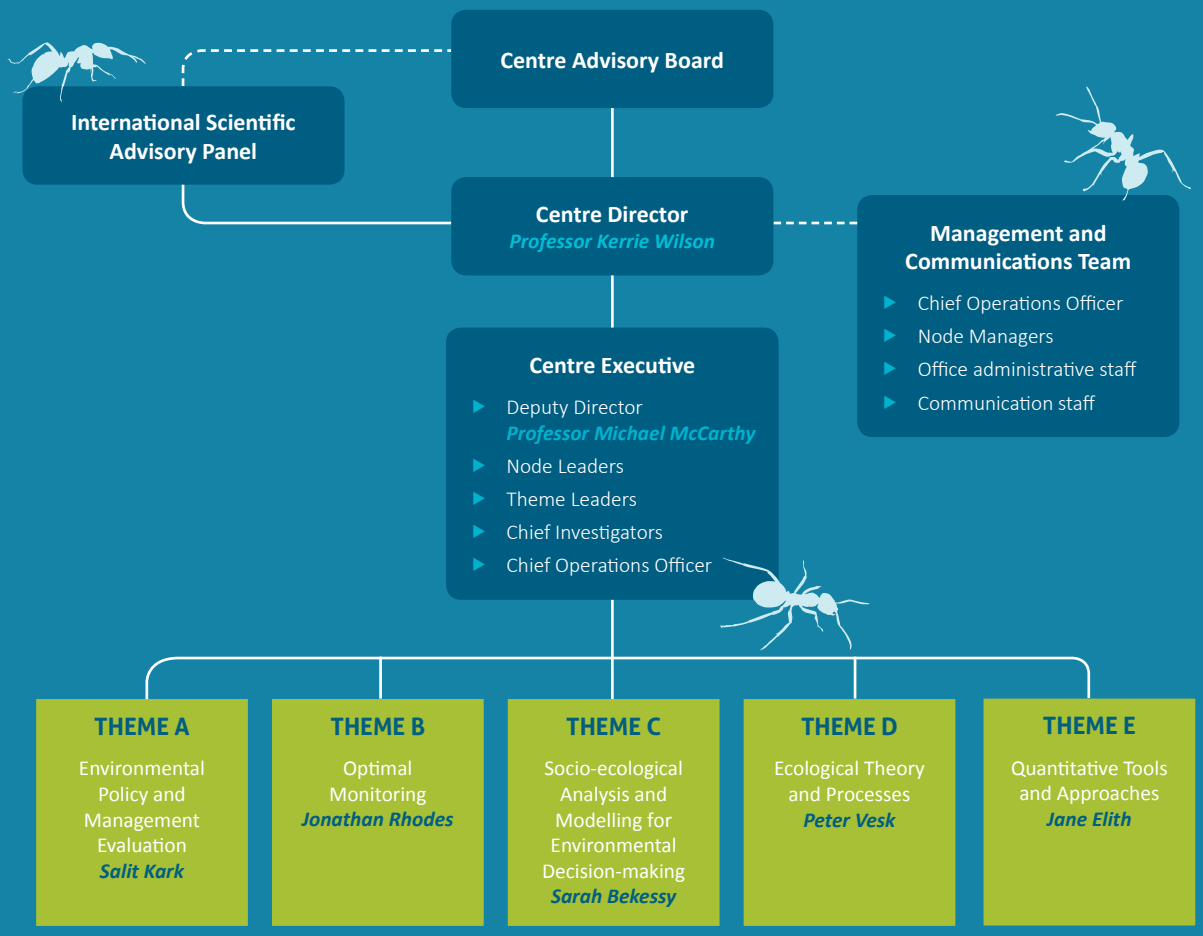
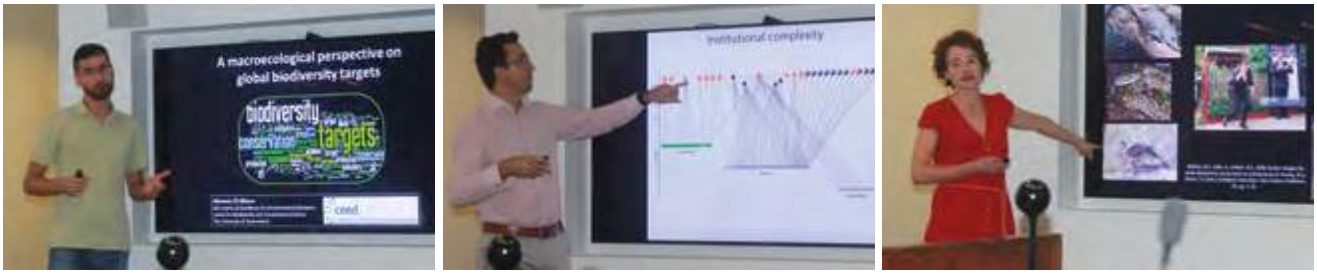


FIGURE 1 CEED's governance structure



L–R: Moreno Di Marco, Eduardo Gallo-Cajiao and Sarah Bekessy presenting at the first CEED Advisory Board Meeting of 2017.

Centre Executive

The Centre's Executive guides our operations and consists of the Theme Leaders, Node Directors, Chief Investigators, and the Chief Operations Officer. The Director Professor Kerrie Wilson and Deputy Director Professor Michael McCarthy provide the overarching guidance and day-to-day leadership of the Centre and its research.

The Executive met every two months via teleconferences or face-to-face at events to discuss Centre management, research, operations and policy.

Executive Members

- Professor Kerrie Wilson (Director), UQ
- Professor Michael McCarthy (Deputy Director), UM
- Professor David Lindenmayer, ANU
- Professor David Pannell, UWA
- Associate Professor Jonathan Rhodes, UQ
- Professor Sarah Bekessy, RMIT
- Professor Brendan Wintle, UM
- Associate Professor Jane Elith, UM
- Professor Richard Hobbs, UWA
- Associate Professor Salit Kark, UQ
- Dr Eve McDonald-Madden, UQ
- Dr Anthony Richardson, UQ
- Associate Professor Peter Vesk, UM
- Dr Kathy Avent, (Chief Operations Officer), UQ

Centre Advisory Board

The Centre Advisory Board (CAB) is comprised of members from the research, industry, policy and philanthropic sectors and provides strategic advice to the Centre's Executive leadership team with a particular focus on governance, communication, impact, outreach, research management and future planning.

The Board membership was reconfigured in early 2017 and two face-to-face meetings were held in 2017 (February, Brisbane and June, Perth). Discussions focussed on progress against the strategic plan, implementation of early and mid-career researcher development activities, increasing CEED external engagement and outreach efforts and increasing the impact of our research.

Members

- Professor Alistar Robertson (Chair), UWA
- Dr Margaret Byrne, Western Australian Department of Biodiversity, Conservation and Attractions
- Mr David Shelmerdine, Myer Foundation
- Dr Tony Peacock, CEO, CRC Association
- Professor Melissa Brown, Executive Dean, Faculty of Science, UQ

Ex Officio Members

- Professor Kerrie Wilson (Director), UQ
- Professor Michael McCarthy (Deputy Director), UM
- Dr Kathy Avent (Chief Operations Officer), UQ

Reflections

Professor Alistar Robertson, CAB Chair

The last year has seen a close engagement between researchers in CEED and members of the Centre's Advisory Board (CAB).

The CAB was keen to support the new Director, Prof Kerrie Wilson, as she settled into her role and outlined her vision to ensure that CEED achieved a lasting legacy in research outputs and outcomes. All members of the CAB continue to be impressed and amazed at what CEED and its researchers are achieving. The CAB looks forward to continuing our excellent relations with the Director, Deputy Director and Chief Operating Officer of CEED to ensure that the centre is acknowledged nationally and internationally as a leader in the conservation of biodiversity.

CAB members (Back left to front right): David Shelmerdine, Alistar Robertson, Michael McCarthy, Kerrie Wilson, Margaret Byrne, Melissa Brown, Tony Peacock.

International Scientific Advisory Panel

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

Members

- Professor Antoine Guisan, University of Lausanne
- Professor Claire Kremen, University of California, Berkeley
- Professor Bill Murdoch, University of California, Santa Barbara
- Professor Bill Sutherland, Miriam Rothschild Professor of Conservation Biology, Cambridge University
- Professor Peter Kareiva, Director, Institute of the Environment and Sustainability, UCLA

In 2017 the ISAP meeting was held as an invitation event to capitalise on the attendance of international experts at the ICCB conference in Cartagena, Columbia by seeking feedback on CEED achievements and recommendations on future areas of focus. Attendees included:

Invited Guests

- Amanda D. Rodewald, Cornell University
- Andres Etter Rothlisberger, Pontificia Universidad Javeriana
- Bill Sutherland, Cambridge University
- Bob Smith, University of Kent
- Emily Nicholson, Deakin University
- Kartik Shanker, Indian Institute of Science
- Leah Gerber, Arizona State University
- Mark Burgman, Imperial College London
- Mark Schwartz, University of California
- Peter Arcese, University of British Columbia
- Rafael Loyola, Universidade Federal de Goias
- Rebecca Shaw, Chief Scientist WWF
- Simon Ferrier, CSIRO
- Nathan Bennett, Stanford University
- Morena Mills, Imperial College London

CEED CIs and PIs

- Kerrie Wilson, UQ
- Hugh Possingham, TNC
- Brendan Wintle, Melbourne University
- Sarah Bekessy, RMIT
- EJ Milner-Gulland, Oxford University

CEED Guests & ECRs

- Angela Guerrero Gonzalez, UQ
- Jennifer McGowan, UQ
- Sofia Lopez, UQ
- Stephanie Avery-Gomm, UQ
- Katrina Davis, University of Exeter and UQ

2017 Highlights

77 National Collaborating Institutions

28 Countries Involved in Collaborations

43 Postdoctoral Fellows

35 Memberships on National Boards and Committees

7 Partner Investigators

13 Chief Investigators

68 PhD Scholars

43 Postdoctoral Fellows

3 Masters Students

3 National Plenaries

4 Honours Students

17 Memberships on International Boards and Committees

59 International Presentations

54 National Presentations

5 International Plenaries

100 International Collaborating Institutions

4 Honours Students

11 PhD Graduations

2 Masters by Research Graduations

43 Early Career Researchers

4 Honours Student Graduations

9 Submissions to Government on Policy-Related matters

157 Peer-Reviewed Journal Publications

42 Government, Industry and Community Briefings

42 International Visitors

Recognition of Research Excellence

2017 Awards & Prizes

Kerrie receiving the Nancy Millis award at the Australian Academy of Science, Shine Dome. Photo: Australian Academy of Science, Bradley Cummings Photography

2017 Nancy Millis Medal for Women in Science (Australian Academy of Science)

CEED Director **Professor Kerrie Wilson** was awarded the 2017 Nancy Millis Medal for Women in Science. Professor Wilson received the award at the annual Science at the Shine Dome event in May 2017, held by the Australian Academy of Science. The academy's citation stated she had "made significant discoveries in the environmental sciences that resulted in more effective conservation practices".

"Professor Wilson identified how significant funds for conservation could be saved, and investments could be more equitable, through incorporating socio-economic principles into setting priorities for conservation investments," the citation said.

"This has resulted in new theory and novel decision support tools to inform how limited conservation funds should be allocated to achieve multiple objectives, further enhancing the legacy and impact of her influential applied research program.

"Her research has led to innovative ways to efficiently protect and restore natural ecosystems and her ability to translate this new knowledge into practical applications has positioned her as a global, national and local leader in conservation science."

UQ 2017

Emerging Adviser Award for mentoring

CEED Chief Investigator **Associate Professor Jonathan Rhodes** won this **University of Queensland award** in September 2017.

The Emerging Adviser Award recognises "the special achievement of an early career staff member in supervising, mentoring and training HDR candidates".

Winners of the University of Queensland Research Week awards. Jonathan Rhodes (front row, second from the right). Photo: The University of Queensland

National 2017 Peer Prize for Women in Science

Dr Hannah Fraser completed her PhD with CEED in mid 2017 and was shortlisted in the annual Peer Prize for Women in Science which recognises top Australian female researchers. All entrants can showcase their work and the winners are chosen by a global peer network. This year, there were 45 entrants in two categories. Dr Fraser was awarded fifth place in the *Earth, Environmental & Space Science Prize* for her research on woodland birds.

Katrina Davis receiving her postgraduate prize from the AARES.

Australian Agricultural and Resource Economics Society Postgraduate Prize for 2016

Postdoctoral Research Fellow **Dr Katrina Davis** received the award at the 61st AARES annual conference dinner in Brisbane on February 8, 2017.

The Elsevier Atlas Award

CEED PhD student **James Allan** received the award as the lead author on a paper published recently in Elsevier's *Biological Conservation* journal.

The Atlas is awarded to a single journal article each month, from the thousands of articles recently published in Elsevier's journals. James' article ***"Recent increases in human pressure and forest loss threaten many natural world heritage sites"*** revealed that over 100 world heritage sites were being damaged by human activities. The international team behind the paper also included CEED researchers and associates **Sean Maxwell, Kendall Jones, James Watson** and **Oscar Venter.**

The award, announced in February 2017, was presented by Elsevier's publishers Fiona Barron and Diana Jones at The University of Queensland's St Lucia campus in May.

James Allan, recipient of the Elsevier Atlas award, with Prof Melissa Brown (UQ Executive Dean of Science) and Prof Aidan Byrne (UQ Provost). Photo: The University of Queensland

Jane Elith giving an address to the Australian Academy of Science upon becoming a Fellow of the AAS. Photo: Australian Academy of Science, Bradley Cummings Photography

Australian Academy of Science

CEED Chief Investigator **Associate Professor Jane Elith** became a Fellow of the Australian Academy of Science in May 2017. Associate Professor Elith specialises in species distribution models, statistical models that describe relationships between the occurrence or abundance of species and the environment. She has made outstanding original academic contributions to species modelling acknowledged by her 2015 Prime Minister's Prize for Life Scientist of the Year and the 2016 Frank Fenner Medal from the Academy of Science.

Recipients of the Mahathir award, Hugh Possingham, Kerrie Wilson and Erik Meijaard.

Malaysia's 2016 Mahathir Science Award

UQ research by **Professor Hugh Possingham**, **Professor Kerrie Wilson** and **Dr Erik Meijaard** and their teams has prompted government policy changes in Malaysia, Indonesia and around the world. The researchers' work advancing natural resource management knowledge in the tropics has won them Malaysia's 2016 **Mahathir Science Award**, which was announced in March 2017 following a stringent vetting and shortlisting process by Academy of Science Malaysia Fellows and by an International Advisory Panel. **Professor Possingham, Professor Wilson** and **Dr Meijaard** from CEED are the first research group — rather than an individual — to win the award which recognises scientists, institutions or organisations worldwide for tropical research that has an impact on the well-being of society.

Justine Shaw

National 2017

Peer Prize for Women in Science

Dr Justine Shaw was honoured for her work as part of a multidisciplinary team, including 14 women, that contributed to the Species on the Move Thinkable submission, based on their research published in *Science*. They were led by Associate Professor Gretta Pecl of the University of Tasmania. The team included researchers from James Cook University, Monash University, Southern Cross University, University of Western Australia, University of Wollongong and University of New South Wales.

Awarded by the science and innovation website Thinkable.org and sponsored by The Sun Foundation Australia, the prize was voted on-line by researchers from around the world.

The $20,000 annual prize is designed to accelerate open knowledge exchange and cross-disciplinary innovation among women in science.

The team will use the prize money to support research and preparations for a follow-up Species on the Move conference to be held in South Africa in 2019, particularly to support women scientists.

Queensland

Young Tall Poppy Science Award

CEED Postdoctoral Research Fellow **Dr Alienor Chauvenet** received the award in August 2017.

The Young Tall Poppy Science awards are presented by the Australian Institute of Policy and Science to recognise early career researchers who produce outstanding research and who also actively engage in helping the community to understand science better. Dr Chauvenet and the other recipients will work with school students and teachers in a community outreach program to inspire the community and young people.

Alienor (left) with other recipients of the 2017 QLD Tall Poppy Awards. Photo: AIPS (twitter)

Dr Moreno Di Marco

Journal of Applied Ecology Editor's Choice Award

The editor of the *Journal of Applied Ecology* was so impressed with the species distribution maps and analysis undertaken by **Dr Moreno Di Marco** and his colleagues that he made their paper the Editor's Choice in issue 54. The Editor commented: "Protected Areas have been the 'big idea' of biodiversity conservation over the last one hundred years. The total area and the number of protected areas have increased dramatically from a handful in the 1900s to over 160,000 covering over 28 million km² today. However, they still only cover about 5.6% of the earth's surface which is not sufficient to slow down the extinction crisis.

Setting up new protected areas is a challenging task. One of the important aspects of the process is to minimise costs of effectively protecting an area with choosing an area to maximise the biodiversity inside. Di Marco *et al.* (2017) have made a valuable contribution to this optimisation problem. This paper is a fine example where a global-scale analysis has very practical value for site-specific conservation challenges such as protected area planning. Di Marco *et al.* also pave the way for future work to analyse the trade-offs for less-studied groups of species such as amphibians, reptiles and insects."

Read the entire blog at
https://jappliedecologyblog.wordpress.com/2017/03/17/editors-choice-542/

Maria Martinez Harms

Future Earth Natural Assets Knowledge-Action Network Development Team

CEED researcher **Dr Maria Martinez Harms** has joined the development team of the Natural Assets Knowledge-Action Network of Future Earth, which is a major international research and engagement organisation. Future Earth is building on the four global environmental change programs (DIVERSITAS, the International Human Dimensions Programme for global change research, the International Geosphere-Biosphere Programme and World Climate Research Programme) with a legacy of global research projects and networks.

It is a boundary organisation facilitating new, inter- and trans-disciplinary approaches to ensure that knowledge is generated in partnership with society and users of science.

It is open to scientists of all disciplines, natural and social, as well as people in engineering, the humanities and law. The Future Earth Secretariat comprises five global hubs, which function as a single entity, located in Montreal (Canada), Paris (France), Tokyo (Japan), Stockholm (Sweden) and Colorado (United States).

Supporting Management and Practice

Grow your own

There are five features that help collaborative wildlife gardening programs engage residents to manage their land to achieve landscape-focused conservation goals:

1. On-site garden assessment
2. Indigenous community nurseries
3. Communication hubs
4. A framework that fosters experiential learning and community linkages
5. Endorsement of each garden's potential conservation contribution.

The superb fairy-wren feeds on insects and small grubs, and will often appear in small groups in gardens with dense, low, native shrub cover. Photo: Geoff Park

Involving communities in appreciating and caring for nature is a key goal in most conservation strategies. How is this achieved, particularly in cities where ''nature'' is sometimes hard to come by? Wildlife gardening is one commonly suggested solution, but what ingredients make for a successful program?

Although the urban landscape is dominated by human activities and cannot be restored to a wild state, the persistence of native flora and fauna can be fostered. Effective native species conservation requires sympathetic management of plots of public and private land in a way that protects and improves patches of native habitat (generally on public land). This is enhanced by establishing protective buffers around them and improving connectivity between them through corridors and stepping stones in residential and other land-use areas.

Residents may feel this is the responsibility of experts and parks staff, or that they have little to offer. Yet residential gardens are important: they make up a large proportion of urban land, many community members have them, and they can provide habitat that is important for the survival of native species.

Currently there is little guidance on how best to involve residents in wildlife gardening and align their work with public land management.

To help fill this hole, the research looked at how a partnership between a local council (Knox City Council) and community group (Knox Environment Society — KES) in greater Melbourne involved residents in gardening to help conserve the biota native to the municipality. The wildlife gardening program, Knox Gardens for Wildlife (G4W), began in 2006 and currently has over 700 participating households (see **www.knox.vic.gov.au/g4w**).

Interviews were conducted with sixteen G4W members of varying ages, backgrounds and gardening experience who had varying property characteristics and had spent varying amounts of time in the program. The aim was to understand what program features motivated and supported the members to change their gardening to assist the council and KES to foster locally native (indigenous) species. The interview data was supplemented with a council survey of the G4W membership.

So, what motivates people to make an effort to get into wildlife gardening? Program features instrumental in supporting wildlife gardening are:

- an inspiring, face-to-face garden assessment;
- a community nursery to which members can return for advice and support;
- communication hubs, including the nursery and council offices;
- a framework that fosters experiential learning; and
- community linkages and endorsement by the council and KES of each garden's potential conservation contribution.

Interviewees with or without prior intention or knowledge of wildlife gardening became involved; what was common to all of them was an interest in keeping a garden.

The resulting conclusion was that wildlife gardening programs with community features can engage urban residents to manage their land to help council and community to conserve indigenous biota. The hands-on involvement of community members

and local government is critical to stimulate interest and support for municipal biodiversity conservation. Beyond stimulating and supporting members to create wildlife gardens, the program builds relationships between participating members, the community group and council around a shared interest in fostering the municipality's wildlife.

In part informed by research from this study, a pilot program called Gardens for Wildlife Victoria has been initiated to support urban local government-community group partnerships to engage residents in caring for nature through gardening and other habitat-improvement activities. A consortium that includes the Victorian Department of Environment, Land, Water and Planning, a regional catchment management authority and local government and community group members has been established to provide leadership. The consortium intends to help make Victoria's new biodiversity strategy understood and pragmatically applied in urban communities and to develop research tools and knowledge about how to facilitate community engagement in fostering biodiversity while strengthening social cohesion.

Reference

Mumaw L & S Bekessy (2017). Wildlife gardening for collaborative public-private biodiversity conservation. *Australasian Journal of Environmental Management.* http://dx.doi.org/10.1080/14486563.2017.1309695

Prescribed burning for multiple objectives

Reducing fuel around assets is considered a good hazard-reduction strategy. However, a more effective approach may be to burn for a mosaic throughout the ecosystem. This may reduce the overall fuel of the system, as well as having an added benefit for the environment.

Land managers and scientists increasingly recognise the importance of identifying areas for burning that not only reduce fuel load around assets but also effectively reduce the overall fuel load of the system.

CEED researchers are helping to identify these areas by developing a decision-support framework for planning prescribed burning. Applying this framework to the dry sclerophyll forests of south-east Queensland in collaboration with the City of Gold Coast the team has quantified the trade-offs between asset protection and conservation objectives and shown that it is possible to achieve good outcomes for conservation with minimal impact on asset protection.

The framework also improves asset protection by identifying a better distribution of prescribed burns in space and time. This work provides a transparent, objective and flexible framework that can be applied to many different prescribed burn scheduling problems at large spatial scales.

Reference

Williams BA, LP Shoo, KA Wilson & HL Beyer (2017). Optimising the spatial planning of prescribed burns to achieve multiple objectives in a fire-dependent ecosystem. *Journal of Applied Ecology*. http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12920/abstract

Introducing CEED Research Briefs: If you would like to read more about this research, check out our new CEED Research Brief on Williams et al, 2017. This is the first in a series of research briefs that CEED will be posting on its website over the coming months.

To weed or not to weed

Key messages:

- *Birds with varying sensitivities to urban areas interact in different ways with habitat restoration*
- *Revegetation provides the greatest benefit for urban-sensitive species, and weed control provides neutral, or in some cases, negative outcomes*
- *Weed control should be implemented in concert with replanting of native vegetation to provide understory structure*

Urbanisation drives the decline of birds in many cities. Land managers often manage green spaces as wildlife refugia. The value of some refugia was examined to find that not all forms of vegetation restoration serve the needs of the bird species preferably retained in our cities. The analysis suggests that careful thought is needed on which bird species are targeted in conservation efforts before plans are implemented.

Native bird species are in decline in many parts of our landscapes. That decline is even visible in our back gardens. Urban development, through intensification and expansion, poses a serious threat to wildlife living in green spaces scattered around cities. Protecting and restoring green spaces is important, as cities often overlay highly productive areas that are hotspots for biodiversity. Retaining native bird species is important in itself, and it is also one way to connect people to nature and to promote a conservation ethic in society.

Habitat restoration is an activity often undertaken by local councils, non-government organisations and environmental consultancies. A common goal often cited in these efforts is to ''increase biodiversity''.

One bird's 'weed' is another bird's refuge. Lantana, pictured here, is widely recognised as an undesirable and noxious invading weed, and its removal is often the aim of many restoration efforts. New research is suggesting this is not helping many species of urban-sensitive bird such as this chestnut-breasted manikin. Photo: Esther Horton – Van Der Woude

This goal is vague at best, as clearly some species can be viewed as more valuable conservation targets than others. Increasing populations of common birds like noisy miners and magpies probably is not synonymous with increasing populations of small songbirds such as fairy wrens and silvereyes. It is important to identify how individual bird species and groups of birds are interacting with habitat restoration actions to ensure these efforts are promoting the species that we want to inhabit our urban parks.

Habitat restoration is expensive to implement, and such effort is expected to benefit urban bird diversity. However, birds known to be sensitive to urbanisation may not interact with restoration in the anticipated ways. For example, controlling weedy plant species, such as lantana, and revegetating with native species are two common restoration actions, but how do they benefit different bird species? A survey of birds in restoration sites in Brisbane was undertaken to determine if these restoration actions were a benefit to the birds that found living in cities difficult; or if they simply benefited those species that had adapted well to urban environments (species that already call cities their home).

These sites are owned by local councils and maintained by community members, and the main form of restoration they have experienced is revegetation and weed control. A hierarchical community model was applied to estimate the response of different bird groups to these management actions. The three groups examined were classed as: urban exploitative, adaptable and sensitive bird species. This allowed creation probability curves of individuals and

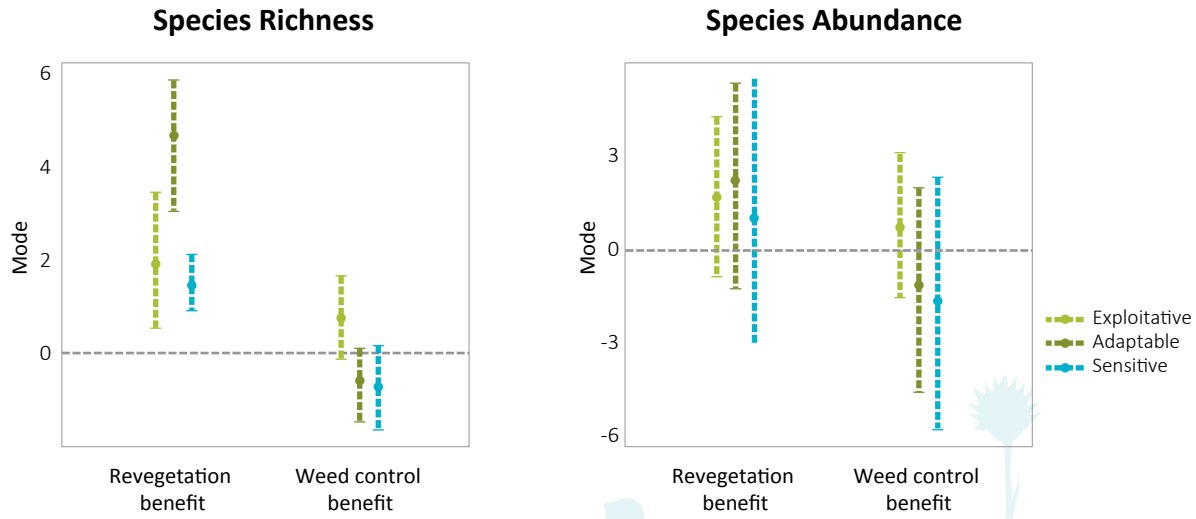


FIGURE 2 Species richness (a) and species abundance (b) of birds in the three urban classes for each restoration type—weed control and revegetation. Values represent mean and credible intervals, where by the proportion of the line above zero indicate positive responses to the treatment, and values below the line indicate negative responses.

Source: Archibald et al, 2017

species group responses to urban restoration. Providing probabilities of ''success'' for individual species and species groups expands the information available to land managers within their decision-making space.

Birds most reliant on nature in cities do not seem to benefit in patches that have been controlled for weeds, while birds that exploit the urban environment do benefit. These shifts in diversity might relate to the possibility that shrubby habitat, whether native plants or exotic weeds, is needed by bird species that are sensitive to urban landscapes. Or it could be an effect of territorial species such as noisy miners infiltrating and displacing birds in these areas. The outcome could have serious implications for urban bird diversity, which may have flow-on implications for the way in which cities experience and relate to nature.

Revegetation, on the other hand, appears to benefit all groups of species, even though some individual species may suffer declines in abundance.

Habitat restoration is a common conservation practice in cities; with a lot of time, money and effort invested into making it happen (especially in community managed spaces). To achieve a greater conservation benefit from these areas, especially for birds that rely on green spaces, a change in the implementation of these actions is needed. To increase bird diversity within cities, it is necessary to disentangle the effect of different types of habitat restoration and make sure management of these areas occurs with urban-sensitive species in mind.

Reference

Archibald CL, M Mc Kinney, K Mustin, DF Shanahan & HP Possingham (2017). Assessing the impact of revegetation and weed control on urban sensitive bird species. *Ecology and Evolution* 00: 1–10. https://doi.org/10.1002/ece3.2960

A silvereye amidst the (lantana) thorns. Photo: Jasmine Zeleny

Lines in the sand

Key messages:

- *We digitised anthropogenic disturbances in the Great Western Woodlands to estimate the cumulative development footprint*
- *We discovered that the majority of the development footprint in the region consists of roads, tracks and other linear infrastructure (an estimated 150,000 km exists in the region; half has never been mapped)*
- *This study highlights the pervasiveness of linear infrastructure and the importance of managing its cumulative impacts*

Most of the developmental impact on the Great Western Woodlands is in the form of linear infrastructure such as roads and tracks. The region is criss-crossed by around 150,000 km of them, half of which don't appear on maps. Photo: Keren Raiter

How do you quantify the development footprint in a large but poorly mapped area? And how do you understand the drivers of development impact, and how these drivers interact, to better provide information that informs the long-term management and conservation of natural values in a region?

Increasing population and scarcity of natural resources are pushing development further into areas that have, until recently, remained relatively intact. Accounting for such impacts is essential for mitigating them, although it can be a challenging task.

Consider the Great Western Woodlands in south-western Australia. While this is the world's largest remaining temperate woodland, few people (including most Australians) have ever heard of it, and it is under threat from myriad developments.

A special place

The Great Western Woodlands are special for many reasons. The woodland is home to a fifth of Australia's eucalypts, more than 3000 flowering plant species (many of which are endemic to the region), and it provides a refuge for many species that have become locally extinct from the adjacent, heavily cleared, WA wheatbelt. Located in the interzone between the continent's arid interior and the relatively wet south-west, the region consists of large expanses of diverse eucalyptus woodlands, shrublands, salt lake systems, banded ironstone formations and mallee vegetation. It is also the driest place in the world where tall woodlands such as this occur. What is more, the region remains largely intact and functions ''naturally''. It has been identified in some studies as a national and international priority for conservation, but the natural values that make the region so important are under attack. Large parts of the region have been degraded by timber harvesting, stock grazing and the invasion of exotic species. It is also a rich mineral province with widespread gold, nickel, and iron ore reserves. Mineral exploration and extraction bring their suite of impacts. More than half of the region is covered by over 5000 active mineral tenements. There are over 330 operating mines and more than 100,000 abandoned mines dotting the landscape, and the Western Australian Government is actively promoting the state as a desirable mining destination.

Estimating the footprint

The anthropogenic footprint of the various developments in the region has never before been estimated, and the area was poorly mapped. To understand what was at play, we created a stratified, almost-random set of sample areas (each of ~490 km^2) to represent a range of mining activities in areas with and without pastoral activity. High-resolution aerial imagery was then used to manually digitise all the anthropogenic disturbances that we could see. Disturbances were digitised as either ''hubs''

An aerial view of exploration grid lines associated with mineral exploration. The grids pass through shrubland and woodland vegetation. The white dots are drill pads. Photo: Landgate

Keren Raiter in the Great Western Woodlands, the largest remaining temperate woodland in the world. The woodlands face multiple threats but also present an outstanding opportunity for large-scale conservation. Photo: Keiran Golby

(e.g., mine pits, waste rock dumps, mining villages, dams and tailings dumps), or ''linear'' (i.e., roads, tracks, railways, exploration gridlines and fence lines). The results were used to estimate the total development footprint and length of linear infrastructure for the entire region. A set of analyses were conducted to identify the key drivers of the development footprint and estimated what proportion of the surrounding landscape was likely to be affected by edge effects from the developments we observed. Unmapped linear infrastructure, only detectable through manual digitisation, accounts for the greatest proportion of the direct development footprint. Across the 160,000 km^2 expanse of the Great Western Woodlands, the estimated development footprint is 690 km^2 of which 67% consists of linear infrastructure and the remainder being ''hub'' infrastructure. An estimated 150,000 km of linear infrastructure exists in the study area, equating to an average of 1 km per km^2. Beyond the direct footprint, a further 4000–55,000 km^2 (3–35% of the region) lies within edge effect zones. The principal factor found to significantly predict the extent of development footprints in the Great Western Woodlands was mining activity. Pastoral grazing was also found to be a significant predictor of development footprints, but it also had other interesting interactions. It became clear that at low mining project densities development footprints are more extensive in pastoral areas, but at high mining project densities the development footprints tend to be smaller on pastoral tenure compared with non-pastoral areas.

Good neighbours?

It was expected that the effect of pastoral activity and mining would be approximately cumulative, so this result came as a surprise. It may reflect the ''good neighbour policy'' and related codes of conduct whereby there is a stronger onus on exploration companies operating within pastoral leases to use existing roads where possible and rehabilitate all cleared areas once the exploration is complete. This finding indicates that there is substantial scope for development proponents to reduce footprints outside of pastoral leases. Other factors affecting development footprints included proximity to a town, greenstone lithology, clearing restrictions and the presence and type of a conservation estate.

This study demonstrated the extensive and largely unmapped nature of anthropogenic disturbance in the world's largest remaining temperate woodland. It highlighted the dominance of linear infrastructure as a component of the development footprint and the large potential extent of edge effects, although large tracts of largely undisturbed vegetation do remain and can be conserved. Targeted manual digitisation of direct development footprints in stratified sample areas combined with spatial analyses and hypothetical edge effect zones gleaned from the literature, allowed for a relatively comprehensive quantification and characterisation of actual and potential ecological impacts. Mining activity was identified as the main predictor of development footprints. Around the world, there is a proliferation of development infrastructure (especially linear infrastructure) in otherwise traditionally remote locations. Our study concludes that both direct and offsite ecological impacts of linear infrastructure should be explicitly considered in environmental impact assessments (including cumulative EIAs), land-use and impact assessments, land-use and conservation planning and in monitoring.

Reference

Raiter KG, SM Prober, RJ Hobbs & HP Possingham (2017). Lines in the sand: quantifying the cumulative development footprint in the world's largest remaining temperate woodland. *Landscape Ecology* 32: 1969–1986. https://doi.org/10.1007/s10980-017-0558-z

Fire in the foothills

Key messages:

- *Important insights can be gained by modelling how fire regimes, not just fire events, influence biota in forests*
- *Management of fire regimes needs to be complemented by an understanding of the underlying environmental gradients and key elements of habitat structure that influence resource availability for plants and animals*

''Foothill forests'' cover approximately 7.5 million ha in the state of Victoria (see Figure 3) and encompass broad gradients of temperature, rainfall and vegetation type. Along these gradients, fires create mosaics of vegetation with different disturbance histories relating to the time between fires, fire type and spatial pattern in the landscape.

The forests are a priority for fire management containing significant biodiversity and posing fire risks to people and property. So how do you manage a major natural disturbance such as fires when they occur across a broadscale environmental gradient found in foothill forests?

This study brought together data from six major studies (representing more than 600 biodiversity survey sites) to provide a more complete picture of the links between biodiversity, fire regimes and environmental gradients in foothill forests (Kelly *et al.*, 2017).

The aim was to advance fire ecology by quantifying species responses to recurrent fires, by modelling species responses to a greater range of fire regimes and environmental gradients and by comparing species-environment relationships between multiple taxonomic groups in one ecosystem.

A typical scene in the foothill forests of Victoria. In the morning mist this patch of woodland doesn't look particularly fire prone but the blackened trunks, open canopy and epicormics buds (leaves sprouting from the main tree stem) suggest a major fire has passed through here recently. Indeed, this image was captured some 15 months after large wildfires seared parts of central Victoria. The foothill forests cover a wide range of environmental conditions. How do you manage for fire in such situations? Photo: Steve Leonard

Species distribution modelling of 32 bird species (493 sites), three small mammal species (175 sites) and 77 vascular plant species (615 sites) showed that common to animals and plants was a strong influence of broad temperature and rainfall gradients. For example, a suite of species was closely associated with high rainfall (e.g., silver wattle, Tasman flax lily, yellow-faced honeyeater), whereas others were associated with low rainfall (e.g., small grass tree, white-eared honeyeater).

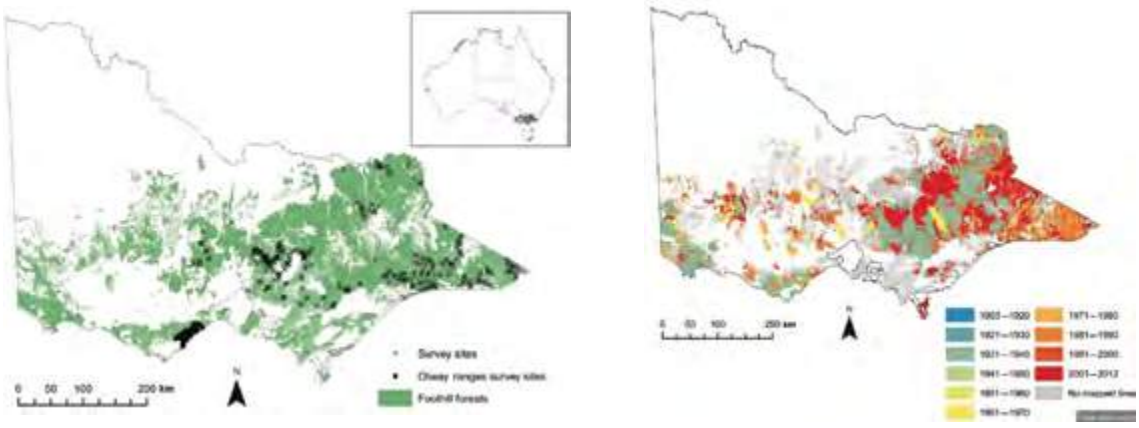


FIGURE 3 Extent of foothill forest vegetation in Victoria and (right) fire history of foothill forest.
Source: Kelly et al, 2017

Fire interacted with these environmental gradients and shaped species distributions. Building on previous work the analysis showed that interactions between fire, climate and vegetation type influenced the distributions of plants and animals: with species having different responses to fire along broad rainfall and temperature gradients (e.g., narrow-leaved wattle and Australian king parrot).

Most fire ecology studies model the effects of fire on plants and animals by using time since the most recent fire. These results underscore the important insights that can be gained by modelling how fire regimes, not just fire events, influence biota in forests. Inter-fire interval (i.e., the average number of years between successive fires at each site) was the most influential component of the fire regime on both plants and animals. For example, the occurrence of vascular plants such as messmate and prickly currant bush was associated with longer inter-fire intervals, in addition to gradients in local vegetation types.

Multiple characteristics of fire regimes influenced the distribution of forest species. Time since fire also influenced vertebrates, particularly bird abundance, more than plants.

Of the species that responded to time since fire, most were associated with older fire ages (e.g., rose robin, golden whistler, yellow-faced honeyeater). The insectivorous flame robin was one of few vertebrate species that was most likely to occur in recently burnt vegetation.

As predicted, animals closely associated with direct measures of habitat structure, such as tree diameter and leaf litter, were those most strongly influenced by fire regimes. Species distribution models including habitat structure had a moderately higher model fit and predictive ability than those using fire regime variables. For example, the flame robin was more likely to occur in open areas. It is likely that resources available in the more open understorey of recently burnt forests drive this species' relationship with time-since-fire.

Foothill forests are dominated by trees that rapidly recover from wildfires and, on the whole, the results show that common plant and animal species in foothill forests are likely to be tolerant of wide variation in fire regimes. However, although many plants and animals in these forests are resilient to variation in current fire regimes, the potential for large wildfires at shorter intervals, associated with a warmer and more extreme climate, warrants attention from both scientists and land managers.

Managing fire for biodiversity conservation is becoming increasingly important in forests worldwide. This work in the foothill forest ecosystem in south-eastern Australia usefully illustrates several points applicable to other forest areas with high biodiversity, flammable vegetation and that are experiencing growing use of prescribed burning.

First, this study shows that understanding fire regimes, not just fire events, is important for managing plants and animals in forests. Forest managers are recommended to go beyond simple measures of fire events and develop strategic objectives for plants and animals based on fire regimes.

Second, fire regimes in forests need to be understood and managed in the context of environmental gradients, even within a single forest type. Variation along environmental gradients is linked to biodiversity and influences management options and the effectiveness of fire suppression and prescribed burning.

Finally, it is necessary to complement management of fire regimes with an understanding of the key elements of habitat structure that influence resource availability for plants and animals. Species relationships with fire regimes may be easier to translate into management plans, but this approach risks missing key habitat components on which taxa depend.

Reference

Kelly LT, A Haslem, GJ Holland, S Leonard, J MacHunter, M Bassett, AF Bennett, MJ Bruce, EK Chia, FJ Christie, MF Clarke, J Di Stefano, R Loyn, MA McCarthy, A Pung, N Robinson, H Sitters, M Swan & A York (2017). Fire regimes and environmental gradients shape vertebrate and plant distributions in temperate eucalypt forests. *Ecosphere* 8: e01781. http://onlinelibrary.wiley.com/doi/10.1002/ecs2.1781/abstract

The flame robin (Petroica phoenicea) is an insectivore that feeds from open ground. Statistical analysis showed that it was one of few vertebrate species more likely to occur in recently burnt vegetation. Photo: Rohan Clarke

Choosing between options with limited resources

Key messages:

- *Decision scientists working with national park managers have developed a user-friendly Cost-Effective Resource Allocator*
- *The allocator prioritises the set of management strategies that maximise the total number of years that a suite of species is expected to persist given a constrained budget*
- *The allocator uses a series of linked Microsoft Excel worksheets and can be used to analyse up to 50 candidate management strategies for a total of 30 species*

Faced with increasing rates of biodiversity loss and modest conservation budgets, it is essential that natural resource managers cost-effectively allocate their limited resources. While numerous excellent strategies have been formulated by conservation scientists to guide managers many of these frameworks are highly technical and require significant skill to implement. It is a concern that many managers have to make critical resource-allocation decisions every day and either don't have access to the expert skills or aren't even aware of the research.

CEED researchers have developed a reliable and user-friendly decision tool which only requires the ability to run a Microsoft Excel spreadsheet. The Cost-Effective Resource Allocator was developed in conjunction with national park rangers based on Christmas Island in the Indian Ocean and Kata Tjuta National Park in Australia's arid interior to solve their specific problems (see Figure 4).

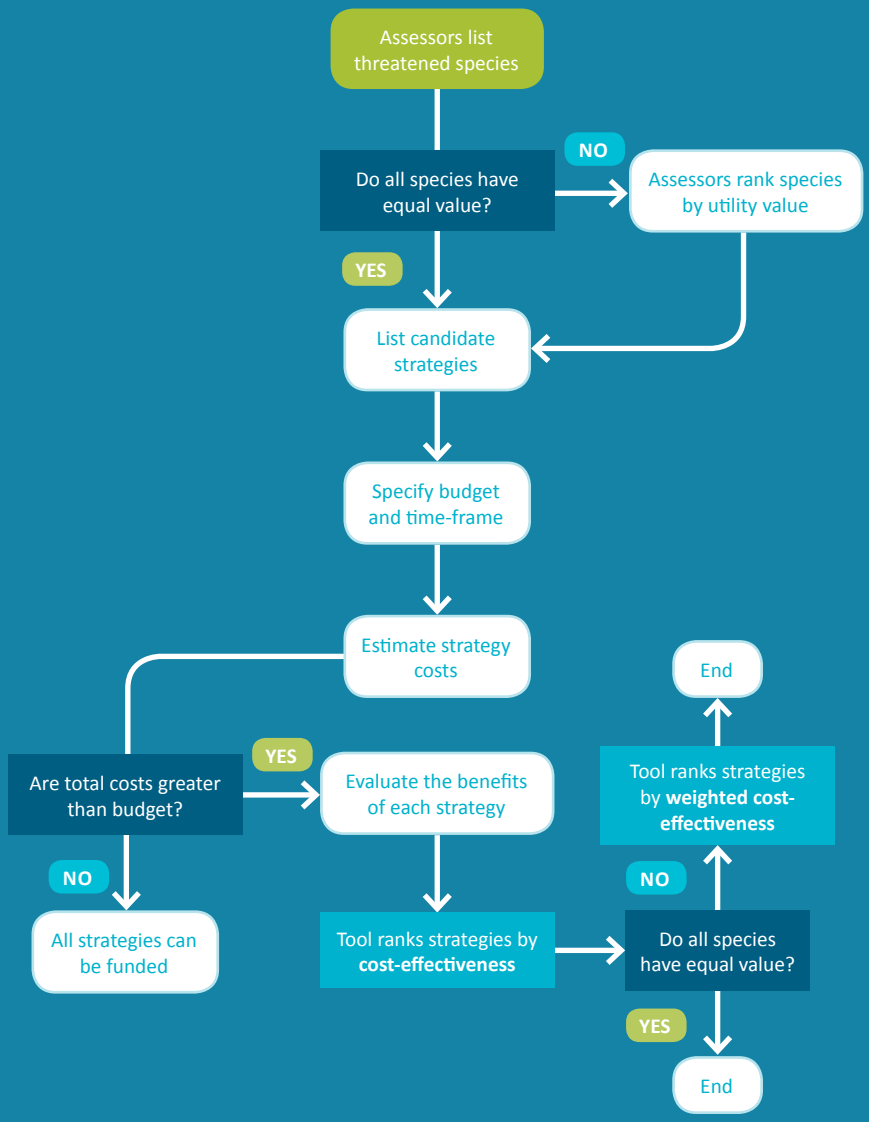


FIGURE 4 Flowchart representing the steps involved in the 'Cost-Effective Resource Allocator' Decision support tool.

The association with CEED researchers and officers from Parks Australia began several years ago with a joint workshop to discuss a range of challenges being faced in national parks around Australia. One recurring theme was how does a manager choose between different options to protect different species?

The approach follows that outlined in the Project Prioritisation Protocol, a cost-effectiveness framework that compares the benefit and cost of different actions to save threatened species.

The mass migration of red crabs on Christmas Island is one of the natural wonders of the world. But the red crab and many other species on this isolated island are under threat. Given limited resources, how do Christmas Island National Park managers choose between multiple actions to protect multiple species? Photo: Max Orchard, Parks Australia

"The tool provides users with a transparent decision-making process for determining which on-ground conservation strategies should be funded to maximise the number of expected years of persistence for a set of threatened species, while taking into account assessors' uncertainty and distinctions in the value attributed to different species," explains Dr Martina Di Fonzo, the lead researcher on the project.

To demonstrate how the tool works, the team used a case-study of four locally threatened species from the Christmas Island National Park. These were a native fern *(Pneumatopteris truncata)*, the Christmas-Island red crab *(Gecarcoidea natalis)*, the golden bosun bird *(Phaethon lepturus fulvus)*, and Abbott's booby *(Papasula abbotti)*. Under a hypothetical total budget of approximately $9 million over 10 years, in which all species are considered to be equal, the tool recommends funding fern propagation and planting, rat control, cat control and surveying and controlling the yellow crazy-ant *(Anoplolepis gracilipes)*.

"We found that the cost-effectiveness rankings of these strategies were sensitive to the importance that assessors' assigned to different species," comments Di Fonzo.

"Just as important as the results the tool came up with was the ease of using it. We developed this tool with the input of a group of potential users from two Australian Commonwealth National Parks (Uluru-Kata Tjuta and Christmas Island National Parks), and refined it based on further feedback from two park staff (one of whom had no prior experience of the tool)."

While the tool was valuable in choosing between management actions on Christmas Island, it can be used in any management situation involving choice and a limited budget.

"The tool can accommodate input from up to eight assessors and can be used to analyse a maximum of 50 candidate management strategies for a total of 30 species," explains Di Fonzo.

"We encourage the input of multiple assessors. This avoids overconfidence and encourages collective decision-making (which is appropriate for many decisions).

"It can be expanded to include more assessors, strategies and species if required. We recommend that the tool is operated by a single assessor/expert, charged with eliciting information from the remaining experts using the instruction sheets (see Di Fonzo *et al.*, 2017)."

References

Di Fonzo MMI, S Nicol, HP Possingham, S Flakus, JG West, L Failing, G Long & T Walshe (2017). Cost-Effective Resource Allocator: A decision support tool for threatened species management. *PARKS Journal* 23: 101–113. http://parksjournal.com/wp-content/uploads/2017/04/PARKS-23.1-Di-Fonzo-et-al-10.2305IUCN.CH_.2017.PARKS-23-1MMIDF.en_-1.pdf

The Microsoft Excel tool and further supplementary material can be downloaded from *PARKS Journal* 23.1: http://parksjournal.com/parks-23-1/

Devil facial tumor disease threatens the survival of wild populations of the Tasmanian devil. The disease is believed to be transmitted through biting and causes tumors on the face or inside the mouth. Once tumors develop, death typically occurs within months. The disease was first detected in NE Tasmania in 1996 and has since spread across most of the devil's habitat, resulting in an 80% decline in wild populations. Photo: Menna Jones

Monitoring for diseased devils

CEED researchers from the Universities of Melbourne and Queensland working with the Save the Tasmanian Devil Program have developed a user-friendly model to help managers decide whether an area is free from devil facial tumour disease.

Led by Dr Tracy Rout, the researchers modelled the removal of a diseased Tasmanian devil population from Forestier Peninsula (Tasmania) and analysed the costs and benefits of declaring the area disease-free before the reintroduction and establishment of a healthy insurance population (Rout *et al.*, 2017).

"I think it's a great example of scientists and practitioners working together to ensure on-ground decisions are informed by up-to-date modelling and decision analyses," says Tracy. "We developed a model that can be run from an Excel spreadsheet, so the management team could use it to plan monitoring intensity while in the field."

Reference

Rout TM, CM Baker, S Huxtable & BA Wintle BA (2017). Monitoring, imperfect detection, and risk optimization of a Tasmanian devil insurance population. *Conservation Biology*. http://onlinelibrary.wiley.com/doi/10.1111/cobi.12975/full

Informing Policy with Science

Urban development and the growling grass frog

Key messages:

- *Linking a population viability analysis (PVA) with a cost-effectiveness analysis (CEA) determined which actions would best help the growling grass frog persist in a development zone*
- *The approach allows uncertainty in species persistence to be explicitly accounted for in the CEA of different actions*
- *This analysis found that simply reserving core habitat for the frog entailed high risk*
- *Creating and maintaining wetlands dedicated to the growling grass frog is a better way to go*

How are choices made among conservation options when resources are scarce, and there is uncertainty regarding the effectiveness of actions?

It is the core challenge of good environmental decision-making, and its dimensions make more sense when applied to a specific situation. In this study, the actions that would give the endangered growling grass frog (*Litoria raniformis*) a better chance to persist in the developing urban zone around Melbourne were explored by linking a PVA with a CEA (Rose *et al.*, 2016). While this approach had been used in other places, no-one had adequately accounted for uncertainty in such integration.

Well-developed tools exist for prioritising areas for one-time, binary actions such as making a plot of land a protected area (or not), but methods for prioritising incremental or ongoing actions (such as creating or maintaining habitat) remain uncommon. An approach was devised that combines metapopulation viability and cost-effectiveness analyses to select among alternative conservation actions while accounting for uncertainty.

In this study, cost-effectiveness is the ratio between the benefit of an action and its economic cost, where the benefit is the change in metapopulation viability. The interest here was in the metapopulation of the endangered growling grass frog, which is threatened by urban development such as in the rural north of Melbourne, Victoria.

Extending this analysis using a Bayesian model to predict metapopulation viability under nine urbanisation and management scenarios and incorporate the full probability distribution of possible outcomes for each scenario into the cost-effectiveness analysis. This allowed distinction between cost-effective alternatives that were robust to uncertainty and those with a relatively high risk of failure.

A relatively high risk of extinction following urbanisation occurred only if the action was reservation of core habitat (which is often the only thing that happens in these situations). Actions that foster the creation of habitat performed better than enhancement actions and cost-effectiveness ranking changed depending on the consideration of uncertainty.

The results suggest that the creation and maintenance of wetlands dedicated to the growling grass frog is the only cost-effective action likely to result in a sufficiently low risk of extinction. This is the first study to use Bayesian metapopulation viability analysis to explicitly incorporate parametric and demographic uncertainty into

The growling grass frog is one of Australia's largest frog species. It likes to live amongst reeds, sedges and rushes growing in and along slow moving streams, ponds, lakes and farm dams. Photo: Geoff Heard

a cost-effective evaluation of conservation actions. The approach offers guidance to decision-makers aiming to achieve cost-effective conservation under uncertainty.

The most satisfying outcome from this work is that it has had a real influence on the decisions made by key decision-makers involved in the case study. Both Melbourne Water and the Victorian Government have read the work and contacted the research team for advice about how to modify plans in the area so that these findings are taken into account.

This gives the growling grass frog a far greater chance of hanging in there. It also highlights the importance of strengthening networks and sharing knowledge among practitioners, government and academia. In addition to making the findings public through the traditional peer-reviewed publishing process, direct communication with Melbourne Water at the beginning and end of the study (through discussions and a presentation) drove changes in decision-making.

Reference

Rose LE, GW Heard, YE Chee & BA Wintle (2016). Cost-effective conservation of an endangered frog under uncertainty. *Conservation Biology* 30: 350–361. doi: 10.1111/cobi.12626 http://onlinelibrary.wiley.com/doi/10.1111/cobi.12626/abstract

The April 2014 bushfires in central Chile. Photo: Patricio Novoa Quezada, FlickrCC BY-NC 2.0

After Chile's fires

CEED researchers have recently published a letter in *Science*, in the wake of devastating fires through central Chile.

Recent large-scale wildfires have affected almost 1000 km² of native forest in Mediterranean Chile (a globally threatened biodiversity hotspot). In the aftermath of the fires, the government plans to restore the Mediterranean landscape with native forest on public land. However, almost all of the native forest affected by the fires occurs on private land. Researchers Maria Martinez-Harms, Hernan Caceres, Duan Biggs and Hugh Possingham make an urgent call to the Chilean government to facilitate the restoration of native forest on private land through government compensation to landowners. Central Chile is particularly sensitive to climate change, and the recent fires highlight the need for a robust landscape-scale institutional response to reduce the risk fire poses to people, ecosystem services and biodiversity in Mediterranean native forest.

Reference

Martinez-Harms MJ, H Caceres, D Biggs and HP Possingham (2017). After Chile's fires, reforest private land. *Science* 356:147–148. http://doi.org/10.1126/science.aan0701.

Humpback whale. Photo: Viv Tulloch

Viv Tulloch presents at the International Whaling Commission

Dr Viv Tulloch recently completed her PhD with CEED working on several different threat-management problems in collaboration with the Wildlife Conservation Society, The Nature Conservancy, CSIRO, and the International Whaling Commission (IWC).

At the May 2017 IWC Scientific Meeting in Slovenia, she presented findings from the multi-species model developed during her PhD. The model explores interactions between krill and five key baleen whale species that feed on krill and predicts the future recovery of the whales given changes in primary productivity caused by climate change.

"The model presents an updated assessment for blue, fin, humpback, right and minke whales," says Tulloch.

"It provides a basis for exploring ecosystem dynamics in the Southern Hemisphere. Results demonstrate key differences in population trajectories and estimates between models that account for or ignore, predator-prey linkages.

"This is a strategic model that provides a platform for exploring additional hypotheses and management strategies, and it is being modified in a step-wise fashion to explore predator-prey interactions and the effects of future environmental change on krill and whales."

The International Whaling Commission. Photo: Viv Tulloch

Of bandicoots and ecosystem processes

UWA's Leonie Valentine and co-authors examined how small-scale digging activities of the southern brown bandicoot (*Isoodon obesulus*) influence broader-scale landscape processes by modifying soil and litter properties, trapping organic matter and seeds and altering seedling recruitment.

Valentine and colleagues examined the environmental characteristics of the bandicoot's foraging pits and found they typically contained a higher moisture content and lower hydrophobicity than undisturbed soil; as well as higher amounts of fine litter material and lower amounts of coarse litter.

The quenda or southern brown bandicoot (Isoodon obesulus). Photo: Leonie Valentine

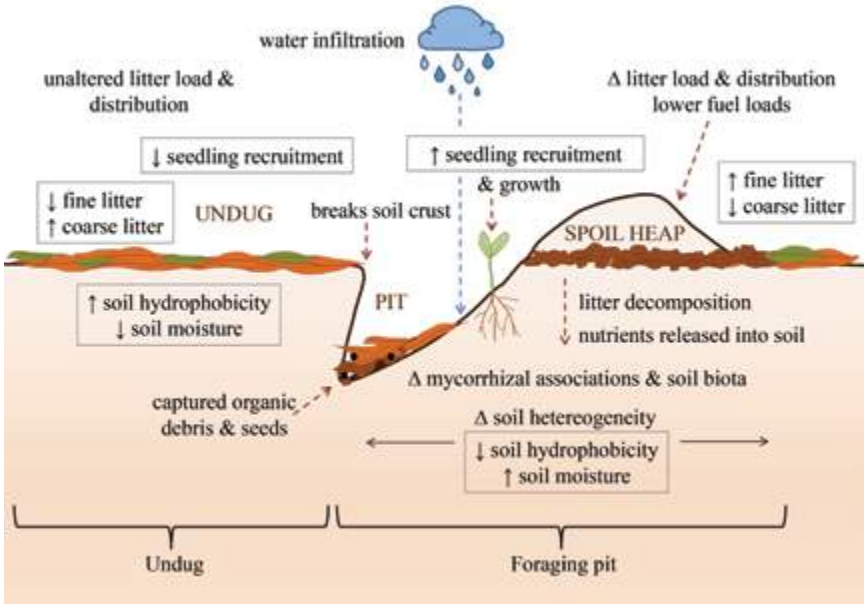


FIGURE 5 Schematic representation of how a foraging pit may alter biotic and abiotic processes (modified from Figure 1 of Valentine 2014). The enclosed boxes represent results detected during our study comparing attributes between a bandicoot foraging pit and adjacent undug ground. The area surrounding the foraging pit contains lower soil hydrophobicity, higher soil moisture, a higher proportion of fine litter and lower proportion of coarse litter (within the first 3 months of creation) and more seedling recruitment than adjacent undisturbed ground. Foraging pits may also capture organic debris and seeds, while the spoil heaps may enhance litter decomposition, potentially releasing nutrients into the soil and alter fuel loads (Valentine 2014). As the foraging pit ages, the spoil heap erodes into the pit, potentially covering captured seeds and providing sites for recruitment.

Source: Valentine et al. *2016*

Foraging pits are likely to provide a conducive microhabitat for litter decomposition, potentially reducing litter loads and enhancing nutrient decomposition. Seedling recruitment for native plant species was also higher in areas with artificial diggings.

The majority of Australian digging mammals are threatened with many suffering substantial population and range contraction. However, their persistence in the landscape plays an important role in maintaining the health and function of ecosystems.

Reference

Valentine L, M Bretz, KX Ruthrof, R Fisher, GE Hardy & PA Fleming (2016). Scratching beneath the surface: Bandicoot bioturbation contributes to ecosystem processes. *Austral Ecology* e-view doi:10.1111/aec.12428.

Stewardship: More than just dollars and cents

Key messages:

- *While financial incentives may be important for increasing uptake of private land conservation, they do not necessarily engender stewardship values*
- *Private land programs would be better served by focusing on proper implementation, continued extension support, building capacity to manage lands for biodiversity and creating networks between landowners*
- *A multiple-mechanism mix will enhance the potential for long-term ecological benefits*

BSP landowner surveying their privately protected area near Paarl, South Africa. Photo: Matthew Selinske

Recognition of stewardship efforts, such as this BSP sign, are another important ingredient for ensuring program satisfaction. Photo: Matthew Selinske

Changing human behaviour is fundamental to the success of conservation programs. Fostering an ethic of ''stewardship'' on private land is one form of behaviour change increasingly being sought to protect key biodiversity areas. When planning private land conservation (PLC) initiatives, multiple incentives are employed to attract landowners into short-term and long-term conservation contracts.

These varied incentives are used to entice different types of landowners. They also cater to the different motivations or drivers landowners have for participating. Given the long-term horizons for biodiversity conservation, we were curious to discover which incentives contributed to long-term stewardship. Long-term outcomes are important given uncertain political support for conservation initiatives across many local- and national-level governments.

This research sought to understand how programs and their incentives contributed to participation and the continued management of lands for biodiversity. Interviews of 113 landowners were conducted across three different program types and contexts:

- the Biodiversity Stewardship Program (BSP), a long- and short-term conservation contract program in the Western Cape of South Africa
- the Greenfleet biodiverse carbon-offset program in Victoria, Australia
- EcoTender, a reverse auction and covenanting program run by the Victorian Government.

Why do people participate in private land conservation?

Across the three studied programs, landowners have a pre-existing stewardship ethic that forms the basis of an environmental identity (this finding is supported by previous research). Financial incentives may help in increasing participation by reducing barriers to uptake and to pay for management projects, but for participants across these three programs financial incentives were not the main driver to participation. Over 90% of respondents participate because they care about their land and have a desire to restore and protect it (often in perpetuity). The mechanism that protects the land (such as a covenant or easement) becomes the main incentive to join. As one EcoTender participant put it: “Because [the restoration is] something I would have done anyway, but I think the real bait for me was the covenant. If I did all this [work] and

*Pincushion (*Leucospermum cordifolium*) on BSP land near Cape Town, South Africa. Photo: Matthew Selinske*

after I've gone somebody buys the land and knocks it all over, what's the point [of restoration]?"

What drives continued participation and management?

Common themes emerged when investigating what drives continued participation among the three programs. Satisfaction with the program was overwhelmingly dependent on continued delivery of management support and perceived efficacy of program participation.

In the Biodiversity Stewardship Program, those that were dissatisfied felt that they had ''held up their end of the bargain'' but the implementing agency had not; its input had amounted to very few visits by an extension officer.

Across all three programs, landowners wanted more extension support to help build their capacity in managing their land, supporting their sense of self-efficacy, which is vital to behaviour change. In both the Victorian programs, the advice and assistance provided to landowners through property visits from extension officers ranked as an important aspect of the program, but it happened informally as there was not a formalised role for extension support.

Networks of connection

Landowners also wanted to be connected to other landowners to share ideas and provide support for each other. Engagement with like-minded landowners is key to the continued reinforcement of the stewardship ethic and adaptive management. Programs unable to support landowners with continued extension visits would be wise to facilitate and build landowner networks, to pass management information through and establish communities of support.

As with most conservation initiatives, the research suggests looking towards longer-term impacts and forecast changes that may change biodiversity benefits. In the private landowner context, this is fundamental. Simply signing landowners up to conservation contracts is not sufficient. Consideration of what drives landowners to continue participation in conservation activities is needed. Financial incentives may be instrumental for uptake but are not suitable as the backbone of a program for long-term conservation. The kay recommendation is to embrace multiple approaches to private land conservation with an awareness of what capacities landowners need to continue to make the right decisions for biodiversity.

This work has had an impact on the thinking of South African conservation planning, and as a result additional enrolment has been delayed until all current landowners can be properly supported with extension support.

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What is stewardship?

The definition of ''stewardship'' varies from place to place and person to person. In a general sense, it relates to people taking responsibility for the many values of a landscape usually with the aim of ensuring those values persist for subsequent generations.

The South African Biodiversity Stewardship Program sets out its vision of stewardship like this:

- To ensure that privately owned areas with high biodiversity value receive secure conservation status and are linked to a network of other conservation areas in the landscape.
- To ensure that landowners who commit their property to a stewardship option will enjoy tangible benefits for their conservation actions.
- To expand biodiversity conservation by encouraging commitment to and implementation of good biodiversity management practice on privately owned land in such a way that the landowner becomes an empowered decision-maker.

www.capenature.co.za/care-for-nature/stewardship

Swings and roundabouts and private land conservation

Key messages:

- *The effectiveness of a conservation revolving fund for land acquisition relies on selecting the right properties*
- *While conservation factors are important, financial and social factors are also highly influential with a major determinant being whether the property can be on-sold within a reasonable timeframe, and at a price that replenishes the fund*
- *To facilitate the on-sale process, it is common for selected properties to include the potential for the construction of a dwelling*

Much private land holds considerable conservation value. Purchasing land and locking it up in a reserve is an expensive option. Encouraging owners to sign up to conservation contracts can be more cost effective. Revolving funds provide a unique, self replenishing approach to make this happen. Photo: Mat Hardy

Acquiring private land with significant conservation value (and then protecting it) can be a powerful way to protect important species and ecosystems. But this approach can be expensive, particularly in areas where land values are high.

An alternative to buying the land and making it a reserve is to enter into permanent agreements with private landholders. Such agreements, such as conservation covenants or easements, restrict both current and future landowners from conducting activities that would be harmful to their land's ecological value. In recent years, some conservation organisations have developed an innovative approach that integrates targeted land acquisition with permanent conservation agreements, drawing on the use of a revolving fund.

A revolving fund is a pool of money that conservation organisations can use to acquire land with high conservation value as it becomes available for purchase. The organisation then ''on-sells'' the land to conservation-minded owners including the condition that the new owners enter into a conservation covenant or easement. Owners of existing land can't be ''forced'' to enter a conservation agreement, but anyone wanting to purchase these revolving-fund blocks needs to agree to enter a covenant as a condition of buying the land.

The proceeds from the sale are then used to purchase, protect and on-sell additional properties, incrementally increasing the amount of protected private land. It is a great way to buy and conserve land that needs protecting, while also being able to recover costs, and then go out and do it all again.

The beauty of the revolving-fund approach is that it is potentially self-sustaining. However, the effectiveness of this approach is based on selecting the right properties. In a general sense, a ''good'' property shouldn't cost too much to purchase, should possess features of high conservation value and should be desirable enough to attract new buyers, even with the requirement of entering into a conservation covenant. If these conditions aren't met, then the revolving fund might start shrinking or be less effective in delivering worthwhile conservation outcomes.

But how do these requirements translate into specific day-to-day decision-making for the various revolving funds in operation? The approach must be working, as almost 146,000 ha have been protected. But until this study, no-one had explored the various factors that influenced the property selection decisions being made.

Semi-structured interviews were conducted with managers from each of the five major revolving funds in Australia to explore how they go about choosing properties. They were

asked about the factors they currently considered when buying properties for the scheme and how these factors were integrated into their decision-making.

Pulling out the common themes from the managers' responses revealed that, while conservation factors are of course important, there are also some financial and social factors in the mix with a major determinant being whether the property can be on-sold within a reasonable timeframe and at a price that replenishes the fund. This makes sense if you are trying to turnover properties and protect as much important land as possible.

There are several challenges surrounding these decisions. Managers are faced with clear trade-offs between conservation, financial, amenity and other factors. For example, there is a need for managers to make sure there is room on the land for the new owners to build a house if they wish to, without compromising the ecological integrity of the property. The study identified ways that managers work through these trade-offs and mitigate the risks of using revolving funds to conserve private land.

Managers have a huge wealth of on-the-ground experience in making the revolving fund approach work as documented by this study to help others who are either running or considering setting up a private land conservation revolving fund.

Based on the commonalities between programs, there is scope for further development of shared learning and an opportunity for an adaptive approach to property selection decisions. It is likely that working together, managers can better navigate the challenges of revolving fund property selection. In so doing, they will be able to manage better the trade-offs, risks and challenges that arise from this promising new approach to private land conservation.

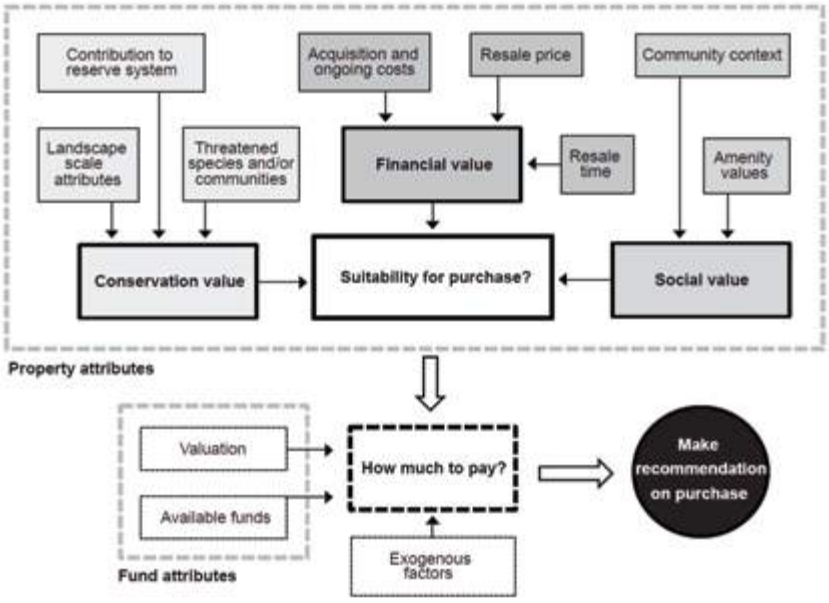

FIGURE 6 Influence diagram of the revolving fund purchasing decision. Solid boxes represent factors influencing the suitability of the property, dashed boxes represent factors influencing the decision of how much fund managers are willing to pay for the property. Exogenous factors in the decision of how much to pay may include, for example, the current trend in the property market or the manager's desire to avoid inflating land prices in the region (which may make future purchases more difficult).

The Smiths Lake House. Give me a home among the gum trees. Many people place a high value on living with natural ecosystems. Photo: Sandberg Schoffel Architects

Reference

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Planning for an expanding ice-free Antarctica

Key messages:

- *Antarctica is being impacted by climate change, invasive species and an expanding human footprint*
- *Ice-free areas, home to nearly all Antarctic terrestrial biodiversity, are projected to expand by 2100 with potentially severe consequences for native species*
- *There is no better time than now to be researching to feed into Antarctic policy*

Jasmine Lee in an Adelie penguin colony in West Antarctica. Ice and snow cover the Antarctic continent with bits of land poking through here and there. Climate change is set to increase the amount of ice-free land and this poses a range of challenges for conservation planners and decision makers. Photo: Peter Ryan

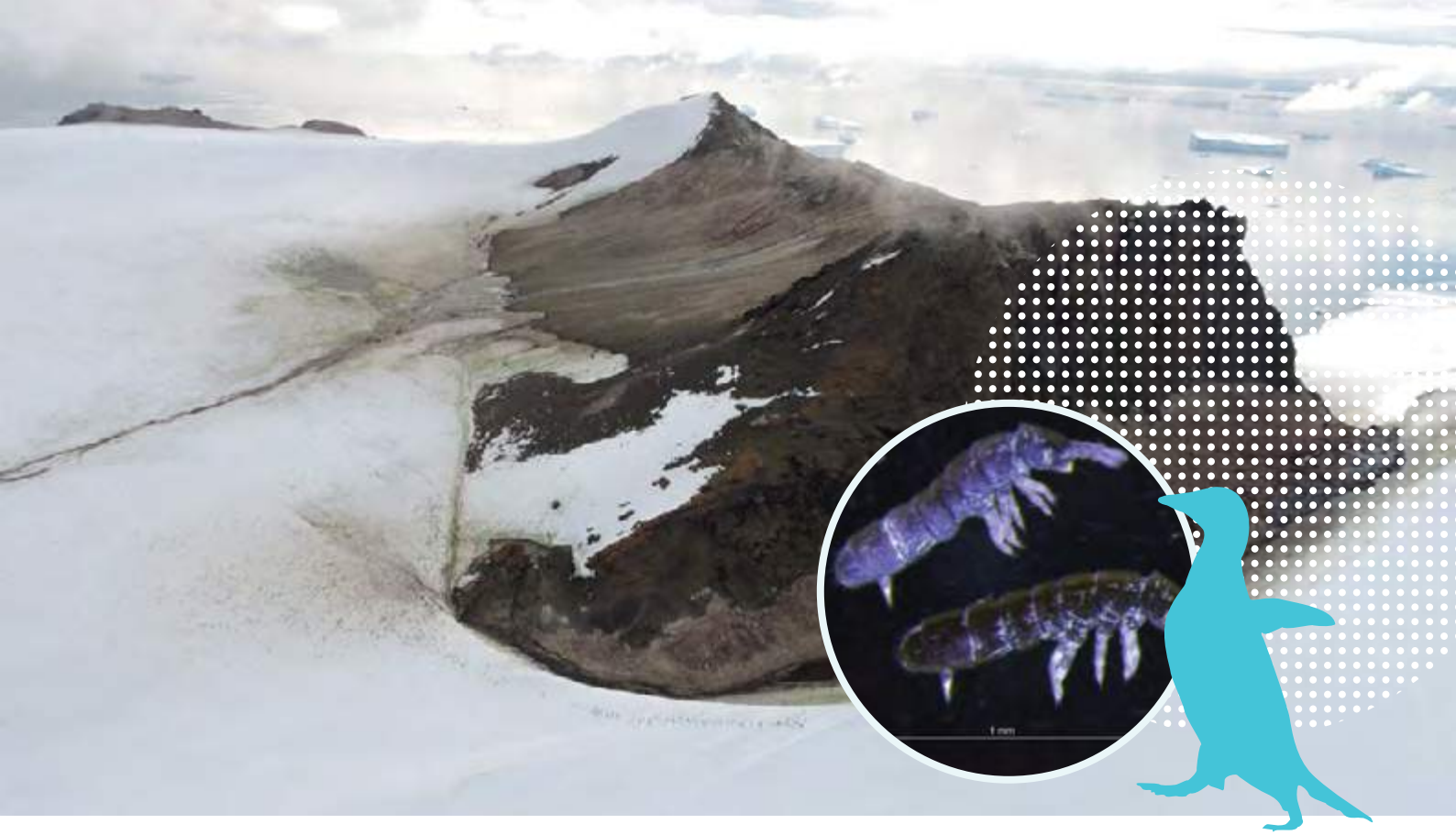
Mention Antarctica and nature and most people think killer whales, seals and penguins. But there is so much more when it comes to biodiversity on this frozen continent.

Often overlooked is a suite of native species only found on the land, not in the sea. This terrestrial biodiversity consists of microbes, moss, lichen, two native plants and an array of invertebrates (including tardigrades, springtails, nematodes, rotifers and mites) some of which occur nowhere else in the world. Living in an extreme environment means these species use a range of unusual adaptations to survive including dehydrating (anhydrobiosis) to survive long periods without water and increased growth or activity rates, when suitable environmental conditions come along.

Antarctica's terrestrial biodiversity is simply amazing, but it is also quite constrained — limited to the small patches of ice-free land that make up less than 1% of the continent. Ice-free areas occur on mountain tops, cliffs or coastal oases and can vary in size from a couple of square metres to hundreds of square kilometres. A large amount of regional endemism within Antarctic taxa (i.e., many species are only found in a single patch or region) reflects the isolated nature of these ice-free areas. Some patches may be separated by hundreds of kilometres from their nearest neighbour. The important question is: Are these ice-free patches under threat? Antarctica has been proclaimed as pristine and a "nature reserve devoted to peace and science". Despite this, Antarctica and its dependent biodiversity are not as well protected as you might think. In fact, terrestrial biodiversity is at risk from climate change, invasive species and expanding human activity (including from scientists and tourists). The Antarctic protected area network has been labelled as inadequate, unrepresentative and at risk. Conservation planning in the region is often considered to be lagging behind the rest of the world. So, while this means there is some ground to makeup, it also presents a wonderful opportunity to undertake conservation in the region before the risks materialise.

Making decisions for Antarctica

Policy and decision-making operate differently in Antarctica. The region is governed through the Antarctic Treaty System (ATS). While it can be challenging to achieve consensus among signatory countries on any Antarctic decision, multiple mechanisms exist within the ATS purely for management of the Antarctic environment. Foremost is the Environment Protocol, which is administered by the Committee on Environmental Protection (CEP). The Protocol is the international agreement that establishes the framework for the comprehensive protection of the Antarctic environment. The CEP has identified several priorities to focus on in the next five years. These include how do we deal with the introduction of non-native species, tourism activities, revising the protected area network and understanding and considering



Ice-free land in Antarctica is a rare commodity (only 1% of the icy continent exists in this state). But this is set to change dramatically as climate change begins to bite, and that will have enormous consequences for the biodiversity that currently depend on these areas. Photo: Jasmine Lee

INSET: Meet Cryptopygus antarcticus, *an Antarctic springtail that has evolved to cope with some of the harshest living conditions on the planet. You'll only find it on patches of ice-free land, and its fate in a climate-change future is very uncertain. Photo: Melissa Houghton*

the impact of climate change on the environment? Given this willingness to engage with these issues, there is no better time than now to contribute research to help inform conservation decisions in the region.

Planning for climate change

Climate change is already happening in Antarctica — parts of it are some of the most rapidly warming places on the planet. One of the major barriers to robust conservation decisions is a lack of understanding of the potential impact of climate change on biodiversity and the environment. We began to fill this gap by determining the impact climate change might have on ice-free areas by the end of this century. The analysis reveals that as ice melts around ice-free areas, over 17,000 km^2 of the new ice-free area could emerge around the continent (Lee *et al*., 2017). This is a 25% increase on the current ice-free area. The majority of this (14,000 km^2) will be on the Antarctic Peninsula, where the current amount of ice-free area could more than triple by the year 2100. While the amount of ice-free area will increase, the total number of ice-free patches is projected to decrease across the Peninsula. This is because as individual patches expand they will start to merge leading to an increase in connectivity in the region. The impact of this change in habitat on biodiversity, therefore, could be profound. The expansion and increasing connectivity will undoubtedly provide new dispersal and colonisation opportunities for some native species. However, it may also enhance the spread of non-native species, some of which are already present. Currently, Antarctica's greatest protection against non-native species is its extremely harsh weather and climate. Climate change is expected to take some of the edge off this harshness by making the weather warmer and milder. The warmer change will allow for the establishment of new non-native species that previously wouldn't have had a chance. And the opportunities for new species to make it to Antarctica are also likely to increase as the number of scientists and tourists visiting the region grows. Most non-native species reach the continent via ships and planes carrying scientists or tourists, with many species arriving in food or cargo shipments.

A new playing field

The expansion of non-native species along the Antarctic Peninsula may lead to competition with native species. Antarctica's native species, which are currently largely constrained by abiotic factors (availability of water, sunlight and nutrients) may fare poorly if they have to cope with competition for limited space and resources. It's largely unknown how they will perform. Over longer time periods, this may lead to regional homogenisation and extinction of some native Antarctic species. And, as climate change continues, the impacts described for the Peninsula are likely to become more prominent across the rest of the continent. This work was submitted as an Information Paper to the annual Antarctic Treaty Consultative Meeting held in Beijing in May 2017. It was recognised by the CEP as an important piece of research to help inform conservation decision-making in the region. By identifying sites and biogeographic regions that are likely to be heavily impacted by climate change, sites can be pinpointed for increased biosecurity and monitoring. This work will also help inform the design of a new protected area network for continental Antarctica.

Reference

Lee JR, B Raymond, TJ Bracegirdle, I Chadès, RA Fuller, JD Shaw & A Terauds (2017). Climate change drives expansion of Antarctic ice-free habitat. *Nature* 547, 49–54. http://dx.doi.org/10.1038/nature22996

Getting systematic with Important Bird and Biodiversity Areas

Important Bird and Biodiversity Area (IBA) is a program run by BirdLife International that has been developed over 30 years. It aims to identify sites significant for their contribution to the persistence of bird species and other biodiversity. Initially, IBAs were identified only for terrestrial and freshwater environments, but over the past decade the IBA process and method has been adapted and applied in the marine realm.

Today, IBAs are one of the most widely distributed spatial datasets for the world's oceans and these sites are considered by BirdLife International to be "the most significant sites for biodiversity conservation worldwide". The team set out to see how this information might add value to Australia's effort at marine spatial conservation prioritisation (as a case study of how this program might be used globally).

The marine IBA program has nominated around 2000 sites around the world for protection. That's approximately 4.3% of the oceans. As countries race to achieve a 10% marine protected area expansion, marine IBAs will be increasingly used to inform conservation planning, yet no research exists on how to integrate these sites into systematic spatial conservation planning.

In a recent analysis, the team evaluated how marine IBAs influence spatial plans about important aspects of marine spatial prioritisation: representation, irreplaceability, complementarity and cost-efficiency across 15 planning scenarios for Australia (McGowan *et al.*, 2017).

IBAs are intended to delineate sites that are essential for the survival of birds considered at risk (while also protecting the non-bird biodiversity contained in these areas). Candidate marine IBAs consist of seaward extensions of seabird breeding colonies, non-breeding coastal congregations, migration bottlenecks and ocean distributions. The IBA dataset is one of the most comprehensive species-specific datasets available for the oceans. Pictured here is an IBA trigger species, the black-browed albatross. Photo: Rohan Clarke

The ability of IBAs to act as surrogates was also tested for other forms of marine biodiversity and offer best-practice guidelines on how to incorporate IBAs into marine protected area planning. Two performance metrics were used to evaluate these scenarios, including the newly published metric Proportional Protection Equality (the development of which was led by CEED's Dr Alienor Chauvenet, (see Chauvenet *et al.*, 2017), which directly ties into the CBD's Aichi Target's (no.11) for achieving representative protected area networks.

The study revealed that planners should treat marine IBAs as any other conservation feature and set an explicit conservation target. Approaches to do this according to the underpinning characteristics of the IBA program include the threat status of the trigger species, defining criteria and the method of IBA delineation. Importantly, treating IBAs in this manner does not preclude setting 100% targets for particularly critical IBAs, but considering all IBAs as irreplaceable sites for conservation is impractical and inefficient.

To progress the integration of marine IBAs into spatial conservation prioritisation, planners must be equipped with more specialised knowledge of how and why individual IBAs exist. Prescriptive actions should be declared and released with the IBA polygons as some IBA sites are far more likely to drive non-spatial policy recommendations than serve as the basis for protected areas.

This research has broader policy implications for other threshold-based spatial delineations including Key Biodiversity Areas, Ecologically or Biologically Significant Areas, and other species-specific approaches attempting to delineate important marine areas (e.g., Important Marine Mammal Areas) with the goal of influencing international policy.

Reference

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Another IBA trigger species, the masked booby. Photo: Rohan Clarke

Deforestation in Brazil. Photo: Daniel Bebber

Tropical forest reserves slow down global warming

An audit of national parks and nature reserves in South America, Africa and Asia has revealed that these areas are preventing the release of more than two and a half times as much carbon into the atmosphere as Australia emits each year.

The study by CEED Post-Doctoral researcher Dr Nathalie Butt and University of Exeter ecologist Dr Dan Bebber is the first to analyse the impact of all protected areas of tropical forest on reducing carbon emissions into the atmosphere.

"These protected areas account for 20% of the world's tropical forest and play a crucial role in providing habitats for iconic species including tigers, Asiatic lions, jaguars and forest elephants," Dr Butt said.

"They are also designated to conserve world heritage sites such as the historic Incan ruins of Machu Picchu in Peru, and to preserve territory for indigenous peoples in South America."

The researchers analysed the likely level of tree loss in protected areas — and the resulting carbon emissions from 2000 to 2012, with the research showing that protected areas of forest prevented millions of tonnes of carbon emissions from being lost through logging and deforestation.

"Tropical protected areas are often valued for their role in safeguarding biodiversity," Dr Butt said.

"Our study highlights the added benefit of maintaining forest cover — to reduce carbon dioxide emissions to the atmosphere, to help slow the rate of climate change."

The study found that deforestation releases nearly twice as much carbon than is absorbed by intact forests, further highlighting the importance of protected areas.

Tropical forests account for around 68% of global forest carbon stocks but globally are under pressure from clearing to produce cash crops such as soya beans in South America, palm oil in South East Asia and for agriculture and to produce charcoal for cooking in Africa.

Reference

Bebber D.P and Butt, N. (2017) Tropical protected areas reduced deforestation carbon emissions by one third from 2000–2012, *Scientific Reports 7 Article 14005* doi:10.1038/s41598-017-14467-w

A 'good' decision is a 'fair' decision

Key messages:

- *Improving social equity is important to good environmental outcomes*
- *What constitutes equitable outcomes and processes is highly normative and subject to ethical deliberation*
- *We encourage a more analytical incorporation of equity into conservation decision-making (and provide a guide on how this might be done)*

There are many reasons to consider social equity in conservation decisions. On the one hand, it is a nice thing to strive for — we all would like to think we are ''fair'' in the decisions we are a part of (both as an individual and as a society).

On the other, it can help build community support and participation (social capital), which is valuable for successful conservation outcomes. But how do you integrate equity into conservation decisions? What does it even mean to be equitable? Understanding the multiple ways that equity can be perceived is key to answering these questions. Exploring different ethical frameworks can help us understand some fundamentally different perspectives of what is meant by ''good'' or ''right''. For example, three broad schools of ethical thought in Western philosophy include consequentialism, deontology and virtue. Consequentialism focuses on the outcomes of actions, deontology on the actions themselves and virtue on the inherent character of the decision-maker. These different philosophies then give rise to different motivations and objectives in how we incorporate equity in decision-making.

Equity is an important consideration surrounding decisions relating to ecotourism. Tourism can bring in an alternative source of income, but large numbers of tourists can degrade an area. Who should get to decide if and how much tourism should be allowed? Pictured above is the LA Ciudad Perdida (the lost city) in Colombia. It's an example of ecotourism which tries to incorporate ethics into its practice by employing local guides and providing money to local indigenous groups. Photo: Elizabeth Law

Equity might implicate the process or procedure (e.g., who gets to make the decisions and how), recognition (e.g., what types of information are considered), distribution (e.g., how are outcomes, rights, responsibilities, etc. allocated) and context (e.g., what past injustices and historical legacies are considered).

As is common with complex problems, the multiple objectives can conflict. For example, equitable procedures may not lead to equitable distributions. And egalitarian distributions are rarely equitable in practice. Equity is a highly normative and multifaceted concept where the objectives of equity may not be mutually achievable. So, as a policy goal, equity can be highly contested and problematic to implement. We need to be clear about what our motivations and objectives are for including equity. As researchers studying environmental decisions, how might we proceed in regards to equity? Many of the issues we deal with are controversial and politicised, and social equity is often a concern. We recently developed a framework to help deal with this challenge (Law *et al*., 2017). We identified motivations for considering equity (Figure 7), illustrated how alternative ethical frameworks could influence what is considered equitable and demonstrated how alternative objectives might conflict. To help overcome the challenges associated with incorporating equity in conservation decision-making, here are 10 tips for better integration.

Define motivations and objectives of equity within the context of the problem:

1. Clarify ethical motivations and how this may shape the way we identify the problem, the process and decision.
2. Identify the diversity of potential issues concerning equity at the outset, particularly the opportunities that might arise from instigating, exacerbating or ameliorating conflict.
3. Determine which dimensions of equity are important given the objectives and context and, given the tools and available data, which of these are tractable.

Plan for a diversity of stakeholders and objectives:

4. If stakeholders are involved in the decision process be sensitive to potential conflict. Be aware of potential biases and limitations of the processes of elicitation and negotiation.
5. Determine the implications for equity of targets and objectives, and decide how to manage objectives that might be less measurable (though no less important).
6. Use informed and appropriate metrics of equity and efficiency carefully within planning and prioritisation (if this matches your objectives for equity).
7. Consider what you are asking stakeholders to do and whether this adequately compensates and incentivises them for the duration of the intervention.
8. Consider decision models that allow a level of uncertainty due to self-determination.

Ensure equity is achieved during implementation:

9. Monitor and rigorously evaluate equity objectives during implementation, particularly when conservation actions rely on volunteer participation.
10. Expand, modify or restrict the intervention as required.

We believe there is a big opportunity for conservation decision-making to be guided by these principles of ethical pluralism, particularly in the design of more holistic measures and methods for assessing equity. There is also scope for a better understanding of the preferences stakeholders hold for equity, as well as how policies achieve equity in practice (i.e., applied ethics). Although incorporating equity into conservation decision-making adds a layer of complexity to an already challenging process, embracing this complexity will result in better and more enduring conservation outcomes.

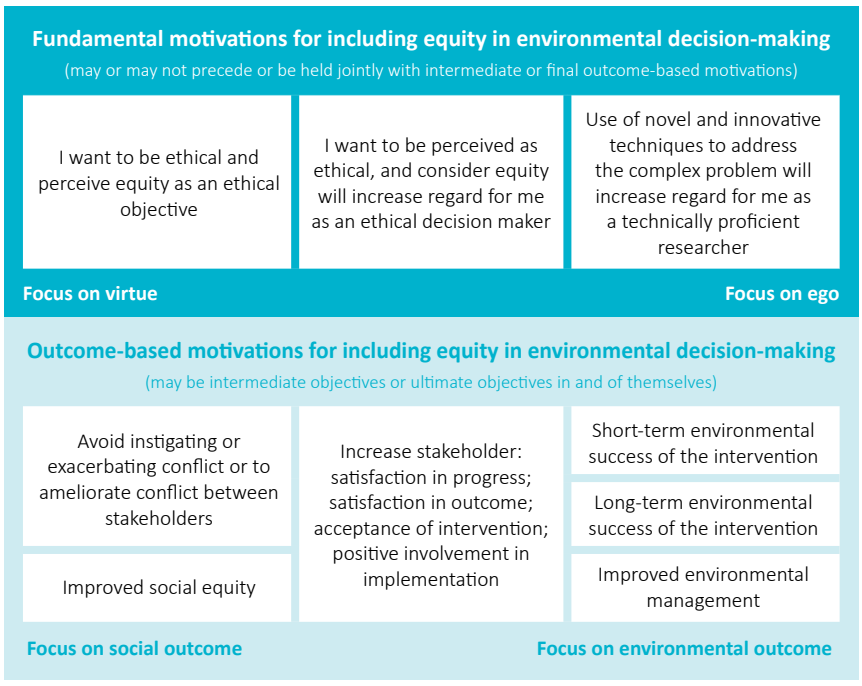

FIGURE 7 Motivations for considering equity in environmental decision making. These different motivations influence which methods and actions are seen as right, appropriate, and useful to include in a conservation decision-making process.

Source: Law et al, *2017*

Reference

Law EA, NJ Bennett, CD Ives, R Friedman, KJ Davis, C Archibald & KA Wilson (2017). Equity trade-offs in conservation decision making. *Conservation Biology*. http://onlinelibrary.wiley.com/doi/10.1111/cobi.13008/abstract

Orangutans in the Bornean forest. Photo: Daniel Murdiyarso

Orangutans and science in trouble

Key messages:

- *For many threatened species the rate and drivers of population decline are difficult to assess accurately*
- *Applying novel methods for integrating field and interview survey data enabled determination of the population trend of the Bornean orangutan over its entire range*
- *Bornean orangutan populations have declined at a rate of 25% over the last 10 years*

The first ever population trend analysis of the Bornean orangutan was published in July 2017 showing that the species has declined at a rate of 25% over the past 10 years (see Figure 8).

Revealing this rate of decline was sufficient for the International Union for the Conservation of Nature (IUCN) to elevate the conservation status of this species to Critically Endangered last year. Dr Truly Santika, an Indonesian statistician and CEED researcher at UQ, led the paper published in *Scientific Reports*.

The study used advanced modelling techniques that allowed the combination of different survey methods (including helicopter surveys, traditional ground surveys and interviews with local communities). This new approach enabled, for the first time, the population trend of the species to be determined over its entire range. The study was conducted by a group of 50 Indonesian, Malaysian, and international researchers with the results building on more than 20 years of collaborative research on the species, its habitats and the perceptions of key stakeholders involved in its conservation management.

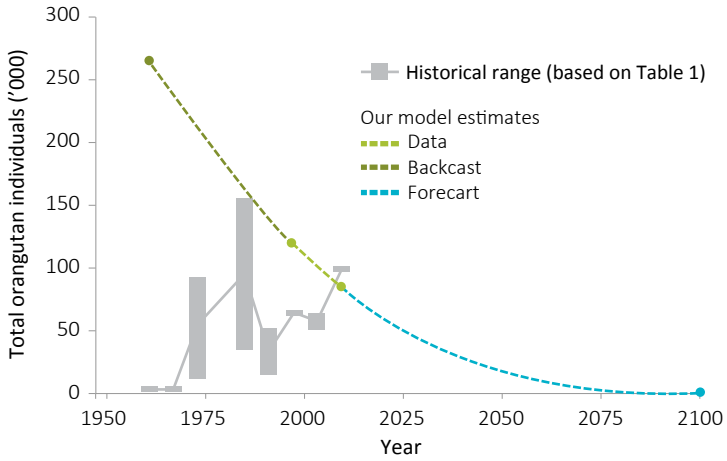

FIGURE 8 A comparison between historical population estimates and the trend predicted by the model proposed by Santika *et al*, 2017. Historical population estimates show an increasing trend through time due to increasing availability of survey data.

Source: Santika et al *2017*

This study should be a wake-up call for the orangutan conservation community and the Indonesian and Malaysian governments who have committed to saving the species. Indeed, every year some $38–50 million is invested by government and non-government organisations to halt the decline of wild populations.

Has the new knowledge and updated endangerment status of the species led to a fundamental rethinking of orangutan conservation strategies? Unfortunately, the answer is no. Indeed, the government response has been to cherry pick evidence that flies in the face of the best science.

Despite the early satisfaction of achieving an accurate measure of the population status and of focusing increased attention on this adaptable but slow-breeding species, the Indonesian government recently announced that orangutan populations in both Borneo and Sumatra had increased during the past 10 years and that the IUCN status change from Endangered to Critically Endangered was misguided.

These conclusions were drawn from a recent Population and Habitat Viability Assessment concluding that 10 years ago there were 50,000 orangutans and now there are 70,000. Unfortunately, the estimate of 10 years ago was likely to be wrong. Such conclusions ignore the evidence of a reduction in population density of 50%, deny that several thousand orangutans are killed annually and turn a blind eye to the extensive deforestation that has occurred.

What's more, in a time when world news is dominated by terrorism, polarising politics and historic hurricanes, the plight of the orangutan seems to have been forgotten. So far, Greenpeace has been the only organisation to push back on the government's conclusions.

This indicates that the government is not accepting this message despite quality (peer-reviewed) science telling us that orangutans are in trouble. It means that the biggest threats to orangutans of habitat loss and killing are unlikely to be effectively addressed and the focus of rescues and rehabilitation will likely continue.

The academic research community is increasingly called on to measure its impact and to up-skill researchers to improve their science translation skills. This experience shows that all the obstacles to up-take also need attention in impact evaluations to ensure all barriers are transparent — including those that are out of the researchers' control.

Reference

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Planning for Better Environmental Outcomes

Using range maps to plan protected areas

Key messages:

- *Planning for new protected areas using range maps can lead to overestimating the level of protection, due to commission errors*
- *The adoption of a coarse analytical resolution can slightly mitigate this effect but leads to inefficient planning*
- *Intermediate resolutions are the best compromise to reduce commission errors while maintaining efficient planning*

From the local to the global scale, conservation decisions are heavily influenced by the knowledge of where species are found. Maps of the geographic range of species (or simply ''range maps'') are typically used to determine the overlap between threatened species and protected areas and to find new places in need of protection.

However, range maps are usually incomplete and often contain errors. Commission errors occur when species are supposed to be present in a location from which they are found to be absent, and omission errors describe the opposite situation in which species are mapped as being absent when they are, in fact, present.

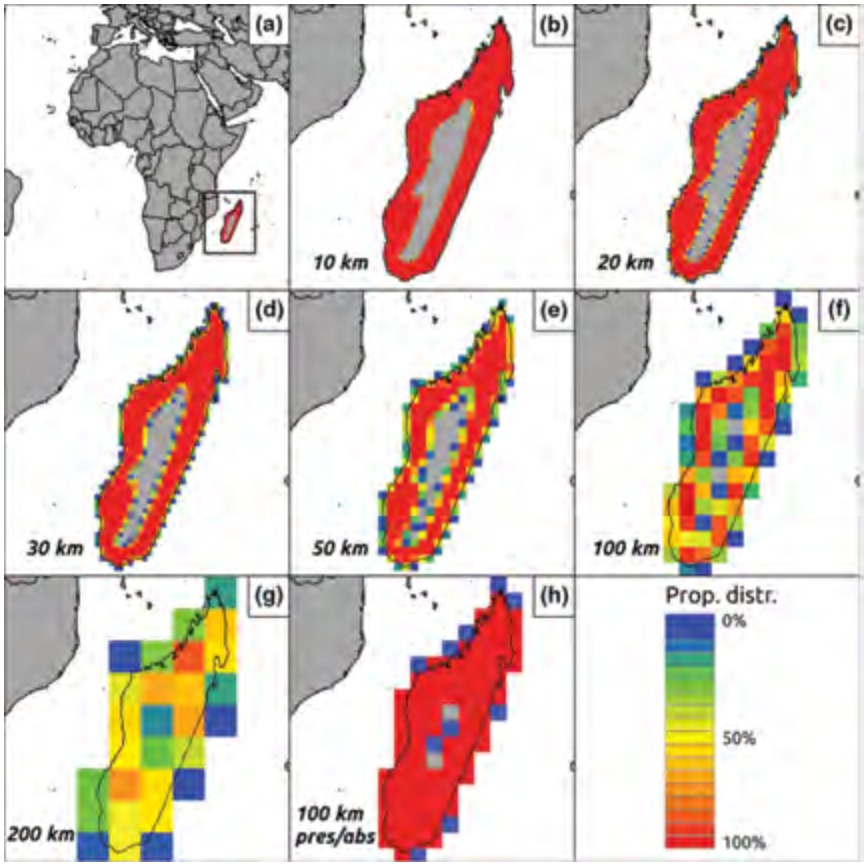
Commission errors are particularly worrisome in conservation because they can lead to a false perception of species protection — i.e., that a species is better protected than is truly the case. They can also steer conservation investment toward areas of little conservation value, where species are not present.

Habitat suitability models can be used to reduce the effect of commission errors by removing from a range map those areas that are considered unsuitable for the species. However, habitat models are data demanding and their use is not always possible especially for analyses focused on many species.

Another method for reducing commission errors is by using a coarser analytical resolution. For example, if a range map uses coarse grids (100–200 kilometre squares), the probability of including unoccupied grid cells is reduced. Commission errors are averaged out. Unfortunately, the adoption of a coarse resolution also affects the efficiency of a conservation plan (i.e., the ability to select a minimal additional area to be protected for achieving an adequate representation of all species).

While the problem of commission errors in range maps has long been known, the size of the trade-offs (i.e., what is lost and gained through the use of coarser analytical resolution), has never been quantitatively explored. This study set out to fill this hole by performing a set of analyses comparing protected-area planning for the world's threatened terrestrial mammals at various resolutions. Comparing species range maps with habitat models shows the difference between protected species ranges and protected habitats (Di Marco *et al*., 2017).

*The fossa (*Cryptoprocta ferox*), a threatened mammal (a cat-like, carnivore closely related to the mongoose) endemic to Madagascar. Photo: Chad Teer*



*Spatial distribution of the fossa (*Cryptoprocta ferox*). Panel (a) shows the global location of the species range. Panels (b–g) show the proportion of species geographic range within grid cells at various resolutions (from 10 km to 200 km). Panel (h) shows a binary reclassification (presence/ absence) of the species range at a 100 km resolution; in this case a cell was considered to be entirely occupied if 5% or more of its area overlapped with the species range, and entirely unoccupied otherwise.*

This study involved a global conservation planning analysis using range maps from the IUCN for the world's 1115 species of threatened terrestrial mammals. When employing a resolution of 10 km per map square, a global protected area expansion of 3 million km^2 (an area almost the size of India) would suffice to achieve adequate protection for all the species.

However, if using habitat models to determine what parts of that designated extra protected area were unsuitable for the species they were supposed to protect, there would be a shortfall of 28 species (i.e., species that appeared to be adequately protected by their ranges but not by their habitats).

At a coarser resolution of 200 km (per map grid), the shortfall for an equal figure of protected area expansion would be just seven species. At this coarse resolution, it was also twice as likely (80% vs 40% at a 10 km resolution) that the priority grids for the protection of species ranges were also considered a priority for protecting species suitable habitats. However, the adoption of a 200 km resolution led to the selection of a total of 12 million km^2 of protected area to achieve adequate coverage for all species, which was four times larger than the area selected under a 10 km resolution.

These findings demonstrate that adopting coarse resolutions in protected area planning results in an unsustainable increase in costs, with limited reduction in the effect of commission errors in IUCN range maps. The recommendation is that, if some level of uncertainty is acceptable to managers, using range maps at resolutions of 20–30 km is the best compromise for reducing the effect of commission errors while maintaining cost-efficiency in protected area planning analyses.

Reference

Di Marco M, JEM Watson, HP Possingham & O Venter (2017). Limitations and trade-offs in the use of species distribution maps for protected area planning. *Journal of Applied Ecology* 54: 402–411. http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12771/full

Impact of a large wildfire

Management guidelines for many fire-prone ecosystems highlight the importance of maintaining a variable mosaic of fire histories for biodiversity conservation.

Managers are encouraged to aim for fire mosaics that include all successional states of vegetation and also include variation in the underlying ''invisible mosaic'' of past fire frequencies, severities and fire-return intervals. But how should a fire mosaic be managed following the occurrence of a large, unplanned wildfire? Does the previous fire history of vegetation and habitats persist after major wildfires? It's a topic has that has rarely been investigated.

In this study, Claire Foster and colleagues at ANU tested to what extent a large wildfire interacted with previous fire history to affect the structure of forest, woodland and heath vegetation in Booderee National Park (NSW south coast). A massive unplanned wildfire burned half the park in 2003. The researchers tracked the recovery of vegetation structure for nine years after the event and found that the strength and persistence of fire effects differed substantially between vegetation types. Vegetation structure was modified in forest, woodland and heath vegetation, but the among-site variability in vegetation structure was reduced only by severe fire in woodland vegetation. There were also persistent legacy effects from the previous fire regime on some attributes of the vegetation structure including forest ground and understorey cover and woodland mid storey and overstorey cover. This suggests that even after a large, severe wildfire, underlying fire histories can contribute substantially to variation in vegetation structure.

Consequently, it is important that efforts to reinstate variation in vegetation fire age after large wildfires do not inadvertently reduce variation in vegetation structure generated by the underlying invisible mosaic.

Reference

Foster C, P Barton, C MacGregor, N Robinson & DB Lindenmayer (2017). Effects of a large wildfire on vegetation structure in a variable fire mosaic. *Ecological Applications*. http://onlinelibrary.wiley.com/doi/10.1002/eap.1614/full

Evaluating CEED's Impact

The CEED Director and Chief Investigators initiated an evaluation of CEED's impact to measure the difference CEED research is having on our society and around the world. However, the wide scope, sheer volume of CEED research and scarce availability of published work on a methodology to use makes evaluating its impact a considerable task.

The analysis evaluated the social and environmental impacts occurring from the interdisciplinary research produced by members, partners and associates of CEED. A set of criteria were developed to measure the initial impact of affecting change, such as the extent to which the research attributed to a change in policy, an improvement in decision making processes or an improvement in management practices. The amount of collaboration, engagement and knowledge transfer activities were also considered. Traditional academic metrics were also analysed to provide a supportive context to the claims of impact.

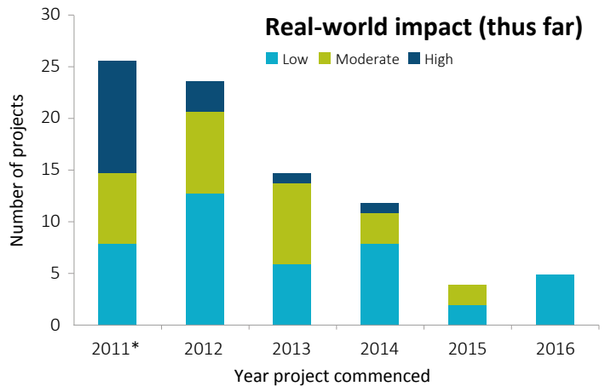


FIGURE 1 CEED research project were ranked on impact.
** Nine projects that started before 2011 under other funding sources*

The findings reveal that CEED has achieved a very high level of academic impact and currently has a mixed influence on public policy and management practices. The key limitation is the time lag between results from research being made available to the contribution to a policy change. Figure 1 demonstrates that the projects commencing at the inception of CEED have achieved far greater impact than those recently commenced. Through the development and presentation of case studies, the analysis seeks to illustrate the breadth and extent of the research impacts and associated challenges for some of the 89 research projects.

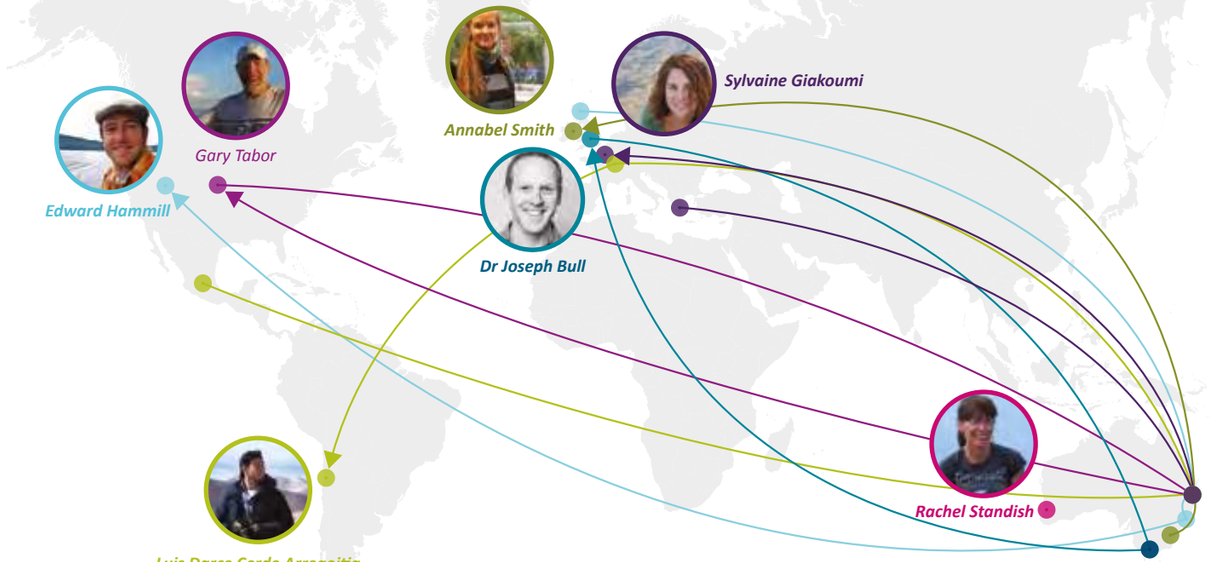
Our work evaluating CEED's impact will, we hope, demonstrate a process and contribute to a better understanding of the various drivers at play. The complete report will be freely available on CEED website.

Professor David Pannell
University of Western Australia

ARC ceed
Centre of Excellence for Environmental Decisions

CEED Alumni
Where are they now?

CEED keeps track of a collective Alumni cohort comprised of over 200 Post Doctoral Fellows, PhD, Masters and Honours students contributing to environmental decisions science, its implementation and uptake globally. Here are some of their stories...



Dr Joseph Bull

Dr Joseph Bull

My best publications have all involved CEED collaborators – I'm not sure I ever truly left

Today, seven years after I first became part of CEED as an associate undertaking a PhD at Imperial College London, I still collaborate and publish with my valued CEED colleagues, so I am not sure I truly ever left. Since finishing my PhD and becoming a CEED Alumni, I have gone on to pursue a career in applied biodiversity conservation research through post-doctoral and other institutional positions. I have been awarded funding for projects including a "no net loss" project in Uganda and a "business and biodiversity" project with the University of Oxford. I have also set up a biodiversity consultancy called Wild Business, which puts our research into practice. We have worked on numerous conservation projects throughout the world, from Canada to Kazakhstan. During this time, I also married my partner and had a baby, with a second on the way.

In my first year with CEED, I organised a biodiversity offsetting workshop with Sarah Bekessy's group at RMIT, which kicked off productive collaborations. I greatly benefited from exposure to leading thinkers in decision science and working with such applied conservationists, who blur the line between research and implementation. In fact, my best publications have all involved CEED collaborators.

I think my best memory of CEED was the month I spent at RMIT in 2011, at the end of the Melbourne summer. We ran the workshop I mentioned and developed the ideas that would become three key chapters in my PhD. I met so many other interesting people working on related (or even unrelated) topics at RMIT and the University of Melbourne. I got out into the Victorian countryside – to the coast – cycling, hiking and wildlife spotting. I drank a lot of good coffee. I even had the honour of playing in Ascelin Gordon's band.

CEED also strongly influenced the way I approach science, encouraging me to think more creatively and practically about my research and its outcomes. Back then, I was returning back to academia, having spent the previous four years in industry. The experience of living the academic life in Melbourne and working at RMIT that month was so intellectually stimulating – and generally fantastic – that I think it was one of the reasons I have subsequently embraced and pursued a career as a scientist. Yes, without this influence, I might have gone back to industry.

Luis Darce Cerde Arregoitia

Luis Darce Cerde Arregoitia

Studying mammals in Chile, remembering CEED retreats and beautiful Queensland locations

I joined CEED in 2011 as a PhD student in Kerrie Wilson's lab. The constant exposure to quality collaborative science at the regular seminars, lab meetings and social events was always motivating. The group retreats were my fondest memories. Not only because of the great bonding experience with my colleagues but the brainstorming discussions in beautiful south-east Queensland locations, which led to new projects and publications.

After graduating, I was awarded a one-year post-doctoral fellowship at the Natural History Museum in Bern, Switzerland. Now, I am a post-doctoral researcher at the Instituto de Ciencias Ambientales y Evolutivas, Universidad Austral de Chile – where I continue to study the ecology, evolution and conservation of mammals.

Being part of CEED was a unique experience I will never forget. The dynamic environment was stimulating, but not overwhelming, and I have yet to experience it elsewhere.

Annabel Smith

Annabel Smith

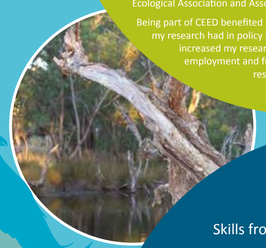
CEED collaborations lead to global employment and funding opportunities

I joined CEED as a post-doctoral researcher in 2012 after finishing my PhD at ANU. I was selected as a representative for the Australian Research Council's (ARC) mid-term review, where I provided feedback to the ARC on the impact the Centre was making to the scientific community, environmental policymakers and the public at an international level.

CEED was also a great place to collaborate and form relationships with other researchers at different career stages. During a conference I co-led, I met Professor Yvonne Buckley, who I didn't know at the time, and would later become my employer at Trinity College Dublin and one of the most influential mentors in my career to date.

Since finishing my appointment at CEED, I have worked as a freelance researcher, and in May 2016 I moved to Ireland to take up a position at Trinity College where I lead the landscape genomics component of the international research network PLANTPOPNET. The network uses *Plantago lanceolata* as a model species to analyse variation in plant population performance across global environmental gradients. In January 2018 I commenced a Marie Sklodowska-Curie Research Fellowship and am on the Organising Committee for the second IEA conference to take place in Galway in December 2018 I am also the Meetings Officer for the Irish Ecological Association and Associate Editor of the *Journal of Applied Ecology*.

Being part of CEED benefited me in three big ways: It increased the impact my research had in policy and environmental management; it vastly increased my research network; and, it provided future employment and funding opportunities in the global research community.



Edward Hammill

Edward Hammill

Skills from CEED that cemented a solid and successful career path

I joined CEED in 2013 with no former experience in spatial analyses but had a strong desire to work in decision science for conservation. CEED provided me with the skills to produce high impact publications, including one in *Nature Communications* which became the subject of a TED talk. The highly collaborative nature of CEED, substantially expanded my research network and CEED conferences were not only useful for meeting researchers from other universities, but they provided a great sense of being part of a large group focused on the same mission.

While at CEED, I learned how to implement Marxan, and developed a new method to specifically analyse the consequences of not accounting for risk in landscape decisions. I've continued to use both techniques in the majority of my projects and have subsequently expanded these landscape ideas to rivers and streams.

Following my time at CEED, I have taken up a faculty position at Utah State University, where I lead the Spatial Community Ecology lab. The techniques I learned at CEED were crucial in obtaining this position and underpin my subsequent successes. Recently, I began working with state agencies and The Nature Conservancy to address how the threat of climate change should be incorporated into management activities in the western US. In 2018, I will start working with the Department of Defence to investigate how best to conserve endangered aquatic species on military lands in California.

I am also continuing the work I began during my time at CEED, investigating how the risk of armed conflict should be incorporated into conservation decisions. None of these projects would have been possible without the expertise, professional networks and advantages I gained while working at CEED.

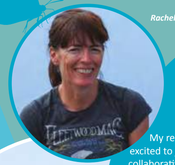
Sylvaine Giakoumi

Sylvaine Giakoumi

Leading marine conservation research and conservation planning

In 2012 I joined CEED just after commencing my post-doctoral fellowship funded by the European Union and the Greek Government. Thanks to financial support from CEED, I was able to organise international workshops, which also gave me the opportunity to meet and collaborate with leading scientists in my field of marine conservation. Training sessions run by CEED broadened my skills and capabilities. But most importantly, being part of CEED gave me the opportunity to collaborate and share experiences with an amazing group of people.

I left CEED and Australia in 2015 to undertake post-doctoral research at the University of Nice Sophia Antipolis, France, where I lead a collaborative project with the Interdisciplinary Studies of Coastal Oceans. I am a principal investigator on a three-year project assessing the relationships between marine protected areas and invasive species, funded by the French National Research Agency. I am also a group leader on a four-year European Union COST project, investigating integrated conservation planning.



Rachel Standish

Rachel Standish

CEED gave me the opportunity to work with people outside my discipline

My research sits at the nexus between ecological theory and practice so I was excited to join CEED in 2012. Being part of the centre gave me the opportunity to work collaboratively with other motivated researchers in a wide variety of disciplines outside my own. Through CEED, I developed new, productive and fulfilling collaborations and gained valuable mentoring experience through the CEED ECR mentoring program.

I appreciated CEED workshop initiatives bringing ecologists together. In December 2013 Jane Catford and I hosted a CEED/NERP workshop at Rottnest Island, a 20-minute ferry ride from Fremantle, Western Australia. It was my first experience hosting a workshop and a great opportunity to collaborate with Jane and other renowned ecologists. I have fond memories of the workshop which combined — serious intellectual pursuit in an informal and relaxed natural setting — and it was productive too! We published a meta-analysis on the response of ecosystems to disturbance using datasets attendees brought to the workshop.

Lastly, and perhaps the most beneficial outcome was that CEED reporting improved my ability to communicate the impact and benefit of my research beyond academia. Since physically leaving CEED in 2015 I have become a Senior Lecturer in Ecology at Murdoch University, Perth and in late 2017 I was awarded tenure.

Gary Tabor

Gary Tabor

Setting up a new conservation group for the IUCN, advising the President and missing the morning teas at CEED

I arrived at CEED as a Professional Fulbright Scholar in Climate Change and Clean Energy in 2013-2014. I chose CEED because of its pool of talented scholars who were making advances in decision support science using a range of qualitative and quantitative approaches.

The CEED morning tea gatherings at the UQ node helped to foster a truly collaborative community. In general, we don't have these social breaks in the US, and I miss them now that I have returned home. I think tea is a small thing, but it truly helps cement teams.

After CEED, I returned to the US where I was appointed to serve on two US Department of Interior advisory councils during the last years of the Obama Administration:

- The International Landscape Conservation Cooperative Council of the US Fish and Wildlife Service which oversees 22 large-scale federal conservation collaborative operations from the Pacific Islands to the Caribbean Sea, from the Arctic realms to the tropical forests of Puerto Rico.
- The National Invasive Species Council that advises the Secretary of Interior on the latest threats and potential solutions to address the nation's invasive species problems.

In 2016, I was asked by the IUCN World Commission on Protected Areas to chair a new technical group to advance ecological connectivity conservation – the Connectivity Conservation Specialist Group. We are developing a new conservation designation to conserve a critical ecological process – connectivity – through Areas of Connectivity Conservation. We hope that as the world develops more ambitious targets for conservation, connectivity will figure more prominently.

Being exposed to the CEED cohort of innovators proved to be an inspiration for my work helping policymakers and conservation practitioners make better decisions. I still stay in touch with my colleagues and collaborators at CEED who continue to help and inspire me.

Dr Carly Cook

Dr Carly Cook

CEED allowed me to meet and collaborate with world leaders in decision science

I joined CEED in 2011 after completing my PhD at the University of Queensland. CEED provided an outstanding intellectual environment for me to develop as an independent researcher. Richard Fuller and Hugh Possingham were fantastic mentors for me, contributing to the science I was conducting and in providing invaluable advice about how to develop my career in academia. One of the greatest benefits for me from CEED was being amongst a large group of outstanding young researchers all pursing interesting research questions.

I benefited greatly from an early career researcher travel grant which enabled me to meet two UK leaders in evidence-based conservation: Professor Bill Sutherland from Cambridge University and Professor Andrew Pullin at Bangor University. The experience has had a lasting impact on my career by facilitating collaborations with both research groups and encouraged me to become one of the founding members of the Australian arm of the Collaboration for Environmental Evidence: The Centre for Evidence-Informed Policy and Practice.

After finishing my post-doctoral research with CEED, I moved to the University of Melbourne to take up a postdoctoral role in the School of Botany, with Brendan Wintle and Mark Burgman, as part of the National Environment Research Program Environmental Decisions Hub. In this role, I explored the use of strategic foresight to help decision-makers plan for an uncertain future.

I focused on questions such as:

- How can we identify emerging threats to biodiversity before they become entrenched problems?
- How can decision-makers plan actions that will be robust to a range of possible futures?
- Where will conservation opportunities be in the future, and how can we best take advantage of them?

I am now a lecturer at Monash University with the School of Biological Sciences and lead my own research group, focusing on integrating evidence into conservation decisions and developing decision support tools.

International Travel Award Recipients

In 2017 CEED supported 20 Travel Awards including seven international visitors to collaborate at CEED Nodes.

Jane Catford

Tatsiana Barychka

Johannes Refish

Michaela Pacifici

Paul Armsworth

Sam Lloyd

Jane Feeney

International Visitors

Prof Wiktor Adamowicz, University of Alberta, Canada

Prof Peter Arcese, University of British Columbia, Canada

Prof Paul Armsworth, University of Tennessee, USA (CEED travel grant)

Ms Tatsiana Barychka, PhD Student, University College London, UK (CEED travel grant)

Prof Ian Bateman, Land, Environment, Economics and Policy Institute, University of Exeter, UK

Prof Mark Boyce, University of Alberta, Canada

Ms Ellen Bruno, PhD Student, University of California, USA

Prof Yvonne Buckley, Chair of Zoology, Trinity College Dublin, Ireland

Mr Michael Burgass, PhD Student, Imperial College London / University of Oxford, UK (CEED travel grant)

Mr Antoine Camus, AgroParisTech, France

Dr Jane Catford, University of Southampton, UK (CEED travel grant)

Prof Hayley Chouinard, Colorado State University, USA

Ms Kristina Chyn, PhD Student, Texas A&M University, USA

Christopher Clements, University of Zurich, Switzerland

Ms Andrea Duane, PhD Student, Forest Sciences Centre of Catalonia, Spain

Ms Jane Feeney, PhD Student, Trinity College Dublin, Ireland (CEED travel grant)

Dr Erica Fleishman, Colorado State University, USA

Ms Joan Giménez, Phd Student, Spanish National Research Council, Spain

Dr Adelina Gschwandtner, University of Kent, UK

Dr Edd Hammill, Utah State University, USA

Dr Amots Hetzroni, Agricultural Research Organisation, Israel

Prof Patrick Hostert, Humboldt University of Berlin, Germany

Prof Gene Likens, Cary Institute of Ecosystem Studies, USA

Mr Sam Lloyd, PhD Student, Imperial College London, UK (CEED travel grant)

Prof Evelyn Merrill, University of Alberta, Canada

Prof Jean Paul Metzger, University of São Paulo, Brazil

Dr David L Miller, University of St Andrews, UK

Ms Larissa Oliveria, PhD Student, Federal University of Rio Grande do Sul, Brazil

Ms Michaela Pacifici, PhD Student, Sapienza University of Rome, Italy (CEED travel grant)

Mr Chris Pollard, PhD Student, University of Stirling, UK

Dr Dave Redding, University College London, UK

Dr Johannes Refisch, United Nations Environment Programme, Kenya

Prof Amanda Rodewald, Cornell Lab of Ornithology, USA

Dr Alex Rogers, University of Oxford, UK

Prof Katriona Shea, Penn State University, USA

Ms Freya Shearer, PhD Student, University of Oxford, UK

Assoc Prof Jay Shimshack, University of Virginia, USA

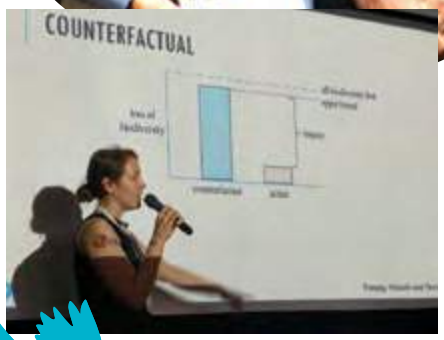
Prof Niels Strange, University of Copenhagen, Denmark

Mr Urtzi Urzelai, PhD Student, University of Oviedo, Spain

Conferences, Workshops and Training

International Congress for Conservation Biology (ICCB), Cartagena, Colombia, 23–27 July 2017

CEED PhD student Eduardo Gallo Cajiao (Editor) presenting a copy of Decision Point en Español *to Julia Miranda, Director of the National Parks Service of Colombia.*



Caitlin Kuempel presenting her research on marine protected areas at ICCB 2017, Cartagena, Colombia.

The ICCB is the world's largest conservation biology conference and can attract over 2000 delegates. CEED had a strong presence at the 2017 event, with 33 presentations involving 59 current CEED students and staff and 42 alumni.

They spoke on a wide range of topics including sessions on conservation planning in post-conflict Colombia, indicators of collapse for ecosystem risk assessments, crowdfunding conservation, the future of conservation technology, red listing human behaviours that impact global biodiversity, a synthesis of coral reef restoration efforts, acquisition strategies for revolving conservation funds, and the governance of biodiversity offsetting. CEED also hosted a booth at the conference to highlight opportunities for undergraduate and post graduate studies and showcase our research and outputs such as *Decision Point* and Research Briefs.

CEED Director Professor Kerrie Wilson officially launched *Decision Point en Español #3*, and was joined at a workshop on the theme of conservation in the Spanish-speaking world by the magazine's editors Eduardo Gallo Cajiao and Duan Biggs. The audience hailed from many different countries including Chile, Costa Rica, Peru and Colombia and many conservation researchers keen to subscribe and contribute articles.

Copies of the latest issue were given to NGO staff, academics, and staff from government agencies.

Networking for conservation in Colombia ECR perspective

By Marie Dade and Felipe Suarez (University of Queensland)

In July, we travelled to the colourful city of Cartagena in Colombia to attend the Society for Conservation Biology's bi-annual International Congress for Conservation Biology (ICCB) conference.

"Insights for sustaining life on Earth" was the theme for this year's conference, with an emphasis on how to better manage social-ecological systems. This year, the conference was attended by over 1,400 people ranging from conservation practitioners, policy-makers, academics and researchers from 71 different countries.

For PhD students who are still novices at international conferences, we found ICCB to be an amazing source of information and great experience. This conference opened our eyes to the conservation issues being faced around the world, and the wide variety of different approaches to conservation being applied. Though there was a huge variety of talks and issues, there were a couple of themes we noticed that kept resurfacing throughout the five days of the conference and really stuck with us.

As the conference was held in Colombia, it wasn't surprising that a major theme at ICCB was conservation within this corner of the world. It was fascinating to hear about the conservation challenges and opportunities faced in Colombia and other Latin American countries (though as a Colombian native, many of these issues were well known to Felipe). Many talks focused on the increasing threats biodiversity faces within Latin America, such as deforestation, mining, and the illegal wildlife trade.

A major theme was conservation in areas of conflict, such as conservation in post-FARC Colombia. Felipe led a workshop at the conference that focused on identifying new opportunities for biodiversity conservation in Colombia's post-peace agreement era. The workshop started as an initiative of Colombians doing their PhD in Australia, and was partially funded by CEED. The workshop provided participants, including experts from different NGOs, academic and government institutions, with the opportunity to identify potential projects and research questions around accounting for conflict risks in conservation decision-making, while promoting the design of conservation strategies with positive socio-economic impacts.

Conflict between and within countries can put stress on the environment through resource extraction, and can restrict the reach and effectiveness of conservation programs. However, when conflicts are resolved deforestation often increases, which threatens the biodiversity within these regions. However areas that were previously too dangerous to enter also open to up for potential conservation projects.

The workshop also discussed the importance of filling the gap between science and policy to promote conservation in post-conflict scenarios, as well as opportunities to do large scale land use planning in the country. The workshop was a great opportunity to grow Felipe's professional network and learn about cutting-edge research being conducted within this research field.

This and other themes (including the growth of social science and technology in conservation science) presented throughout the ICCB conference suggest that conservation research is moving towards more global, collaborative and interdisciplinary approaches. This has huge potential for the success of conservation projects across the world.

Attending this conference gave us insights into not only the direction that conservation research is heading, but also into the reality faced by conservationists around the world. It was a week full of new ideas, great conversations, and amazing Colombian wildlife and food! If you ever have the opportunity to attend an ICCB conference in the future, we would definitely recommend it.

Note: Marie Dade and Felipe Suarez are PhD scholars in the Rhodes Conservation Research Group at the University of Queensland. This story is an edited excerpt from a blog Marie wrote about the ICCB experience.

ICCB Symposium Sessions

A facilitated suite of presentations (12-minutes each) around a contemporary topic, followed by a discussion.

Conservation challenges and opportunities in areas of armed conflict

1. Duan Biggs. *Complexities of conservation in regions in conflict*
2. Pablo Negret, Moreno Di Marco, Martine Maron, Hugh Possingham & James Watson. *Need for conservation planning in postconflict Colombia*
3. Kerrie Wilson. *Integrating social and ecological factors in environmental decision making*

New tools for ecosystem assessment and monitoring

4. Jessica Rowland, Lucie Bland, Matthew Linn & Emily Nicholson. *Indicators of collapse for ecosystem risk assessments*

Successful scenario planning

5. Sean Maxwell. *Scenario planning: a tool for conservation*
6. April Reside, Diana Fisher, Sean Maxwell, James Trezise & James Watson. *Priority areas for landscape protection and restoration in the face of climate change*
7. Hedley Grantham, Djoan Bonfills, Fiona Maisels, Tim Rayden, Samantha Strindberg & Ayesha Tulloch. *Balancing carbon, forestry, indigenous and mining values in the Congo*
8. Brendan Wintle, Heini Kujala & Amy Whitehead. *Minimising the cumulative impacts of urban expansion scenarios for 600 species*

Shaping the future of conservation technology

9. José Lahoz-Monfort. *The current landscape*

Developing the scientific basis that enables businesses to support biodiversity conservation

10. Prue Addison, Joseph Bull & E.J. Milner-Gulland. *Engaging with business to revolutionize biodiversity conservation*

The impact of earths changing human footprint on biodiversity and humanity

11. James Allan. *Wilderness conservation and the World Heritage Convention*
12. Matthew Selinske, Sarah Bekessy, Fiona Fidler, Georgia Garrard, Ascelin Gordon, Manfred Lenzen & Isaac Peterson. *Red Listing human behaviors that impact global biodiversity*
13. Kendall Jones. *One third of the global protected area estate under intense human pressure*
14. Bonnie Mappin. *Global restoration priorities for achieving protected area targets*
15. Brooke Williams. *The human influence on fire dependent ecosystems, where to from here?*

Biodiversity indicators: measuring change in a dynamic and uncertain world

16. Emily Nicholson, Alberto Barausse, Ben Collen & E.J. Milner-Gulland. *Testing whether biodiversity indicators detect policy induced change in marine ecosystems*
17. Michael Burgass, Benjamin Halpern, E.J. Milner-Gulland & Emily Nicholson. *Navigating uncertainty in environmental composite indicators*
18. William Arlidge, Prue Addison, Joseph Bull, Michael Burgass, Dimas Gianuca, Taylor Gorham, Taylor Gorham, Sam Lloyd,E.J. Milner-Gulland, Nicole Shumway, James Watson & Chris Wilcox. *A global mitigation hierarchy for nature conservation*

Linking conservation science to decisions in the real world

19. A Paz Durán, Andrew Balmford, Duan Biggs, Neil Burgess, Simon Croft, Edegar de Oliveira Rosa, Toby Gardner, Jonathan Green, Angela Guerrero Gonzalez, Malika Virah-Sawmy & Chris West. *Linking biodiversity impact to global supply chain actors: The case of soy production in Brazil*

Land acquisitions for conservation reconciling plans with empirical reality

20. Elizabeth Law, Peter Arcese, Amanda Rodewald, Richard Schuster & Kerrie Wilson. *Who will conserve? Understanding stakeholders to improve prioritization of private land conservation*
21. Mathew Hardy, Sarah Bekessy, James Fitzsimons & Ascelin Gordon. *Comparing acquisition strategies for private land conservation revolving funds*

Using interdisciplinary frameworks to address coral reef conservation

22. Megan Barnes, Gabriella Ahmadia, Helen Fox, Louise Glew, Michael Mascia & Fitry Pakading. *Tradeoffs and Synergies in MPA Impact for Social and Ecological Objectives*
23. Vanessa Adams, Simon Linke, Hugh Possingham & Vivitskaia Tulloch. *National scale land-sea planning for Papua New Guinea*

The future of conservation one movement or many (Diversity, Equity and Inclusion Journey)

24. Duan Biggs & Ray Ison. *The future of conservation: Insights from contentious debates on the illegal wildlife trade*

Wildlife crime bridging the gap between conservation science and criminology part ii

25. Matthew Holden, Payal Bal, Duan Biggs, Henry Brink, Eve Mcdonald-Madden & Jonathan Rhodes. *Innovation a necessity to save the African elephant from illegal ivory trade*

26. Hubert Cheung. *Rhino Horn: Perspectives in Traditional Chinese Medicine*

Lost in translation: navigating complex policy processes to deliver conservation outcomes

27. Sarah Bekessy, Georgia Garrard & Alex Kusmanoff. *The role of message framing in delivering effective threatened species conservation programs*

28. Megan Evans. *Understanding the governance of biodiversity offsetting: information, institutions & politics*

Conservation planning where is it now what is its potential and how do we get there

29. Sam Lloyd, Andrew Knight, Emma McIntosh, E.J. Milner-Gulland, Hugh Possingham & Bob Smith. *The status quo of systematic conservation prioritisation: A global survey*

Monitoring invisible places: eco-acoustics in marine and freshwater environments

30. Angela Recalde Salas, Christine Erbe, Robert McCauley, Hugh Possingham & Chandra Salgado Kent. *Analysing detection probabilities of baleen whales to develop passive acoustics monitoring protocols*

Co-benefits as incentives for conservation in human dominated landscapes

31. Rebecca Runting & Oscar Venter. *Reducing carbon emissions and attaining cobenefits from timber production landscapes in Borneo*

32. Elizabeth Law, Brett Bryan, Tim Capon, Rochelle Christian, Shaun Cunningham, Sue Eber, Marit Kragt, Martin Nolan, Michael Perring, Anna Renweick, Rebecca Runting & Kerrie Wilson. *Robust strategies for carbon policies to maximise biodiversity co-benefits*

33. Peter Arcese, Elizabeth Law, Tara Martin, Amanda Rodewald, Richard Schuster & Kerrie Wilson. *High complementarity in biodiversity, riparian and carbon values: tax-shifting pays in three ways*

What are we willing to lose? Reframing adequacy to achieve conservation outcomes

34. Caitlin Kuempel, Kendall Jones, Hugh Possingham, James Watson. *Are marine protected areas tackling threats?*

35. Hugh Possingham. *Adequacy: Conservation science's dark secret*

Knowledge cafés

Participants move among multiple stations and join in to discussions on particular topics. The aim is to learn and share knowledge. At each station, the station organiser began the discussion with an informal 5-minute talk before facilitating a 10-minute discussion.

Conservation priorities and practice

36. Gwenllian Iacona & Jonathan Rhodes. *How important is flexibility in conservation*

Threatened species management and recovery

37. Elisa Bayraktarov, Megan Barnes, Joris Driessen, Glenn Ehmke, Stephen Garnett, Sarah Legge, David Lindenmayer, Louise McRae, James O'Connor, Hugh Possingham, Ayesha Tulloch, John Woinarski. *Assessing the suitability of species monitoring data for trend analyses*

Workshop

A 60-minute lunchtime session in which the organiser shares practical knowledge with participants.

38. Gwen Iacona & Bonnie Mappin. *Conservation cost reporting standards workshop. Learn how to report on your cost data so it can inform conservation decisions.*

Oral presentations

Run for 12 minutes each, with only seven presentations per session.

1. E.J. Milner-Gulland & Emilie Beauchamp. *Tracking medium-term impacts of conservation projects on human well-being in Northern Cambodia*

2. Eduardo Gallo-Cajiao, Carla Archibald, Rachel Friedman, Richard Fuller & Euan Ritchie. *Crowdfunding conservation*

3. Luis Verde Arregoitia. *Publication rates and presenter demographics at the 25th ICCB (Auckland 2011)*

4. Stephanie Pulsford. *Farm management and biodiversity: Conserving reptiles and frogs in grazing landscapes*

5. Carly Cook. *Beyond total area New metrics for measuring progress in building robust protected area networks*

6. Sofia Castello, Y Tickell & E.J. Milner-Gulland. *Human costs of enforcement and compliance in No-Take Marine Protected Areas (NTMPAs)*

7. Felipe Suarez Castro, Martine Maron, Matthew Mitchell & Jonathan Rhodes. *Fragmentation effects on the relationship between species diversity and functional diversity*

8. Kiran Dhanjal-Adams. *Setting conservation priorities in dynamic migratory networks*

9. Jeremy Ringma & Melissa Price. *An impact based prioritization of feral pig management*

10. Elisa Bayraktarov, Catherine Lovelock, Hugh Possingham, Megan Saunders & Kerrie Wilson. *A synthesis on coral reef restoration efforts*
11. Maria Martinez-Harms. *Equity and accessibility of cultural ecosystem services from the protected areas*
12. Silvia Carvalho, Mafalda Barata, Salvador Carranza, Craig Moritz, Ana Portela, Hugh Possingham, Pedro Tarroso & Guillermo Velo-Antón. *Spatial Conservation Prioritization of Biodiversity Spanning the Evolutionary Continuum*
13. Victoria Graham & Oscar Venter. *Three cheap ways of reducing forest carbon emissions in tropical Asia*
14. Rachel Friedman, Nathan Bennett, Christopher Ives, Elizabeth Law, Jessica Thorn & Kerrie Wilson. *How Just? Defining and Measuring Social Equity in Conservation*
15. Sana Bau. *Using evidence to inform conservation evidence based decisions or fact-supported beliefs*
16. Diego Correa, Hawthorne Beyer, Hugh Possingham, Peer Schenk & Skye Thomas-Hall. *Global mapping of microalgal bioenergy production at minimal environmental costs*
17. Victoria Griffiths, Julia Baker, Joseph Bull & E.J. Milner-Gulland. *No Net Loss for people and biodiversity*
18. Isaac Peterson, Sarah Bekessy, Ascelin Gordon & Atte Moilanen. *Offset counterfactuals in an uncertain future an impact assessments framework*
19. Robyn Shaw, Sam Banks, Alex James, Rod Peakall & Katherine Tuft. *Post-fire recovery of a native rodent: Managing fire for conservation in northern Australia*
20. Claire Runge. *Combining ecological and economic knowledge to prevent unexpected outcomes from public lands policy*
21. Julie Groce & Carly Cook. *Supporting the landholders of private protected areas*
22. Laura Kehoe, Julia Baum & Tara Martin. *Prioritizing management actions when data is scarce and systems are complex*
23. Cecilia Larrosa, Cristina Banks-Leite, L. Roman Carrasco, E.J. Milner-Gulland & Leandro Tambosi. *Spatial conservation planning with feedback effects harnessing asymmetric information incentives*
24. Angela Guerrero & Kerrie Wilson. *Using a social-ecological framework to inform the implementation of conservation plans*
25. Katrina Davis, Michael Burton, Antoine Camus, Ram Pandit, Hugh Possingham, Jonathan Rhodes, Abbie Rogers & Alaya Spencer-Cotton. *Reconciling expert and stakeholder preferences for marine management*
26. Stephanie Avery-Gomm, Debby Crouse, C. Drew, Leah Gerber, Gwen Iacona, Richard Maloney, Jeff Newman, Hugh Possingham, Libby Rumpff & Michael Runge. *Cost-effective conservation decisions in the face of uncertainty*
27. Juliet Wright, Noelle Kumpel, E.J. Milner-Gulland & Marcus Rowcliffe. *Local experiences of participating in alternative livelihood projects in Cameroon*
28. Md Anwar Hossain, Lucie Bland, Monika Bohm, Mark Burgman & José Lahoz-Monfort. *Assessment of the vulnerability of freshwater crayfish to climate change*
29. Pablo Negret, Moreno Di Marco, Martine Maron, Hugh Possingham & James Watson. *Need for conservation planning in postconflict Colombia*
30. Jennifer Mcgowan, Rohan Clarke, Moreno Di Marco, Hugh Possingham & Bob Smith. *An evaluation of marine Important Bird and Biodiversity Areas in spatial conservation*

Speed presentations

Provide the audience with a concise overview of research, with each oral presentation in the session lasting only 5 minutes plus question time.

1. Marie Dade, Greg Brown & Jonathan Rhodes. *Identifying trade-offs among recreational ecosystem services in urban green spaces*
2. Michael Craig, Richard Hobbs, Tony Kirkby, Michael Renton & Vicki Stokes. *Water and the conservation of wide-ranging Forest Red-tailed Black-Cockatoos in a drying climate*
3. Moreno Di Marco, David Currie, Hugh Possingham, Oscar Venter & James Watson. *The extent and predictability of the biodiversity-carbon correlation*
4. Hernan Caceres, Scott Atkinson, Katrina Davis & Salit Kark. *Stakeholders' perspectives on species management, prioritising actions to preserve our biodiversity*
5. Blake Alexander Simmons, Brett Bryan, Elizabeth Law, Raymundo Marcos-Martinez, Clive McAlpine & Kerrie Wilson. *Identifying deforestation drivers amidst political and behavioral uncertainty in Queensland*
6. Sylvaine Giakoumi & Alexis Pey. *Exploring the role of marine protected areas in providing resilience to biological invasions*
7. Jeffrey Hanson, Richard Fuller, Jonathan Rhodes & Cynthia Riginos. *Effective surrogates for genetic variation in conservation planning*
8. Brendan Dillon, Michael Bode, Moreno Di Marco, Hugh Possingham & Carlo Rondinini. *Incorporating threats into spatial conservation planning*
9. Carla Archibald. *Spreading like wildfire: Quantifying adoption spread of privately protected areas*

Children's book on the insects of Melbourne

Some of our researchers have created a children's book about insects! The book is a collaboration between RMIT and the City of Melbourne, and is part of the urban ecology project *The little things that run the city*.

Kate Cranney, Prof Sarah Bekessy and Dr Luis Mata created the book to show kids the amazing diversity of insects in and around Melbourne — what do they do, and how can we look after them? The excellent illustrations were done by Kate, and Luis took the great macro photographs.

Read more and look through the book at **www.melbourne.vic.gov.au**

New perspectives on the costs of conferencing and social networking alternatives

Virtual variety

By Hannah Fraser (UM)

While it makes eminent sense, there has been limited uptake of virtual conference technologies in ecology and conservation (with the notable exception of the World Seabird Twitter Conferences). In other fields, virtual conferencing is more common. The great thing about virtual conferencing is that the format is very flexible and only limited by the availability of time and money.

A range of services have been used for virtual conferences and some are even free (eg, secondlife, livestream.com, Twitter, WordPress, and YouTube). Others come with a cost (e.g., LabRoots, iCohere, and vConference online), and each has its own strengths and weaknesses.

The service that's the best will depend on the context of the conference and what it hopes to achieve. For example, if the budget is low, the conference is relatively small, free services like Twitter, YouTube and WordPress can be suitable. However, if the budget is higher and the conference is larger, a proprietary service that provides IT support may be preferable.

Another consideration when choosing (or creating) a service to host an online conference is how well it balances the two main limitations of virtual conferencing: reduced networking and, reduced opportunities for skills development.

Networking: Many people feel that virtual conferences provide fewer opportunities to network and that the opportunities they do provide may not yield the same. At a virtual conference you can't meet people in queues for lunch and you can't go for a drink with the people you do meet. On the other hand, the virtual context may take away some of the inhibitions surrounding talking with senior researchers.

All virtual conferencing services allow some form of discussion but some are less likely to supply networking opportunities than others. For example, the 'Climate Change: views from humanities' conference (part of the Environmental Humanities Initiative 2016) was hosted on WordPress and included a number of keynote talks and a series of panels. The panels included live Q&A sessions where people could post questions in a forum for the speakers and expect a speedy response, though this was not available for keynote talks. However, the possibility for less formal discussions between attendees was limited.

In contrast, during the World Seabird Twitter Conference, people can ask questions about or comment live about each presentation and are easily able to contact other people (publicly or privately) who may be presenting or commenting on topics that interest them.

Skills development: One important reason for attending a conference is to prove to potential employers that you really do have the 'exceptional spoken presentation skills' that they ask for in job applications. Speaking at conferences backs up this claim as well as helping researchers to develop these important presentation skills. In most cases talks at virtual conferences are recorded without a live audience (often they are also prerecorded).

When it comes to Twitter conferences, people don't speak at all. Neither option allows researchers to fully practice and prove their spoken presentation skills.

Both of these limitations could be addressed by developing a hybrid conferencing model where all attendees pre-record talks and then (if possible) travel short distances to local hubs. Attendees could then present their talk live to the local audience (in the same time-slot as their pre-recorded talk goes live) and network with local researchers face-to-face. This, of course, has higher overheads and still produces some carbon emissions, forcing conference organisers to make trade-offs between networking and skills development, cost and carbon emissions.

Virtual conferencing is all about trade-offs. The trade-offs made of each individual conference will be different depending on the size, budget and priorities of the conference. However, when it comes to minimising the impact on the environment, I think it's a trade-off worth reflecting on.

References

Fraser H, K Soanes, SA Jones, CS Jones & M Malishev (2017). The value of virtual conferencing for ecology and conservation. *Conservation Biology*. doi:10.1111/cobi.12837 http://onlinelibrary.wiley.com/doi/10.1111/cobi.12837/full

Spinellis D & P Louridas (2013). The Carbon Footprint of Conference Papers. *PLoS ONE* 8(6): e66508. https://doi.org/10.1371/journal.pone.0066508

Counting costs

Traditional face-to-face conferences are expensive and often require long-distance travel. This is particularly problematic for conservation when you add up the:

- **Dollars:** Most conferences are held in developed nations where costs are high and the currency is strong. The cost of international flights, conference registration and accommodation can exclude researchers from developing nations where some of the more important conservation science is being conducted (Fraser *et al*, 2017).
- **Kilograms:** Travelling long distances to conferences releases staggering amounts of CO_2 into the atmosphere. In 2008, the average attendee of an international conference created 849 kg of CO_2 emissions. Academics from isolated countries, like Australia, emitted up to 1891 kg (Spinellis and Louridas 2013).

Virtual conferences have the potential to address both of these issues.

Conferencing on Twitter

By Stephanie Avery-Gomm (UQ)

I'd like to share with you one format of virtual conferencing that is proving both popular and effective — the Twitter conference.

Twitter is already a popular platform with many academics and we've found online conferences using this platform to be enormously successful.

Twitter conferences are an initiative of the World Seabird Union, and I have been involved with the production of two of these in recent years. We have shown that Twitter conferences can be a cost-effective and carbon-free complement to regular, traditional conferences.

As of April 2017, we have hosted three World Seabird Twitter Conferences and have observed incredible growth (see below on the rise of the Twitter conference). These conferences have fostered communication and increasing engagement among researchers around the globe — even while they work in remote field sites. As an additional benefit our conferences have been a valuable science communication tool — bringing science to the public via Twitter and spin off media engagements.

Because Twitter Conferences are cost-effective and carbon free, we've proposed they are an ideal complement to global conferences seeking to maintain engagement between meetings, or in lieu of annual meetings. There is no substitute for the side-conversations that happen at face-to-face conferences, but for science to move forward, ideas must be exchanged and challenged, networks strengthened and collaborations established. Reducing the frequency of traditional conferences to reduce costs and carbon, and supplementing with Twitter Conferences could go a long way towards maintaining networks, keeping abreast of developments, and identifying new opportunities.

How does a Twitter conference run?

A Twitter conference is advertised across multiple platforms (websites, email lists, posters, Twitter) and abstracts are solicited. These are evaluated by an organizing committee and accepted presentations are scheduled according to themed sessions which span global time zones. Within each chaired session, presenters have 15 minutes to present, but instead of having 12 minutes to summarize key findings, researchers get to share a maximum of 6 tweets (140 characters each) to get their message across. This forces the presenter to be succinct and use photographs, infographics or animations to illustrate their work. Each tweet includes a number, and the conference hashtag (eg, #WSTC3) so that the audience can follow along simply by following that hashtag on Twitter.

Questions are posed by the audience and the presenter answers in real time. After the conference, presentations are collated and circulated (eg, Proceedings of the 2nd World Seabird Twitter Conference #WSTC2). The format of the conference can be expanded, by inviting prominent researchers to give plenary presentations and then participate in a live Q&A broadcast. This discussion can be viewed live on Twitter or afterwards as a link within the Proceedings.

Workshops

CEED hosted ten workshops including two held internationally. Almost half of the participants (47%) were external to CEED, including representatives of Australian and International Universities, Research Organisations, Industry and Government as listed on page 55.

What insights can behavioural economics provide for 'panic clearing' in Queensland?

(Kerrie Wilson, 13–17 February 2017, UQ Brisbane)

This workshop provided training to CEED researchers and other relevant stakeholders on how to use a behavioural economics approach to understand the behavioural drivers of compliance with conservation legislation on private lands. The response to recent land clearing in Queensland (i.e. 'panic clearing') was used as a case study.

Participants gained a good general understanding of behavioural economics approaches and how they could be employed to improve conservation outcomes. In addition, a number of collaborative research papers and future research agendas were developed during the workshop.

The workshop led to the development of a number of different outputs. These include a predictive model of the likelihood of illegal clearing, collaborative research papers (under review), a spatial model to identify land holders who would be interested in private land conservation, and several research projects expected to be completed in June 2018.

ABOVE: The participants of the 4-day workshop on behavioural economics.

INSET: Participants at work during the workshop on behavioural economics.

Beyond Ecological Monitoring: Optimal Monitoring across Ecological, Economic and Social Factors

ABOVE: The participants of the workshop 'Beyond Ecological Monitoring'.

(Jonathan Rhodes, 20–23 February 2017, UQ Brisbane)

Fifteen interdisciplinary researchers from CEED (8) and external organisations (7 from Griffith University, James Cook University Lancaster University and UNEP) came together to expand the focus of *Research Theme B: Optimal Monitoring* beyond ecological systems to include economic and social factors. We developed a new prioritisation framework for monitoring ecological, economic, and social components of conservation problems based on social, economic, and ecological benefits, which we will apply in collaboration with GRASP and Bush Heritage. We also developed two research papers on the topic.

Stepping into the future: driving the Technology agenda in Ecology and Conservation

(Brendan Wintle, 13–16 March 2017, UQ Brisbane)

In March, a diverse group (from computer scientists to ecologists) and career stages (from PhD students to Professors) interested in developing and deploying technology for conservation attended this workshop. Participants came from international conservation organisations (Wildlife Conservation Society, WCS; Zoological Society of London, ZSL; The Nature Conservancy, TNC; and Conservation International, CI), research institutions (UQ, UM, QUT, CSU, Macquarie University, Oxford University, CSIRO), policy organisations (UNEP, Wentworth group) and a business corporation (Microsoft).

"This workshop informed the planning of the Society for Conservation Biology Conservation Technology Working Group agenda for the coming year. It has also influenced the development of Alasdair Davies independent platform to support conservation technology sustainability, which has great potential to become a reference in this area.

The workshop has strengthened important research networks between

ABOVE: Workshop participants discuss conservation technology.

institutions across the globe. These include some of the major players in the conservation technology space."

Longer-term outputs also include the development of research papers currently in press, as well as funding bids. Discussions on this topic continued at the Conservation Technology Think Tank the group organised at the International Congress for Conservation Biology (ICCB, Colombia July 2017), which included all 31 key players in the field. CEED members also organised a symposium on "Shaping the future of Conservation Technology" at ICCB, with six invited presentations. Following the workshop and ThinkTank, the Conservation Technology working group (formed by CEED members Jose and Gurutzeta) obtained official status as a Society for Conservation Biology (SCB) working group.

Correlative and demographic species distribution models: reconciling the theory to support decisions

(Peter Vesk, March 27–30, 2017, University of Melbourne)

This workshop, co-funded by the British Ecological Society, gathered a group of 18 experts who apply and develop models for predicting species distributions and range dynamics. The group's expertise spanned a variety of modelling approaches including mechanistic methods based on biophysiological principles, demographic models and correlative models as well as other modellers with complementary skills and strong representation of experts in linking quantitative methods to environmental decision making.

Connecting experts from different modelling disciplines was an enriching experience. It triggered interesting discussion and ideas, and will likely lead to further future collaborations. Exploiting complementary expertise facilitates efficient and successful progress in tasks involving understanding, interpretation and integration of modelling methods.

BELOW: The participants of the workshop on correlative and demographic species distribution models

The three resulting journal outputs in production reflect well current priority actions:

1. Providing a better picture of what each of the approaches can deliver and how they can inform management and conservation
2. Advancing knowledge about how model outputs can/should be interpreted
3. Developing ways to integrate existing methods. This workshop also contributed to a successful ARC 2018 Discovery Project application for three of our ECRs.

Armed Conflict Workshop

(Andres Felipe Suarez Castro, 22–23 July 2017, ICCB Cartagena Colombia)

Organised by two CEED PhD students and held in conjunction with the ICCB conference in Colombia, participants hailed from 10 institutions, including experts from NGOs, academia and government. The workshop focused on identifying new opportunities for biodiversity conservation in Colombia's post-peace agreement era including potential projects and research questions around accounting for conflict risks in conservation decision-making, while promoting the design of conservation strategies with positive socio-economic impacts.

BELOW: Participants of the armed conflict workshop held at the ICCB conference in Cartagena, Colombia. Photo: Andres Felipe Suarez Castro

The workshop also discussed the importance of filling the gap between science and policy to promote conservation in post-conflict scenarios, as well as opportunities to do large scale land use planning in the country. The workshop was a great opportunity to grow Felipe's professional network and learn about cutting-edge research being conducted within this research field. The workshop has led to a policy document and a scientific paper which are to be published in 2018.

Novel mathematical approaches for modelling and managing ecosystems

(Eve McDonald-Madden, 21–25 August 2017, UQ Brisbane)

This workshop brought together CEED members with external participants from 6 institutions to develop new methods for modelling ecological systems. They also worked to develop applied solutions for management agencies on ecosystem management questions. The workshop led to further collaboration and employment opportunities for participants as well as the development of several research papers which are currently underway.

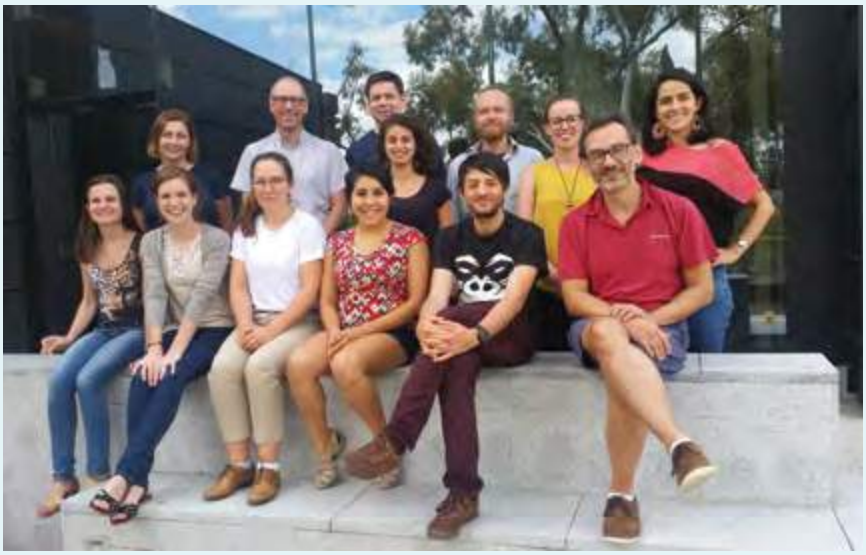
Workshop participants at the UQ node.

Managing ecosystem services in complex landscapes

(Jonathan Rhodes, 31st October — 3rd November, UQ Brisbane)

Researchers from CEED and the University of Sao Paulo collaborated to tackle important policy and planning questions related to the implications of landscape change for managing ecosystem services in complex landscapes. The CEED funding was leveraged to secure a UQ/FAPESP SPRINT grant to Jonathan Rhodes (University of Queensland) and Jean Paul Metzger (University of Sao Paulo).

The workshop involved three sub-groups of researchers to tackle research questions and develop a research paper each. Funding options were also explored to develop global data synthesis, and a follow-up workshop is planned in São Paulo for April 2018.



Participants of the workshop 'Managing ecosystem services in complex landscapes'

Workshop participants

CEED Members & Alumni (# workshops attended)

Angela Guerrero Gonzalez (2)
Alex Kusmanoff
Ascelin Gordon (2)
Ben Phillips
Blake Simmons
Brendan Wintle (2)
Brooke Williams
Caitie Kuempel
Carla Archibald (2)
Chris Baker
Duan Biggs (2)
Diego Correa Gomez
Elizabeth Law
Eve McDonald-Madden (2)
Felipe Suarez Castro
Gurutzeta Guillera-Arroita (2)
Hawthorne Beyer
Hugh Possingham (2)
Hui Xiao
Iadine Chades
James Camac (2)
Jane Elith (3)
Jennifer McGowan (2)
Jian Yen (2)
Johnathon Rhodes (5)
Jose Lahoz-Monfort (3)
Kate Giljohann (3)
Kate Helmstedt
Katrina Davis (2)
Kerrie Wilson (2)
Maria Beger
Marie Dade
Matthew Holden (6)
Matthew Selinske
Michael Bode
Michaela Plein
Michelle Ward
Mick McCarthy (3)
Mike Kearney
Nick Golding (2)

Invited External Collaborators

Andres Etter, Pontifical Xavierian University, Colombia
Angela Recalde-Salas, PhD student, Curtin University, Australia
Anna Metaxas, Dalhousie University, Canada
Arieanna Balbar, M. Sc. student, Dalhousie University, Canada
Beatriz Cano De Oliveira, University of São Paulo, Brazil
Bob Smith, University of Kent, UK
Brendan Markey-Towler, UQ, Australia
Carlos Tapia, Center for the Study of Social Systems, Chile
Cristina Gomez Garcia Reyes, Alexander von Humboldt Biological Resources Research Institute, Colombia
Eric Treml, UM, Australia
Fernando Jaramillo, Stockholm University, Sweden
German Forero-Medina, Wildlife Conservation Society, Colombia
George Antony, Department of Agriculture and Fisheries, Queensland, Australia
Graeme Cumming, JCU, Australia
Hubert Cheung, PhD Student, UQ, Australia
Hugo Fernando Lopez Arevalo, National University of Columbia
Jacob Phelps, Lancaster University, Brazil
Jane McDonald, UQ, Australia
Jaramar Villarreal Rosas, PhD Student, UQ, Australia
Jean Paul Metzger, University of São Paulo, Brazil
Jeremy Simmonds, UQ, Australia
Jessica Metcalf, Princeton University, USA
Jo Clarke, Snowy River Shire Council, Australia
Johannes Refisch, United Nations Environment Programme, Kenya
Jose M. Ochoa-Quintero, Federal University of Mato Grosso do Sul, Brazil
Julia van Velden, PhD Student, Griffith University
Kate O'Brien, UQ, Australia
Kerrie Mengersen, QUT, Australia
Kevin Brown, UC Santa Barbara, USA
Lana Friesen, UQ, Australia
Lani Perlesz, Department of the Prime Minister and Cabinet, Australian Government
Laura Sonter, UQ, Australia
Liliana Davalos-Alvarez, Stoney Brook University, USA
Martine Maron, UQ, Australia
Matthew Dutkiewicz, Department of Environment and Energy, Australian Government
Matthew Adams, UQ, Australia
Mauricio Linares Porto, Del Rosario University, Columbia
Michael Kearney, UM, Australia
Natalie Briscoe, UM, Australia
Navjot Bhullar, University of New England, Australia
Nicola Clerici, Del Rosario University, Columbia
Niels Strange, University of Copenhagen, Denmark
Nigel Bean, University of Adelaide, Australia
Pablo Negret Torres, PhD student, UQ, Australia
Phillip Staniczenko, National Socio-Environmental Synthesis Center, USA
Remi Daigle, Laval University, Canada
Scott Sisson, University of New South Wales, Australia
Sean McMahon, Smithonian Environmental Research Center, USA
Steven Schilizzi, UWA, Australia
Tracy Regan, Arthur Rylah Institute for Environmental Research Energy, Australia
Trish Lavery, Department of Environment and Energy, Australian Government

CEED Communications and Outreach

Communications and Outreach from the Centre saw great success in 2017, building on the communications strategy implemented in 2016. Evaluation of our previous media strategy indicated that using online and social media sources were more effective than standard media releases, this is reflected in the 2017 report.

A review of CEED professional support staff and advice from the Advisory Board in early 2017 led to the recruitment of a part-time dedicated Senior Communications Officer in late 2017 to oversee our activities in this area.

CEED in the news

CEED's research and researchers travelled through Australia and the world in the media, in newspapers, online, as well as television and radio. We had 740 items of news coverage with a potential audience reach of more than 5.6 million people (see Table 1 and Table 2). According to data collected in iSentia, the Advertising Space Rate (ASR) — the dollar value of equivalent airtime or viewership on a particular website or broadcast timeslot — would be worth $3,826,370 million. Most of our coverage was to an online audience, with 124 online news pieces.

Chief Investigators, Partner Investigators and other key researchers at CEED appeared in quality news coverage. The top CEED news item for 2017 was *'Under the Microscope: Pioneering Woman in Science'* on ABC Radio National, featuring Professor Kerrie Wilson. This news item had an estimated audience reach of just over 100,000 listeners and an ASR of $992,915.

The second and third most popular CEED news items both featured Professor David Lindenmayer.

TABLE 1 Top 10 2017 media stories by circulation

CEED Researcher	Topic	Media	Circulation
Jonathan Rhodes	A new acoustic technique is revealing higher koala numbers	*The Australian*	158,000
Danielle Shanahan	Research shows a little green can chase away the blues	*Courier Mail*, syndicated newspapers and websites	144,788
Tara Martin	Interview about a 50-day Antarctica expedition	ABC News, Channel Ten News	108,990
David Lindenmayer	The state's endangered animal emblem and others will be extinct unless the Victorian government acts	*The Age*, syndicated newspapers and websites	103,000
Kerrie Wilson	Women in science	ABC Radio National	100,000
David Lindenmayer	Heyfield timber mill plea misleading	*The Age*, syndicated newspapers and websites	97,419
David Lindenmayer	Barnaby Joyce calls for logging of one of Victoria's protected forests	ABC News	71,000
David Lindenmayer	Interview about the Leadbeater's possum	Radio 3AW	66,000
Jonathan Rhodes	80% of QLD koala population lost in 20 years	Seven News	53,900
David Lindenmayer	Have Regional Forest Agreements been effective?	ABC Radio National	53,990

One on the Guardian website where Professor Lindenmayer commented on logging plans which would 'drive animals to extinction'. This item had 20,119 readers with an ASR of $125,729. The third most significant news item was an interview with Professor Lindenmayer on ABC breakfast radio about regional forest agreements in Victoria. In this news item Professor Lindenmayer commented on the survival of the Leadbeater's possum in Victoria. This piece had an estimated audience of 50,000 listeners and an ASR of $107,225.

TABLE 2 Media coverage

Media Type	Number
AM Radio	264
FM Radio	218
Newspaper	41
Online News	124
TV	68
Magazine	8
Blogs	17

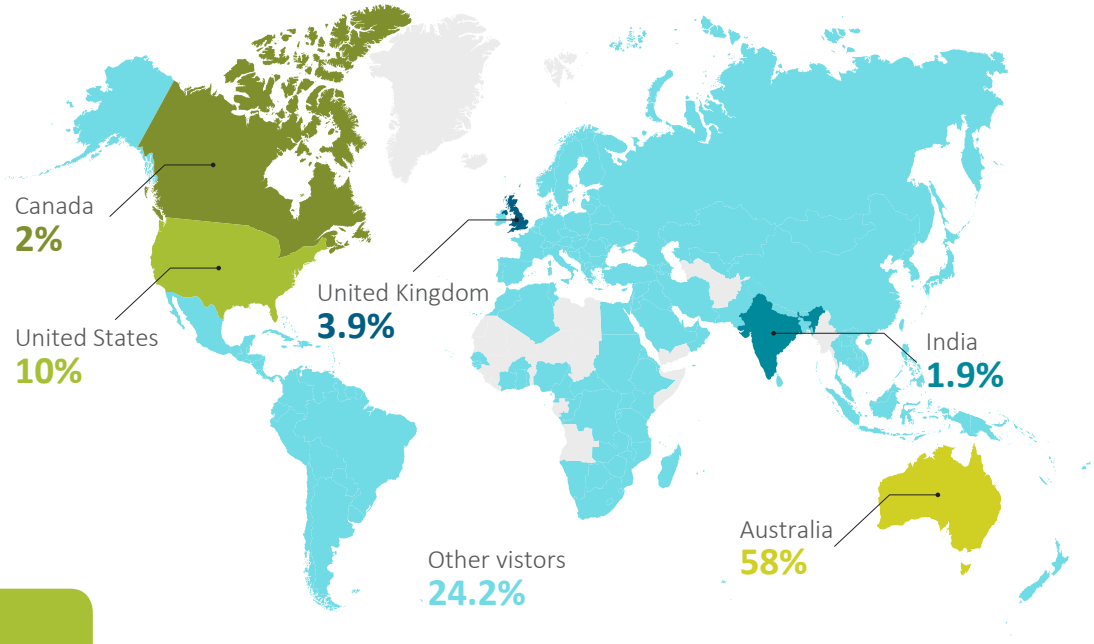


FIGURE 9 CEED website visitors

CEED website

The CEED website also received significantly more traffic than previous years, with 28,738 page views at **ceed.edu.au** in 2017 — compared to approximately 6000 views in 2016 (incomplete data). This is likely due to the high number of new users to the website. In 2016, just 1189 different users interacted with our website. During 2017 that number increased to 6603 individual users.

We also had a high number of return customers, with just over a third of visitors coming back to the CEED website at another point in the year. The website performed well in retaining visitors with a bounce rate (percentage of users who leave after only visiting one website page) of 58% — which is better performing than news websites with similar audiences like the Conversation, which has an 80% bounce rate (data provided to The University of Queensland by The Conversation for benchmarking).

Our website visitors came from countries around the world (see Figure 9) with the majority hailing from Australia (58%), the United States (10%), the United Kingdom (3.9%), Canada (2%), and India (1.9%). Visitors to our website were 56.2% female and 43.8% male, mostly 25–44 years old.

Case Study

Research Communication

A real challenge in effective research communication is getting the right message to the right people at the right time. Knowing who to ask for assistance in developing media releases and related content is often a limiting factor. In mid-October 2017 a casual conversation between Matthew Holden and CEED COO Kathy Avent led to development of his first press release with some clever timing and engagement with the UQ Office of Marketing and Communications to film and produce an on location video all within a week.

The 2017 publication by Matthew Holden and Eve McDonald-Madden on conservation burials suggests that instead of spending vast amounts of money on fancy coffins and tombstones we instead put these resources towards the purchase and restoration of habitat. Within this habitat, the burial process employs natural principles – your corporeal remains decompose in the ground alongside only biodegradable materials (bypassing the embalming process).

The quirky approach taken by Matthew was to align the publication release and associated media stories with Halloween, including the interview being filmed in the Dutton Park cemetery. As a result the story was featured in news, online media and several radio interviews. The New Scientist Facebook post of the story had more than 43,000 shares and 2.2 million views. Due to the media profile and online traffic to the video this publication has the seventh highest altmetric score of all time in the journal Conservation Letters and is in the 99.7 percentile of all publications this year.

So what does Matthew now recommend for researchers wanting to share their findings with the broader community?

- Ask for help from experienced media communicators
- Be bold and quirky in your timing and message
- Plan media well in advance (when the paper is at "minor revisions" stage) so when the paper goes live, everything is ready to share and the story looks nice and fresh
- Prepare yourself for any difficult or controversial questions in case you are asked to do live interviews
- Enjoy the new audiences you'll reach with fun and interesting communication of your research.

Reference

Holden MH & E McDonald-Madden (2017). Conservation from the grave: human burials to fund the conservation of threatened species. *Conservation Letters*. http://onlinelibrary.wiley.com/doi/10.1111/conl.12421/full

Decision Point

In 2017, *Decision Point Magazine* had five English and one Spanish issue, which were produced and made available to its list of more than 6000 subscribers. The dedicated readers are largely made up of key target stakeholders for CEED (see Figure 10). The quality of stories and diversity of topics covered aims to connect conservation policymakers, researchers and practitioners. The magazine's subscribers come mostly from universities, research institutions, government agencies, and NGOs.

Reading *Decision Point* online proved to be popular, with the website accumulating more than 30,000 views in the 2017 calendar year. This marked the third year of our online version which showed solid growth in readership, as did access to the more than 100 editions of *Decision Point* were made available for download in 2016.

The three most popular online stories of 2017 included: *To weed or not to weed, Five things about long term monitoring,* and *Using maths to decide when to put dogs on leashes.*

Social media

Twitter

Twitter is where news breaks and topic trends start, so the fast-moving social media platform is ideal for promoting the latest in decision-science research. We do this both from the CEED Twitter account and by promoting our many researchers who are using Twitter regularly, through retweets and post tagging.

In 2017, we sent out 670 tweets — and they must have been good, as our Twitter account, @ARC_CEED, grew significantly. Our overall impressions reach (the measure of how many accounts your tweets reached) increased by 41% from 338,291 impressions in 2016 to just over 578,000 impressions in 2017. The content posted on Twitter is predominately publication announcements, sharing collaborations and announcing other ARC CEED success that demonstrate the scientific impact we have in the conservation sphere.

Our following also increased by almost 50%, with @ARC_CEED having a total of 2361 followers by the end of 2017, up from 1655 at the end of 2016. Our account profile page, which provides basic information about ARC CEED and a link to our website, had 13,759 unique visits in the 2017 calendar year.

TABLE 3 CEED Twitter followers

Country	Followers (%)
Australia	48
United States	13
United Kingdom	10
Canada	4
New Zealand	2
Spain	2
Colombia	2
Chile	1
France	1
Germany	1
Other	16

Our most popular tweet of the year, which had almost 10,000 unique impressions, was about MARXAN the most widely used decision support software for conservation planning globally (used in 184 countries) and originally created by the previous CEED Director Professor Hugh Possingham.

Top Tweet earned 9,399 impressions

Efficient methods for #conservation planning with #MARXAN. Thanks for the reminder @iadinec, paper by @BeyerHawthorne @Matt_Marxan etal twitter.com?ConservationDe...

FIGURE 10 Subscribers to *Decision Point Magazine*

Facebook

Another avenue of social media we continued to improve in 2017 was Facebook. The world's most popular social media network (with 1.86 billion users) is a great way to share pictures and videos to engage with audiences online and start conversations. The social media strategy during 2016 focused largely on Facebook and Twitter platforms, including a move to management by in-house volunteers. This strategy continued with similar success throughout 2017.

We increased the audience on the ARC CEED Facebook page by approximately 25% in 2017, from 878 page likes at the end of 2016, to 1023 page likes at the end of 2017 (see Figure 11).

We had steady average views throughout the year with some big spikes in November from popular posts. Our post received more than 1000 likes throughout the year.

The top post of the 2017 calendar year was a photo and link for more information about a seminar from Magdalena Lenda on the importance of political history in the presence of invasive species. This post reached 1,837 people and had 48 interactions and 53 link clicks.

Facebook videos was the most successful form of engagement, with the average video post reaching five times as many users while gaining more than double engagement rates (measured by users interacting with a Facebook post by clicking, reaction, commenting, or sharing).

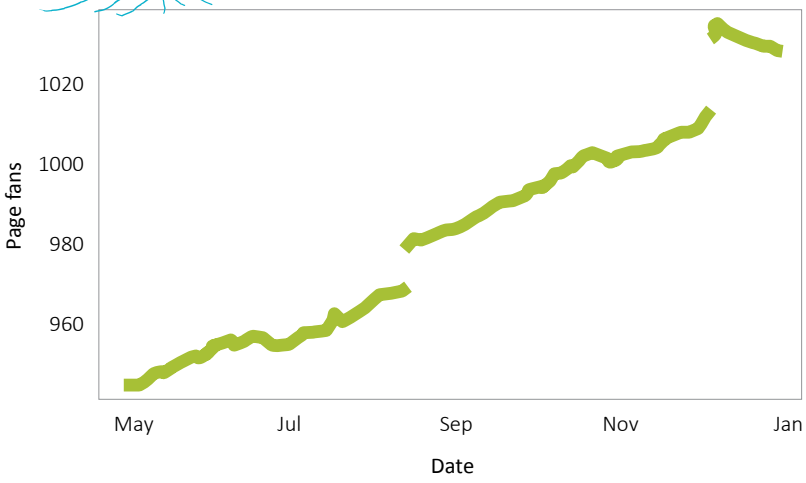
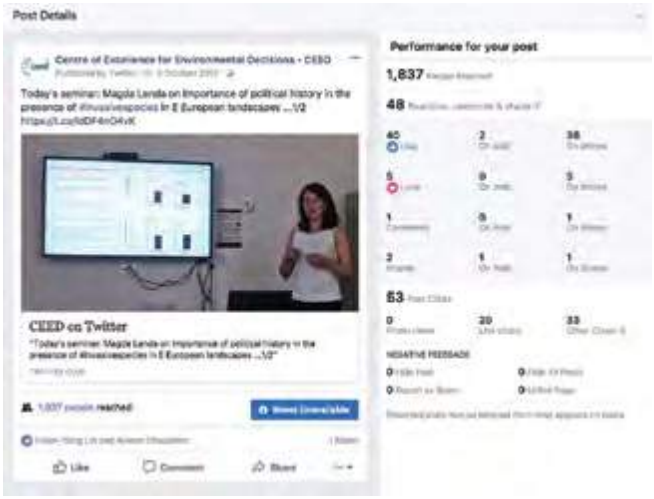


FIGURE 11 Increase in CEED Facebook page fans



Our People — Our Legacy

2017 HDR Scholars

PhD Students

Name	University	Country of Origin	Supervisors	Thesis Title
James Allan	UQ	Australia	James Watson, Hugh Possingham	Cumulative threat mapping and conservation planning
Carla Archibald	UQ	Australia	Jonathan Rhodes	How to utilise privately protected areas in conservation planning to reach local and international conservation targets
Stephanie Avery-Gomm	UQ	Australia	Hugh Possingham, Richard Fuller	Global spatial threats analysis and conservation of marine migratory species
Anna Backstrom	RMIT	Australia	Sarah Bekessy and Georgia Garrard	Managing biodiversity in the city: When should a novel ecosystem be the reference?
Payal Bal	UQ	India	Jonathan Rhodes, Eve McDonald-Madden, Ayesha Tulloch	Biodiversity indices for monitoring and managing ecosystems
Sana Bau	UM	New Zealand	Michael McCarthy, Terry Walshe	Reconciling value judgements and evidence-based decision making theory in conservation
Richard Beggs	ANU	Australia	David Lindenmayer, Jennifer Pierson, Ayesha Tulloch	Impact of noisy miner removal from small fragment of native vegetation on presence and behaviour of small passerines
Donna Belder	ANU	Australia	David Lindenmayer, Jennifer Pierson, Ayesha Tulloch	Survival and persistence of woodland birds in restoration plantings
Louise Blackmore	UWA	Australia	Steven Schilizzi, Sayed Iftekhar, Marit Kragt, Kerrie Wilson, Abbie Rogers	Collaborative conservation: getting landholders to work together to achieve biodiversity outcomes
David Blair	ANU	Australia	David Lindenmayer, Sam Banks, Annabel Smith	Comparisons of vegetation recovery post-fire, logging and salvage logging in the Victorian Central Highlands
Elle Bowd	ANU	Australia	David Lindenmayer, Sam Banks, Andrew Bissett	The Untold Story of Underground Communities: Fungi and Soil Seed-banks in Mountain Ash Forests
Katherine Burton	RMIT	Australia	Luis Mata, Sarah Bekessy, Freya Thomas	Biodiversity sensitive urban design
Hernan Caceres Escobar	UQ	Chile	Salit Kark, Eve McDonald-Madden, Hugh Possingham	Prioritisation of management actions for invasive mammals and threatened species in Southeastern Queensland Islands
Wu Chung-Huey	UM	Taiwan	Michael McCarthy, Cindy Hauser	Design and optimize sequential decision problem under practical constraints and temporal structure in costs and benefits
Colleen Corrigan	UQ	USA	Marc Hockings, Catherine Robinson, Stephen Garnett, Hugh Possingham	Biophysical and social measures of conservation effectiveness: Using the lens of Indigenous and local land and sea management in protected areas as an evidence base
Marie Dade	UQ	Australia	Jonathan Rhodes	Identifying and managing ecosystem service relationships in dynamic landscapes

Name	University	Country of Origin	Supervisors	Thesis Title
Florence Damiens	RMIT	France	Ascelin Gordon, Sarah Bekessy, Libby Porter	The social science of biodiversity offsetting decisions
Brendan Dillon	UQ	Australia	Hugh Possingham, Margie Mayfield	Share or spare? A quantitative framework for optimising investment between restoration of human dominated landscapes and pristine ecosystems
Dini Fardila	UM	Indonesia	Michael McCarthy, Luke Kelly	Relating landscape metrics to ecological processes for spatial planning and management of birds in fragmented habitat
Michelle Freeman	UM	AUS	Brett Murphy, Peter Vesk, Anna Richards, Gary Cook	From Little Things Big Things Grow: Savanna burning, suppressed trees and escape from the fire trap in Australian mesic savannas
Rachel Friedman	UQ	USA	Kerrie Wilson	A multi-level governance networks — participating in social forestry in Indonesia
Eduardo Gallo-Cajiao	UQ	Columbia	Richard Fuller, Salit Kark	How effective is the international regime for the conservation of migratory shorebirds in the East Asian Australasian flyway
Veronica Gama	UQ	Brazil	Hugh Possingham, Richard Fuller, Morena Mills, Simon Blomberg	Are migratory birds more threatened than non-migrants?
Emily Gregg	RMIT	Australia	Sarah Bekessy, Georgia Garrard	Selling the unloved: message framing for conservation of uncharismatic species
Valerie Hagger	UQ	Australia	Kerrie Wilson, John Dwyer, Jacqui England	The costs and success of ecological restoration in Australia and the potential for achieving multiple outcomes for biodiversity and carbon
Nicole Hansen	ANU	Australia	David Lindenmayer, Damian Michael, Don Driscoll, Milton Lewis	Movement of reptiles through fragmented agricultural landscapes
Jeffrey Hanson	UQ	Australia	Richard Fuller, Jonathan Rhodes	Designing reserve networks that are resistant to environmental change
Matthew Hardy	RMIT	Australia	Sarah Bekessy, Ascelin Gordon, James Fitzsimons	The use of decision theoretic approaches to improve private land conservation
David Johnson	ANU	Australia	Phil Gibbons, Don Driscoll, Jane Catford	Restoring floristic diversity of the ground layer in modified ecosystems
Kendall Jones	UQ	Australia	James Watson, Hugh Possingham	Planning for the impacts of land uses on coral reef fisheries under different climate scenarios
Geoffrey Kay	ANU	Australia	David Lindenmayer, Wade Blanchard, Don Driscoll, Saul Cunningham	Conserving endangered ecosystems through environmental stewardship
Lindall Kidd	RMIT	Australia	Sarah Bekessy, Georgia Garrard	Improved message framing for conservation
Alex Kusmanoff	RMIT	Australia	Sarah Bekessy, Ascelin Gordon, Fiona Fidler	How message framing influences environmental decisions
Sofia Lopez-Cubillos	UQ	Columbia	Eve McDonald-Madden, Yvonne Buckley, Justine Shaw, Hugh Possingham	Using ecosystem services for spatial planning in tropical agricultural landscapes

2017 HDR Scholars (cont.)

PhD Students (cont.)

Name	University	Country of Origin	Supervisors	Thesis Title
Bonnie Mappin	UQ	Australia	Hugh Possingham, James Watson, Carissa Klein	Priorities for the restoration and protection of habitat to conserve global terrestrial biodiversity
Maria Martinez-Harms	UQ	Chile	Kerrie Wilson, Brett Bryan, Jonathan Rhodes, Hugh Possingham	Conservation planning for ecosystem services in the system of natural protected areas of Chile
Sean Maxwell	UQ	Australia	James Watson, Jonathan Rhodes, Eve McDonald-Madden	Ecological, social and economic factors for conservation decision making: what should we learn about and when
Jennifer McGowan	UQ	USA	Hugh Possingham, Carissa Klein, Maria Beger	Benchmarking reef health of spatial conversation
Matthew McKinney	UQ	USA	Salit Kark, Jonathan Rhodes, Hugh Possingham	Modelling invasion success: Natural and human-related factors for spatial systematic planning and prioritization of actions to confront invasive species
Courtney Morgans	UQ	Australia	Kerrie Wilson, Erik Meijaard, Kelly Fielding	Conservation Strategy Evaluation
Will Morris	UM	Australia	Peter Vesk	The value of information for vegetation management
Laura Mumaw	RMIT	Australia	Sarah Bekessy, Cecily Maller	Biodiversity decision making and stewardship in urban neighbourhoods
Wendy Neilan	ANU	Australia	David Lindenmayer, Philip Barton, Clive McAlpine	Drivers of beta diversity patterns in modified landscapes: A comparison across biogeographic regions
Thayse Nery	UWA	Brazil	Morteza Chalak, Ben White, Rohan Sandler, Maksym Polyakov	Optimal land-use change to increase water quality, quantity and biodiversity outcomes
Katerina Ng	ANU	Australia	David Lindenmayer, Don Driscoll, Milton Lewis	Movement of ground arthropods in fragmented agricultural landscapes
Christy Nguyen	UWA	Vietnam	Morteza Chalak, Atakelty Hailu, Chubo Ma	Factors influencing calculation of capacity value of wind power: a case study of the Australian National Electricity Market
Junior Novera	UQ	Papua New Guinea	Salit Kark	Incorporating Biological and Cultural Diversity into Conservation Prioritisation: the Mammals of Bougainville, East Melanesia Biodiversity Hotspot as a case study
Estibaliz Palma	UM	Spain	Jane Catford, Peter Vesk	Plant invasion ecology: seeking for generalisation through species traits
Stephanie Pulsford	ANU	Australia	David Lindenmayer, Don Driscoll, Alessio Mortelliti	Exploring methods for improving connectivity of terrestrial native fauna in South East Australian grazing landscapes
Andrew Rogers	UQ	USA	Salit Kark, Berndt Van Rensburg	Avian community response to invasion by non native species
Cristina Romero De Diego	UQ	Spain	James Watson, Morena Mills	Evaluating interventions to manage conservation conflicts
Rebecca Runting	UQ	Australia	Jonathan Rhodes, Hugh Possingham	Managing natural capital assets and ecosystem services under global change

Name	University	Country of Origin	Supervisors	Thesis Title
Gerard Ryan	UM	Australia	Michael McCarthy, Emily Nicholson	Birds in the sky, fish in the sea, money in the bank: quantitative methods for more effective conservation
Matthew Selinske	RMIT	USA	Sarah Bekessy	Predicting human behaviour for better environmental policy decision making
Nicole Shumway	UQ	Australia	Martine Maron, James Watson	Human-predator conflict and conservation policy
Blake Simmons	UQ	USA	Kerrie Wilson, Clive McAlpine, Elizabeth Law, Raymundo Marcos Martinez	Disentangling the political, cultural, and socioeconomic dimensions of tree clearing to inform environmental policy
Freya Thomas	UM	Australia	Peter Vesk	The generation and generalisation of plant functional traits in fire-prone communities
Nooshin Torabi	RMIT	Australia	Sarah Bekessy, Kathryn Hegarty	Understanding landholder participation in biodiverse carbon plantings
Vivitskaia Tulloch	UQ	Australia	Hugh Possingham, Chris Brown, Carissa Klein, Eva Plaganyi	Managing threats to land and sea ecosystems to balance multiple objectives
Els Van Burm	UM	Belgium	Michael McCarthy, Gurutzeta Guillera-Arroita, Brendan Wintle	Optimal monitoring for environmental management
Ruben Venegas Li	UQ	Costa Rica	Salit Kark, Noam Levin, Hugh Possingham	Marine conservation prioritization in a rapidly changing world
Casey Visintin	UM	USA	Michael McCarthy, Rodney van der Ree	Wildlife collisions with linear infrastructure: Modelling, management and mitigation
David Wilkinson	UM	Australia	Michael McCarthy, Reid Tingley, Gurutzeta Guillera-Arroita, Nick Golding	Evaluation of, and Extensions to, the Joint Species Distribution Modeling Framework
Brooke Williams	UQ	Australia	James Watson	Landscape planning in Orinoquia
Steve Wilson	UQ	Australia	Salit Kark, Duan Biggs, Anne Goldizen	Factors affecting the conservation of the critically endangered Javan Rhinoceros
Saras Windecker	UM	USA	Peter Vesk, Jane Catford, Peter Macreadie	Plant traits and carbon sequestration in freshwater wetlands
Melissa Wynn	ANU	Australia	David Lindenmayer, Don Driscoll, Sam Banks	Targeted investment to inform threat mitigation and the reintroduction of critically endangered reptiles on Christmas Island
Hui Xiao	UQ	China	Eve McDonald-Madden	Conservation based on ecosystem complexity using network theory
Ding Li Yong	ANU	Singapore	David Lindenmayer, Phil Barton, Saul Cunningham	Cross-taxonomic surrogates of biodiversity in a woodland setting in Australia
Johanna Zimmerhackel	UWA	Germany	David Pannell, Mark Meekan, Marit Kragt, Abbie Rogers	Interactions of diving tourism and fisheries in marine protected areas: market values and new approaches to deter illegal fishing in the Maldives Shark Sanctuary

2017 HDR Scholars (cont.)

Masters Students

Name	University	Country of Origin	Supervisors	Thesis Title
Daniel Fandino	UWA	Colombia	Richard Hobbs, Leonie Valentine	Does digging by Bandicoots facilitate litter decomposition and nutrient release in soils?
Sachiko Okada	ANU	Australia	David Lindenmayer, Jeff Wood, Alessio Mortelliti	Bird breeding ecology on woodland remnants in forestry and agricultural matrices
Catherine Ryan	UWA	Australia	Richard Hobbs, Leonie Valentine	The influence of the southern brown bandicoot (*Isoodon obesulus*) on microhabitat and surface fuel loads in an urban reserve

Honours Students

Name	University	Country of Origin	Supervisors	Thesis Title
Renae Boyd	UWA	Australia	Richard Hobbs, Suzanne Prober, Craig Macfarlane	Patterns and processes of facilitation in semi-arid Eucalypt woodlands: an investigation of plant shading, water and nutrients
Amelia Holmes	UQ	Australia	Kerrie Wilson	Linking landholders' attitudes regarding property rights and perceptions of responsibility with changes in conservation legislation
Travis Ittensohn	UQ	Australia	Jonathan Rhodes	Identifying urban expansion priorities in relation to biodiversity conservation at broadscales
Ariana Magini	UQ	Australia	Kerrie WIlson	Cost-efficient prioritization of restoration projects to recover threatened ecological communities

Publications

In 2017 CEED researchers produced 164 publications comprised of 157 journal articles, one book and six book chapters. CEED publications appeared in 69 different journals in 2017, across 20 different research areas, as diverse as Ecology, Agriculture, Economics, Forestry, Plant Sciences and Remote Sensing, (ISI Web of Science Categories).

The high publication quality is evident with demonstrated 31.5% of the 157 journal articles being published in journals with an Impact Factor (IF) greater than five, continuing the success CEED has shown in the impact of our Journal Articles since commencing in 2011 (see Figure 12). These include nine journal articles published in some of the most prestigious journals (all IF > 10) including Science, Nature Ecology & Evolution, Global Ecology and Conservation, Trends in Ecology & Evolution, Annals of the New York Academy of Sciences.

CEED has continued to demonstrate exemplary collaboration with 95% of publications involving cross-institutional collaboration, and 65% involving international collaboration.

The strong development of our ECRs is demonstrated by the number 56% of 2017publications involving an ECR with 41% having an ECR listed as the first author.

Evidence of CEED's research impact and quality reputation is apparent in the overall citations for 2017 papers accumulated by March 2018 with 20 (14%) having two or more citations.

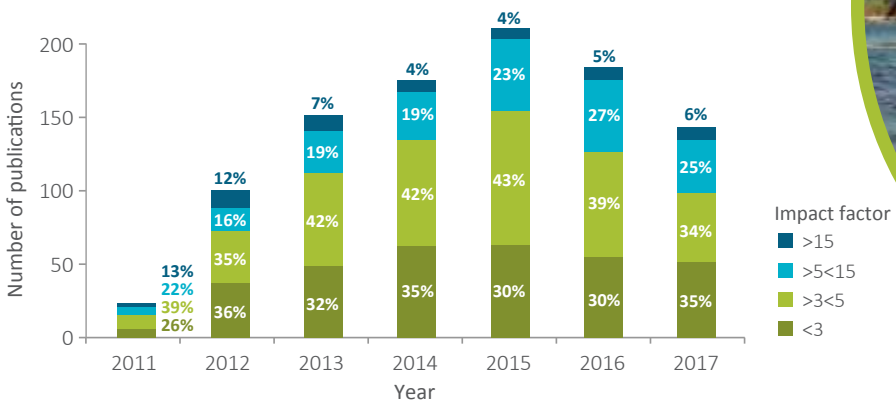


FIGURE 12 Impact factor categories for journal publications

CEED 2017 Publications — 1 January–31 December 2017

Books

1 Lindenmayer DB, DP Blair, L McBurney and SC Banks (2015) Mountain Ash: Fire, logging and the future of Victoria's giant forests. CSIRO Publishing, Clayton South, Australia.

Book Chapters

1 Bekessy S and M Selinske (2017) Social-ecological analyses for better water resources decisions. In (Eds) Hart B and J Doolan, Decision Making in Water Resources Policy and Management. Elsevier.

2 Catford JA, J Roberts, SJ Capon, RH Froend, SM Windecker and MM Douglas (2017) Wetland vegetation of inland Australia. In (Ed) Keith DA, Australian Vegetation. Cambridge University Press.

3 Hansen BD, RS Clemens, E Gallo–Cajiao, M Jackson, GS Maguire, G Maurer, D Milton, DI Rogers, DR Weller, MA Weston, EJ Woehler and RA Fuller (In press) Shorebird monitoring in Australia: a successful long-term collaboration between citizen scientists, governments and researchers. In: Counting Hens Teeth: Making threatened species monitoring an effective part of conservation management. CSIRO Publishing.

4 Kark S (2017) Effects of Ecotones on Biodiversity (Updated 2017, online). In Reference Module in Life Sciences. Elsevier.

5 Lahoz-Monfort JJ and R Tingley (In press) The technology revolution: improving species detection and monitoring using new tools and statistical methods. In (Eds) Legge S, D Lindenmayer, N Robinson, B Scheele, D Southwell and BA Wintle, Making Threatened Species Count. CSIRO Publishing.

6 Schilizzi S and MS Iftekhar (2017) The justice implications of focusing on the economically efficient use of natural resources and environmental impacts. In (Eds) Lukasiewicz A, S Dovers, L Robin, J McKay, S Schilizzi, S Graham, Natural Resources and Environmental Justice: Australian Perspectives. CSIRO Publishing, Clayton, 169–182 pp.

Journal Articles

1 Abesamis RA, P Saenz-Agudelo, ML Berumen, M Bode, CRL Jadloc, LA Solera, CL Villanoy, LPC Bernardo, AC Alcala and GR Russ (2017) Reef-fish larval dispersal patterns validate no-take marine reserve network connectivity that links human communities. *Coral Reefs* 36(3): 791–801 ~ IF: 2.906

2 Abram NK, E Meijaard, KA Wilson, JT Davis, JA Wells, M Ancrenaz, S Budiharta, A Durrant, A Fakhruzzi, RK Runting, D Gaveau and K Mengersen (2017) Oil palm-community conflict mapping in Indonesia: A case for better community liaison in planning for development initiatives. *Applied Geography* 78: 33–44 ~ IF:2.687

3 Addison PFE, LB Flander and CN Cook (2017) Towards quantitative condition assessment of biodiversity outcomes: Insights from Australian marine protected areas. *Journal Of Environmental Management* 198: 183–191 ~ IF: 4.010

4 Aldana AM, B Villanueva, A Cano, DF Correa, MN Umana, LF Casas, S Cardenas, LF Henao-Diaz, PR Stevenson (2017) Drivers of biomass stocks in Northwestern South American forests: Contributing new information on the Neotropics. *Forest ecology and management* 389: 86–95 ~ IF: 3.064

5 Allan JR, O Venter, S Maxwell, B Bertzky, K Jones, Y Shi, JEM Watson (2017) Recent increases in human pressure and forest loss threaten many Natural World Heritage Sites. *Biological Conservation* 206: 47–55 ~ IF: 4.022

6 Almany GR, S Planes, SR Thorrold, ML Berumen, M Bode, P Saenz-Agudelo, MC Bonin, AJ Frisch, HB Harrison, V Messmer, GB Nanninga, MA Priest, M Srinivasan, T Sinclair-Taylor, DH Williamson and GP Jones (2017) Larval fish dispersal in a coral-reef seascape. *Nature Ecology & Evolution* 1(6): 0148 ~ IF: n/a

7 Archibald CL, M McKinney, K Mustin, DF Shanahan and HP Possingham (2017) Assessing the impact of revegetation and weed control on urban sensitive bird species. *Ecology And Evolution* 7(12): 4200–4208 ~ IF: 2.440

8 Armsworth PR, HB Jackson, S-H Cho, M Clark, JE Fargione, GD Iacona, T Kim, ER Larson, T Minney and NA Sutton (2017) Factoring economic costs into conservation planning may not improve agreement over priorities for protection. *Nature Communications* 8: 2253 ~ IF: 12.124

9 Baker CM (2017) Target the source: Optimal spatiotemporal resource allocation for invasive species control. *Conservation Letters* 10(1): 41–48 ~ IF: 7.020

10 Baker CM, PR Armsworth and SM Lenhart (2017) Handling overheads: Optimal multi-method invasive species control. *Theoretical Ecology* 10(4): 493–501 ~ IF: 1.221

11 Baker CM, A Gordon and M Bode (2017) Ensemble ecosystem modeling for predicting ecosystem response to predator reintroduction. *Conservation Biology* 31(2): 376–384 ~ IF: 4.842

12 Barnes MD, ID Craigie, N Dudley and M Hockings (2017) Understanding local-scale drivers of biodiversity outcomes in terrestrial protected areas. *Annals of the New York Academy of Sciences* 1399(1): 42–60 ~ IF: 4.473

13 Bennett JR, RF Maloney, TE Sleeves, J Brazill-Boast, HP Possingham and PJ Seddon (2017) Spending limited resources on de-extinction could lead to net biodiversity loss. *Nature Ecology & Evolution* 1(4): 0053 ~ IF: n/a

14 Biggs D, R Cooney, D Roe, HT Dublin, JR Allan, DWS Challender and D Skinner (2017) Developing a theory of change for a community-based response to illegal wildlife trade. *Conservation Biology* 31(1): 5–12 ~ IF: 4.842

15 Burgar JM, VL Stokes, MD Craig (2017) Habitat features act as unidirectional and dynamic filters to bat use of production landscapes. *Biological Conservation* 209: 280–288 ~ IF: 4.022

16 Camac JS, RJ Williams, C-H Wahren, AA Hoffmann and PA Vesk (2017) Climatic warming strengthens a positive feedback between alpine shrubs and fire. *Global Change Biology* 23(8): 3249–3258 ~ IF: 8.502

17 Carretero-Pinzon X, TR Defler, CA McAlpine and JR Rhodes (2017) The influence of landscape relative to site and patch variables on primate distributions in the Colombian Llanos. *Landscape Ecology* 32(4): 883–896 ~ IF: 3.615

18 Chalak M, M Polyakov and DJ Pannell (2017) Economics of controlling invasive species: A stochastic optimization model for a spatial-dynamic process. *American Journal Of Agricultural Economics* 99(1): 123–139 ~ IF: 1.829

19 Chauvenet ALM, RMA Gill, GC Smith, AI Ward and G Massei (2017) Quantifying the bias in density estimated from distance sampling and camera trapping of unmarked individuals. *Ecological Modelling* 350: 79–86 ~ IF: 2.363

20 Chauvenet ALM, CD Kuempel, J McGowan, M Beger and HP Possingham (2017) Methods for calculating Protection Equality for conservation planning. *Plos One* 12(2): e0171591 ~ IF: 2.806

21 Chong KY, MB Raphael, L Carrasco, ATK Yee, X Giam, VB Yap and HTW Tan (2017) Reconstructing the invasion history of a spreading, non-native, tropical tree through a snapshot of current distribution, sizes, and growth rates. *Plant Ecology* 218(6): 673–685 ~ IF: 1.615

22 Cooney R, D Roe, H Dublin, J Phelps, D Wilkie, A Keane, H Travers, D Skinner, DWS Challender, JR Allan and D Biggs (2017) From poachers to protectors: Engaging local communities in solutions to illegal wildlife trade. *Conservation Letters* 10(3): 367–374 ~ IF: 7.020

23 Correa DF, HL Beyer, HP Possingham, SR Thomas-Hall and PM Schenk (2017) Biodiversity impacts of bioenergy production: Microalgae vs. first generation biofuels. *Renewable & Sustainable Energy Reviews* 74: 1131–1146 ~ IF: 8.050

24 Cox DTC, HL Hudson, DF Shanahan, RA Fuller and KJ Gaston (2017) The rarity of direct experiences of nature in an urban population. *Landscape And Urban Planning* 160: 79–84 ~ IF: 4.563

25 Cox DTC, DF Shanahan, HL Hudson, RA Fuller, K Anderson, S Hancock and KJ Gaston (2017) Doses of nearby nature simultaneously associated with multiple health benefits. *International Journal Of Environmental Research And Public Health* 14(2): 172–185 ~ IF: 2.101

26 Cox DTC, DF Shanahan, HL Hudson, KE Plummer, GM Siriwardena, RA Fuller, K Anderson, S Hancock and KJ Gaston (2017) Doses of neighborhood nature: The benefits for mental health of living with nature. *Bioscience* 67(2): 147–155 ~ IF: 5.378

27 Craig MD, DA White, VL Stokes and J Prince (2017) Can postmining revegetation create habitat for a threatened mammal? *Ecological Management & Restoration* 18(2): 149–155 ~ IF: 1.139

28 Damiens FLP, L Mumaw, A Backstrom, SA Bekessy, B Coffey, R Faulkner, GE Garrard, MJ Hardy, AM Kusmanoff, L Mata, L Rickards, MJ Selinske, N Torabi and A Gordon (2017) Why politics and context matter in conservation policy. *Global Policy* 8(2): 253–256 ~ IF: 0.861

29 Davis KJ, ME Kragt, S Gelcich, M Burton, S Schilizzi and DJ Pannell (2017) Why are fishers not enforcing their marine user rights? *Environmental & Resource Economics* 67(4): 661–681 ~ IF: 1.582

30 Dawson SK, RT Kingsford, P Berney, JA Catford, DA Keith, J Stoklosa and FA Hemmings (2017) Contrasting influences of inundation and land use on the rate of floodplain restoration. *Aquatic Conservation–Marine And Freshwater Ecosystems* 27(3): 663–674 ~ IF: 3.130

31 Dawson SK, RT Kingsford, P Berney, DA Keith, FA Hemmings, DI Warton, C Waters and JA Catford (2017) Frequent inundation helps counteract land use impacts on wetland propagule banks. *Applied Vegetation Science* 20(3): 459–467 ~ IF: 2.474

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Our People

Our Members

CEED Executive

Professor Kerrie Wilson Centre Director	UQ
Professor Michael McCarthy Centre Deputy Director	UM
Professor Sarah Bekessy Chief Investigator	RMIT
Associate Professor Jane Elith Chief Investigator	UM
Professor Richard Hobbs Chief Investigator	UWA
Associate Professor Salit Kark Chief Investigator	UQ
Professor David Lindenmayer Chief Investigator	ANU
Dr Eve McDonald-Madden Chief Investigator	UQ
Professor David Pannell Chief Investigator	UWA
Associate Professor Jonathan Rhodes Chief Investigator	UQ
Dr Anthony Richardson Chief Investigator	UQ
Associate Professor Peter Vesk Chief Investigator	UM
Professor Brendan Wintle Chief Investigator	UM
Dr Kathy Avent Chief Operations Officer	UQ

Partner Investigators

Prof Hugh Possingham	UQ
Prof. Yvonne Buckley	TCD
Assoc. Prof. Noam Levin	HUJI
Dr Iadine Chades	CSIRO
Prof. E.J. Milner-Gulland	OU
Dr Michael Runge	USGS
Dr Andrew Knight	ICL

CEED Chief Investigators with COO Kathy Avent and Decision Point editor David Salt at the CEED writing retreat, Lamington National Park, QLD.

Postdoctoral Research Fellows

Dr Chris Baker	UQ
Dr Philip Barton	ANU
Dr Hawthorne Beyer	UQ
Dr Duan Biggs	UQ
Dr Nathalie Butt	UQ
Dr Alienor Chauvenet	UQ
Dr Michael Craig	UWA
Dr Katrina Davis	UQ
Dr Angela Dean	UQ
Dr Moreno Di Marco	UQ
Dr David Duncan	UM
Dr Claire Foster	ANU
Dr Fiona Gibson	UWA
Dr Nicholas Golding	UM
Dr Ascelin Gordon	RMIT
Dr Angela Guerrero Gonzalez	UQ
Dr Gurutzeta Guillera-Arroita	UM
Dr Asha Gunawardena	UWA
Dr Jacob Hawkins	UWA
Dr Matt Holden	UQ
Dr Gwen Iacona	UQ
Dr Sayed Iftekhar	UWA
Dr Karen Ikin	ANU
Dr Luke Kelly	UM
Dr Holly Kirk	RMIT
Dr Marit Kragt	UWA
Dr Elizabeth Law	UQ
Dr Luis Mata	RMIT
Dr Ram Pandit	UWA
Dr Isaac Peterson	RMIT
Dr Maksym Polyakov	UWA
Dr Anna Renwick	UQ
Dr Abbie Rogers	UWA
Dr Tracy Rout	UQ
Dr Libby Rumpff	UM
Dr Truly Santika	UQ
Dr Justine Shaw	UQ
Dr Luke Shoo	UQ
Dr Tas Thamo	UWA
Dr Freya Thomas	RMIT
Dr Reid Tingley	UM
Dr Leonie Valentine	UWA
Dr Jian Yen	UM

Our Members (cont.)

Research and Technical Support

Georgia Garrard	RMIT
Joshua Volkman	RMIT
Bec Campbell	UWA

PhD Students

James Allan	UQ
Carla Archibald	UQ
Stephanie Avery-Gomm	UQ
Anna Backstrom	RMIT
Payal Bal	UQ
Sana Bau	UM
Richard Beggs	ANU
Donna Belder	ANU
Louise Blackmore	UWA
David Blair	ANU
Elle Bowd	ANU
Katherine Burton	RMIT
Hernan Caceres Escobar	UQ
Wu Chung-Huey	UM
Colleen Corrigan	UQ
Marie Dade	UQ
Florence Damiens	RMIT
Brendan Dillon	UQ
Dini Fardila	UM
Michelle Freeman	UM
Rachel Freidman	UQ
Eduardo Gallo-Cajiao	UQ
Veronica Gama	UQ
Emily Gregg	RMIT
Valerie Hagger	UQ
Nicole Hansen	ANU
Jeffrey Hanson	UQ
Matthew Hardy	RMIT
David Johnson	ANU
Kendall Jones	UQ
Geoffrey Kay	ANU
Lindall Kidd	RMIT
Alex Kusmanoff	RMIT
Sofia Lopez-Cubillos	UQ
Bonnie Mappin	UQ
Maria Martinez-Harms	UQ
Sean Maxwell	UQ
Jennifer McGowan	UQ
Matthew McKinney	UQ
Courtney Morgans	UQ
Will Morris	UM
Laura Mumaw	RMIT
Wendy Neilan	ANU
Thayse Nery	UWA
Katerina Ng	ANU
Christy Nguyen	UWA
Junior Novera	UQ
Estibaliz Palma	UM
Stephanie Pulsford	ANU
Andrew Rogers	UQ
Cristina Romero De Diego	UQ
Rebecca Runting	UQ
Gerard Ryan	UM
Matthew Selinske	RMIT
Nicole Shumway	UQ
Blake Simmons	UQ
Freya Thomas	UM
Nooshin Torabi	RMIT
Vivitskaia Tulloch	UQ
Els Van Burm	UM
Ruben Venegas Li	UQ
Casey Visintin	UM
David Wilkinson	UM
Brooke Williams	UQ
Steve Wilson	UQ
Saras Windecker	UM
Melissa Wynn	ANU
Hui Xiao	UQ
Ding Li Yong	ANU
Johanna Zimmerhackel	UWA

Masters Student

Daniel Fandino	UWA
Sachiko Okada	ANU
Catherine Ryan	UWA

Honours Student

Renae Boyd	UWA
Amelia Holmes	UQ
Travis Ittensohn	UQ
Ariana Magini	UQ

Administration Team

Dr Kathy Avent	UQ
Dolla Boutros	UM
Pauline Byron	UM
Tamara Harold	UWA
Saurang Lonagata	UQ
Claire Shepherd	ANU
Dr Ilva Sporne	UQ
Barbara Whittaker	UQ
Bec Campbell	UWA

Communications Team

David Salt	ANU/UQ
Casey Fung	UQ
Michelle Baker	UQ
Josephine Eynaud Redtail Graphic Design	

Collaborators

Australian Universities and Research Organisations

1 Australian Bureau of Agricultural and Resource Economics and Sciences
2 Australian Institute of Marine Science
3 Arthur Rylah Institute for Environmental Research
4 Australian Research Centre for Urban Ecology
5 Central Queensland University
6 Charles Sturt University
7 Commonwealth Scientific and Industrial Research Organisation
8 Deakin University
9 Griffith University
10 James Cook University
11 La Trobe University
12 Macquarie University
13 Monash University
14 Murdoch University
15 Queensland Herbarium
16 Swinburne University of Technology
17 The Western Australian Biodiversity Science Institute
18 University of Adelaide
19 University of Canberra
20 University of Newcastle
21 University of New England
22 University of Sydney
23 University of Tasmania

National Industry, Government and Not for Profit Organisations

1 Alcoa of Australia Ltd
2 ARUP, Australia
3 Australian Land Conservation Alliance
4 Botanic Gardens and Parks Authority, Western Australia
5 Brisbane City Council, Queensland
6 Bush Heritage Australia
7 Central Tablelands Local Land Services, New South Wales
8 City of Gold Coast, Queensland
9 City of Joondalup, Western Australia
10 City of Melbourne, Victoria
11 City of Moreland, Victoria
12 City of Moonee Valley, Victoria
13 Department of Agriculture and Fisheries, Queensland Government
14 Department of Agriculture and Food, Government of Western Australia
15 Department of Defence, Australian Government
16 Department of Economic Development Jobs, Transport and Resources, Victorian Government
17 Department of Environment and Heritage Protection, Queensland Government
18 Department of Environment and Natural Resources, Northern Territory Government
19 Department of Environment and Primary Industries, Victorian Government
20 Department of Environment, Land, Water and Planning, Victorian Government
21 Department of Environment, Water and Natural Resources, Government of South Australia
22 Department of Health and Human Services, Victorian Government
23 Department of Parks and Wildlife, Government of Western Australia
24 Department of Roads and Maritime Services, Government of New South Wales
25 Department of the Environment and Energy, Australian Government
26 Earthwatch Institute
27 Environment, Planning and Sustainable Development Directorate, Australian Capital Territory Government
28 Friends of Westgate Park
29 Garry Goucher and Associates
30 Gondwana Link Ltd
31 Lake Cowal Foundation
32 Melbourne Water
33 Mingenew Irwin Group
34 Murray Local Land Services, Government of New South Wales
35 Museums Victoria
36 Nature Foundation SA
37 Nyamba Buru Yawuru Ltd
38 Natural Decisions Pty Ltd
39 Nature Conservation Trust of NSW
40 Office of Environment and Heritage, Government of New South Wales
41 Parks Australia
42 Parks Victoria
43 Pew Charitable Trust
44 Queensland Trust for Nature
45 Riverina Local Land Services, New South Wales Government
46 Royal Botanic Gardens Victoria
47 Tasmanian Land Conservancy
48 Terrestrial Ecosystems Research Network
49 The Nature Conservancy Australia
50 The Wilderness Society
51 Trust for Nature
52 Western Australian Museum
53 Wild Mob
54 Zoos Victoria

International Universities and Research Organisations

1 Agricultural Research Organisation, Israel
2 Ben Gurion University of the Negev, Israel
3 Cambridge University, UK
4 Cary Institute of Ecosystem Studies, USA
5 Catalan Ornithological Institute, Spain
6 Center for Ecological Research and Forestry Applications, Spain
7 Center for Strategic and International Studies, USA
8 Colorado State University, USA,
9 Desertification Research Centre, CSIC, Spain
10 Doñana Biological Station, CSIC, Spain
11 Ecopath International Initiative, Spain
12 Hebrew University of Jerusalem, Israel
13 Federal University of Rio Grande, Brazil

Collaborators (cont.)

14 Forest Sciences Centre of Catalonia, Spain
15 German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Germany
16 GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
17 Ghent University, Belgium
18 Institute of Marine Science, CSIC, Spain
19 Israel Institute of Technology, Israel
20 Israel Oceanographic and Limnological Research, Israel,
21 Laboratory of Excellence CORAIL, France
22 Marche Polytechnic University, Italy
23 Massey University, New Zealand
24 Mediterranean Center for Marine and Environmental Research, CSIC, Spain
25 Mediterranean Institute for Advanced Studies, CSIC, Spain
26 National Center for Scientific Research, France
27 National University of Singapore, Singapore
28 Mediterranean Centre for Marine and Environmental Research, CSIC, Spain
29 Oregon State University, USA
30 Pontifical Catholic University of Chile, Chile
31 Pyrenean Institute of Ecology, CSIC, Spain
32 Research Center in Biodiversity and Genetic Resources, Portugal
33 Santa Clara University, USA
34 Stazione Zoologica Anton Dohrn, Italy
35 Stockholm Environment Institute, Sweden
36 Stockholm University, Sweden
37 Spanish National Research Council (CSIC), Spain
38 Stanford University, USA
39 Swiss Ornithological Institute, Switzerland
40 Technical University of Loja, Ecuador
41 Tel Aviv University, Israel
42 Tel Hai College, Israel
43 Thünen Institute of Sea Fisheries, Germany
44 University of Alberta, Canada
45 University College Dublin, Ireland
46 University of British Columbia, Canada
47 University of Burgundy, France
48 University of California, USA
49 University of Cape Town, South Africa
50 University of Central Florida, USA
51 University of Colorado, USA
52 University of Connecticut, USA
53 University of Copenhagen, Denmark
54 University of Côte d'Azur, France
55 University of the Aegean, Greece
56 University of Exeter, UK
57 University of Illinois, USA
58 University of Liverpool, UK
59 University of Hawaii, USA
60 University of Kent, UK
61 University of Kiel, Germany
62 University of Leeds, UK
63 University of Lille, France
64 University of Maine, USA
65 University of Manchester, UK
66 University of Maryland, USA
67 University of Minnesota, USA
68 University of Nottingham, UK
69 University of Otago, New Zealand
70 University of Oxford, UK
71 University of Quebec, Canada
72 University of Salford, UK
73 University of Salento, Italy
74 University of Sao Paulo, Brazil
75 University of Southampton, UK
76 University of St Andrews, UK
77 University of Tennessee, USA
78 University of Toronto, Canada
79 University of York, UK
80 University of Waikato, New Zealand
81 University of Washington, USA
82 University of the Witwatersrand, South Africa

International Organisations- Industry Government & NFP

1 BirdLife International, UK,
2 Blue World Institute of Marine Research and Conservation, Croatia
3 Conservation Biology Institute, USA
4 Department of Conservation, Government of New Zealand
5 Department of National Parks and Wildlife Conservation, Government of Nepal
6 Global Canopy Programme, UK
7 International Rhino Foundation, Indonesia
8 Midpeninsula Regional Open Space District, USA
9 National Council of Rectors, Costa Rica
10 Pro Delphinus, Peru
11 The Nature Conservancy, USA
12 Ujung Kulon National Park Authority, Indonesia
13 U.S. Fish and Wildlife Service, Federal Government of the United States
14 U.S. Forest Service, Federal Government of the United States
15 Wildlife Conservation Society, USA
16 World Wide Fund for Nature, Cambodia
17 World Wide Fund for Nature, UK
18 World Wide Fund for Nature, Brazil

Performance Measures

Key Result Area	Performance Measure	Target 2017	Outcome 2017
Research Findings	Number of research outputs:		
	• Peer reviewed publications	80	163
	Quality of research outputs	50%	26.6%
	• 50% of papers with IF in top 25% of ecology journals		
	Number of invited talks / papers / keynote lectures given at major international meetings:		
	• Plenary talks at international conferences	9	5
	• Invitations to international workshops and conferences not covered above	30	59
Research Training and Professional Education	Number of attended professional training courses for staff and students	20	22
	Number of Centre attendees at all professional training courses	60	75
	Number of new postgraduate students working on core Centre research and supervised by Centre staff (including PhD, Masters by research and coursework)	7	12
	Number of new postdoctoral researchers recruited to the Centre 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 completion times, by students working on core Centre research and supervised by Centre staff:	11	
	• PhD: 3–4 years		11
	• Masters by research: 2 years		2
	Number of Early Career Researchers (within five years of completing PhD) working on core Centre research	15	43
	Number of students mentored	50	70
	Number of mentoring programs	1	1
International, national and regional links and networks	Number of international visitors and visiting fellows:		
	• For 10 days or more	10	29
	• For less than 10 days	20	13
	Number of national and international workshops held / organised by the Centre	8	9
	Number of visits to overseas laboratories and facilities		
	• For 10 days or more	15	17
	• For less than 10 days	30	20
End-user links	Number of government, industry and business community briefings		
	• National	20	37
	• International		3
	Number and nature of public awareness programs[1]	10	18
	Number of website hits	50,000	59,366
	Number of public talks given by Centre staff	80	25

[1] *Measured by public talks*

Key Result Area	Performance Measure	Target 2017	Outcome 2017
Organisational Support	Annual cash contributions from Collaborating Organisations		
	The University of Queensland	386,439	386,439
	University of Melbourne	131,675	132,192
	University of Western Australia	203,184	203,184
	Australian National University	56,109	55,458
	RMIT University	56,630	56,630
	Annual in-kind contributions from Collaborating Organisations		
	The University of Queensland	458,872	458,872
	University of Melbourne	189,333	232,217
	University of Western Australia	203,627	281,264
	Australian National University	138,936	150,070
	RMIT University	51,330	78,870
	Annual cash contributions from Partner Organisations	-	-
	Annual in-kind contributions from Partner Organisations		
	Hebrew University of Jerusalem	15,000	15,000
	CSIRO	26,857	26,857
	Imperial College London	31,421	31,421
	US Geological Survey	12,000	12,000
	Trinity College Dublin	10,437	10,437
	Oxford University	10,182	10,182
	Number of new organisations collaborating with, or involved in, the Centre	2	>10
National Benefit	Contribution to the National Research Priorities and the National Innovation Priorities		
	Briefings to government, business and interest groups		42
	Cross-nodal publications		11
	Cross-institutional publications		135
	Submissions to government on policy matters		9
Centre-specific Performance Indicators	End-user Links:		
	• Internally produced Magazine, issues	10	8
	• Separate media stories (releases)	10	33
	• Media outputs, articles, radio	100	740
	• Memberships of national and international boards and advisory committees		
	— national and	20	35
	— international		17

Finances

The Australian Research Council Centre of Excellence for Environmental Decisions formally commenced operations in 2011. The Centre's financial operations are conducted within the established procedures, controls and delegations of the relevant collaborators and partner institutions and as set out by the Australian Research Council.

In 2017, the ARC CEED received **$2,015,831** in income from the ARC. In terms of expenditure **$2,009,008** was spent during 2017 on personnel, travel, scholarships, administration, communication and consumables. This statement provides an analysis of the income and expenditure of the Centre of Excellence.

Collaborating Organisation Funding

Cash contributions to the Centre of Excellence from the administering and collaborating organisations totaled **$803,903**. This was composed of:

UQ	386, 439
UM	132,192
ANU	55,458
RMIT	56,630
UWA	203,184

In-Kind Contributions

In-kind support totaled **$1,201,293** from the administering and collaborating organisations. The in-kind contributions are primarily for personnel (e.g. salaries and on-costs), support for RHD students, administration and office costs, and facilities.

Partner Contributions

The CEED is very grateful for the support of its partner organisations who contribute expertise towards the Centre's research agenda, and assist in mentoring early career researchers. In 2017 the Centre's partner organisations contributed **$88,404** towards CEED with this primarily to support the partner investigator's time.

Expenditure

Expenditure for CEED totalled **$2,009,008** in 2017. This was composed of salaries for personnel, equipment, travel, research maintenance and consumables, scholarships, communication and administration. The highest expenditure item was salaries for personnel at **$1,607,605**. Travel was also a priority for the Centre with **$173,237** expended to ensure researchers undertook fieldwork, visited other nodes, presented at conferences and attended research workshops and made linkages and collaborations nationally and internationally.

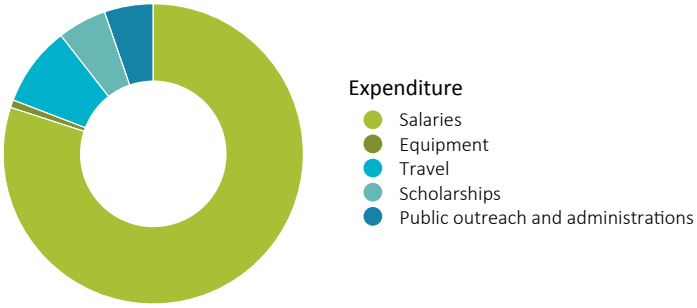

FIGURE 13 Summary of CEED's 2017 expenditure

Statement of Operating Income and Expenditure for Year Ended 31 December 2017

	2017 ($)
Income	
ARC Centre Grant	2,015,831
Host Institutions cash support	833,903
Total Income	**2,849,734**
Expenditure	
Salaries	1,607,605
Equipment	20,630
Travel	173,237
Scholarships	104,262
Public outreach and administrations	103,273
Total Expenditure	**2,009,008**

Abbreviations

AERA	Australian Ecology Research Award
ANU	The Australian National University
ARC	Australian Research Council
ARCUE	Australian Research Centre for Urban Ecology
BBN	Bayesian Belief Network
CBD	Convention of Biological Diversity
CEED	Centre of Excellence for Environmental Decisions
CI	Conservation International
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSU	Charles Sturt University
ECR	Early Career Researcher
GRASP	Great Ape Survival Partnership
HDR	Higher Degree Research
HUJI	The Hebrew University of Jerusalem
ICCB	International Congress for Conservation Biology
ICL	Imperial College London
ISAP	International Scientific Advisory Panel
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
JCU	James Cook University

MPA	Marine Protected Area
NGO	Non-governmental organisation
NNL	No-net-loss
NRM	Natural Resource Management
NUS	National University of Singapore
OU	Oxford University
PM&C	The Dept of the Prime Minister and Cabinet
RMIT	RMIT University
SCB	Society for Conservation Biology
SESYNC	National Socio-Environmental Synthesis Center
TCD	Trinity College Dublin
TNC	The Nature Conservancy
UM	The University of Melbourne
UNEP	United Nations Environment Programme
UQ	The University of Queensland
USGS	US Geological Survey
UWA	The University of Western Australia
WCS	The Wildlife Conservation Society
WWF	World Wide Fund For Nature
ZSL	Zoological Society London

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Kathy Avent: p3, 5, 7 (CAB), 8, 56, 65,

Casey Fung: Cover, p1, 2, 10, 12, 13, 37, 50, 61, 80, inside back cover

Angela Dean: p64

Collaborating Organisations

The University Of Queensland
Australian National University
The University of Western Australia
RMIT University
The University of Melbourne

Partner Organisations

CSIRO
Imperial College London
Trinity College Dublin
University of Oxford
USGS
The Hebrew University of Jerusalem

ARC ceed

ARC Centre of Excellence
for Environmental Decisions

Room 532, Goddard Building 8
The University of Queensland
St Lucia, QLD 4072, Australia

P (+61 7) 3365 6907
F (+61 7) 3365 1692

ceed.edu.au