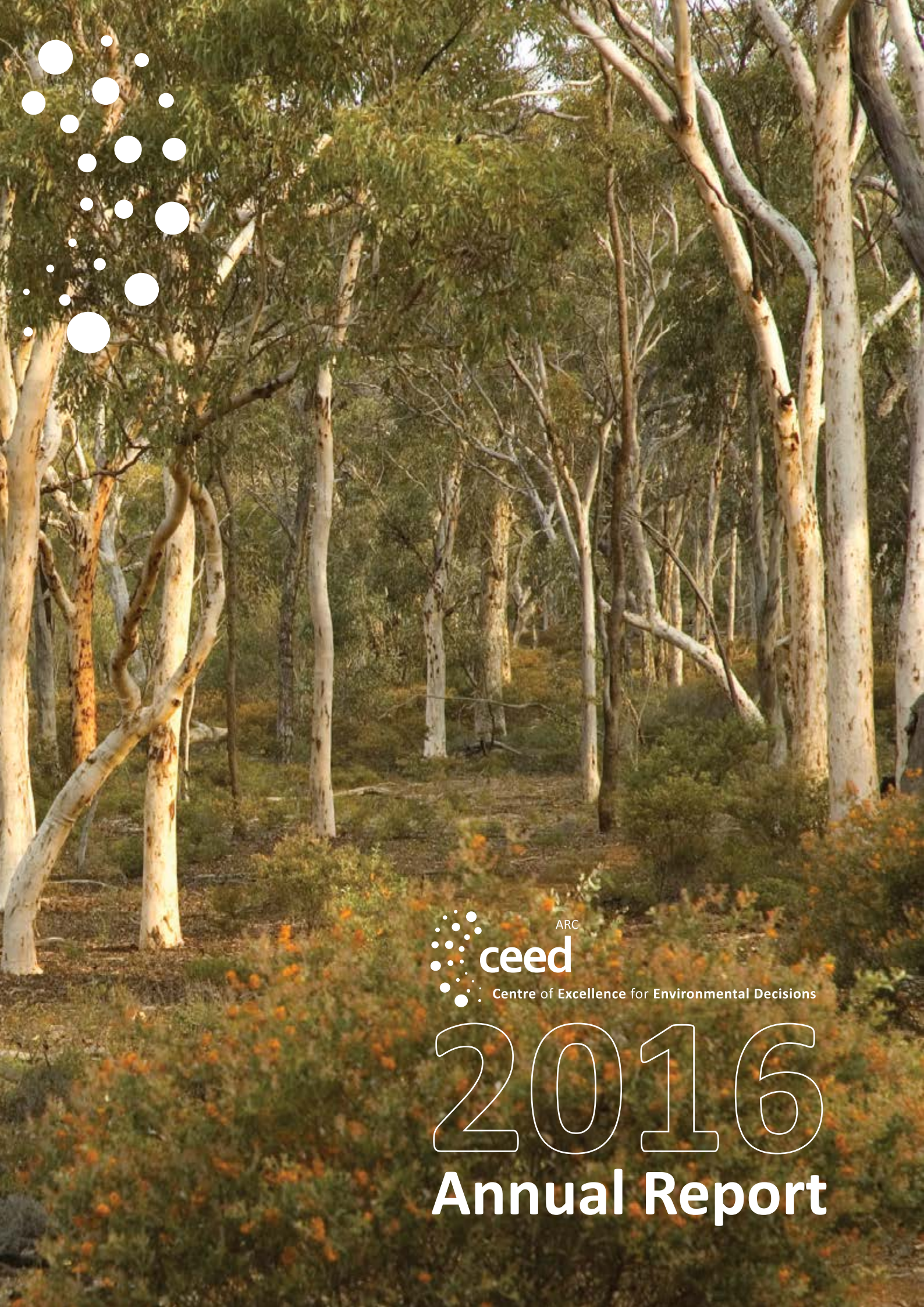

ARC
ceed
Centre of Excellence for Environmental Decisions

2016 Annual Report

Contents

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About CEED

Annual environmental budgets are in the billions of dollars, but remain insufficient to fully protect the environment from adverse impacts. There is a critical need for research and training that enables more efficient and effective environmental decisions.

The Centre of Excellence for Environmental Decisions (CEED) started in 2011 with funding from the Australian Research Council (ARC). The ARC Centres of Excellence are world-class, internationally competitive research teams who investigate and find solutions to, challenging and important Australian and international problems. Since 2011, CEED has pushed the frontiers of environmental decision science.

Our aim is to 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.

The work of CEED is carried out through a partnership between five collaborating organisations — The University of Queensland (UQ), The University of Melbourne (UM), The Australian National University (ANU), RMIT University (RMIT), The University of Western Australia (UWA) — and five partner organisations — the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Trinity College Dublin (TCD), Imperial College London (ICL), Hebrew University of Jerusalem (HUJI) and the US Geological Survey (USGS). The operations of CEED are managed from the University of Queensland, in Brisbane.

How much time do you spend trying to detect difficult to find species? CEED has made several major contributions to the fields of detectability and optimal monitoring. (Photo: Georgia Garrard)

Our researchers are 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 170 researchers includes Chief Investigators, Partner Investigators, Post-Doctoral Fellows and senior researchers, and PhD students, who collaborate extensively across nodes and disciplines. We see this collaborative culture as the key to our success.

OUR VISION

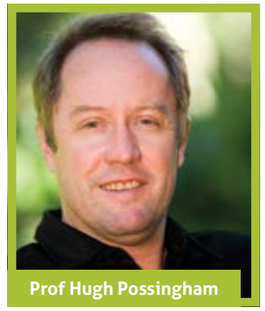
To be the world's leading research centre for solving environmental management problems and for evaluating the outcomes of environmental actions.

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 complement of over 170 researchers collaborate extensively across node and disciplines. We see this collaborative culture as the key to our success.

Director's Report



Prof Hugh Possingham

When I first came back to Australia and started attending Ecological Society of Australia meetings (back in 1990) two things were clear.

First, while statistical ecology in Australia was strong, there were few modellers and virtually no use of decision-science thinking in Australian conservation. Remarkably, these early 90s meetings were characterised by a mistrust of models and the notion that applied research was the work carried out by people not sufficiently talented to do pure ecological research. How things have changed. CEED is both a product and a driver of that change.

As another historical aside, I am struck by the number of topics covered in this annual report that were not typically discussed two decades ago: restoration, monitoring and multi-disciplinarity. Restoration ecology in Australia, championed by our own Chief Investigator Richard Hobbs, has moved from strength to strength with stories in this report focussing on landscape restoration planning plus the cost and feasibility of restoration.

Monitoring and data collection has always seemed like a slightly dull activity but CEED has added a new sparkle — how much information do we really need to make good environmental decisions and what else could we do with those resources?

Finally, I note the increasing prevalence of social science and economics thinking in the work that CEED does. This was always our aspiration and the stories and publications in this annual report attest to that increasing emphasis.

As our centre matures, there are some obvious trends. First, both the quality and quantity of our research continue to grow, as can be seen from the number of publications and the quality of the journals in which they are published. Second, our global impact continues to grow — CEED has become a mecca for applied ecologists and we will capitalise on this with the new Environmental Decisions Alliance led by Eve McDonald-Madden.

It is also critical to highlight that CEED's legacy is far more than our world class research. The impact of basic research on policy is often hard to track, especially since laws and policies implemented by government rarely cite the evidence or influences that underpin their development. As a member of the expert review panel for the NSW biodiversity legislation reform, a process that has taken well over a year, I can attest to the many and varied ways in which CEED research is influencing state and federal policy in Australia. The NSW reforms include the fingerprints of CEED in at least three major ways: the prioritisation of species projects through the Save Our Species program, regional spatial planning as a preferred mechanism for delivering win-win conservation-development outcomes and rigorous, transparent and quantitative biodiversity offsetting. All of these research endeavours have been discussed in previous CEED annual reports, some go back to the beginning of CEED, and now they have significantly informed the policy of one of the most biodiverse regions in the world — trust me, I was there.

This annual report is also filled with stories about another of CEED's legacies — the talented early-career researchers we have helped to nurture. Early-career researchers (ECRs) are the engine room of CEED's innovation. They are involved in the vast majority of our research, and they are already making their mark on the international scene. Further, while mentoring and facilitating the careers of CEED ECRS has been one of our core functions, sometimes we overlook the distinct needs of our mid-career researchers. While I am never entirely sure what mid-career means (I know they are younger than me) I am impressed by the rapid progress of our mid-career researchers in achieving Future Fellowships, being promoted to full Professorships and having impact through workshop and conference invitations on the international stage.

In November of last year I became the Chief Scientist of The Nature Conservancy (TNC), the world's largest environmental non-government organisation. In making that transition I relinquished the honour and privilege of being CEED Director, but the opportunity to lead conservation science in 70 countries, working with 4000 staff, was too good to refuse. My hope is that while working with TNC I will be able to significantly increase the scale of CEED's impact.

I would like to finish this, my final Director's statement in a CEED Annual Report, by expressing my gratitude to Professor Kerrie Wilson for taking over the helm of CEED. The job can be time consuming and, at times, quite challenging.

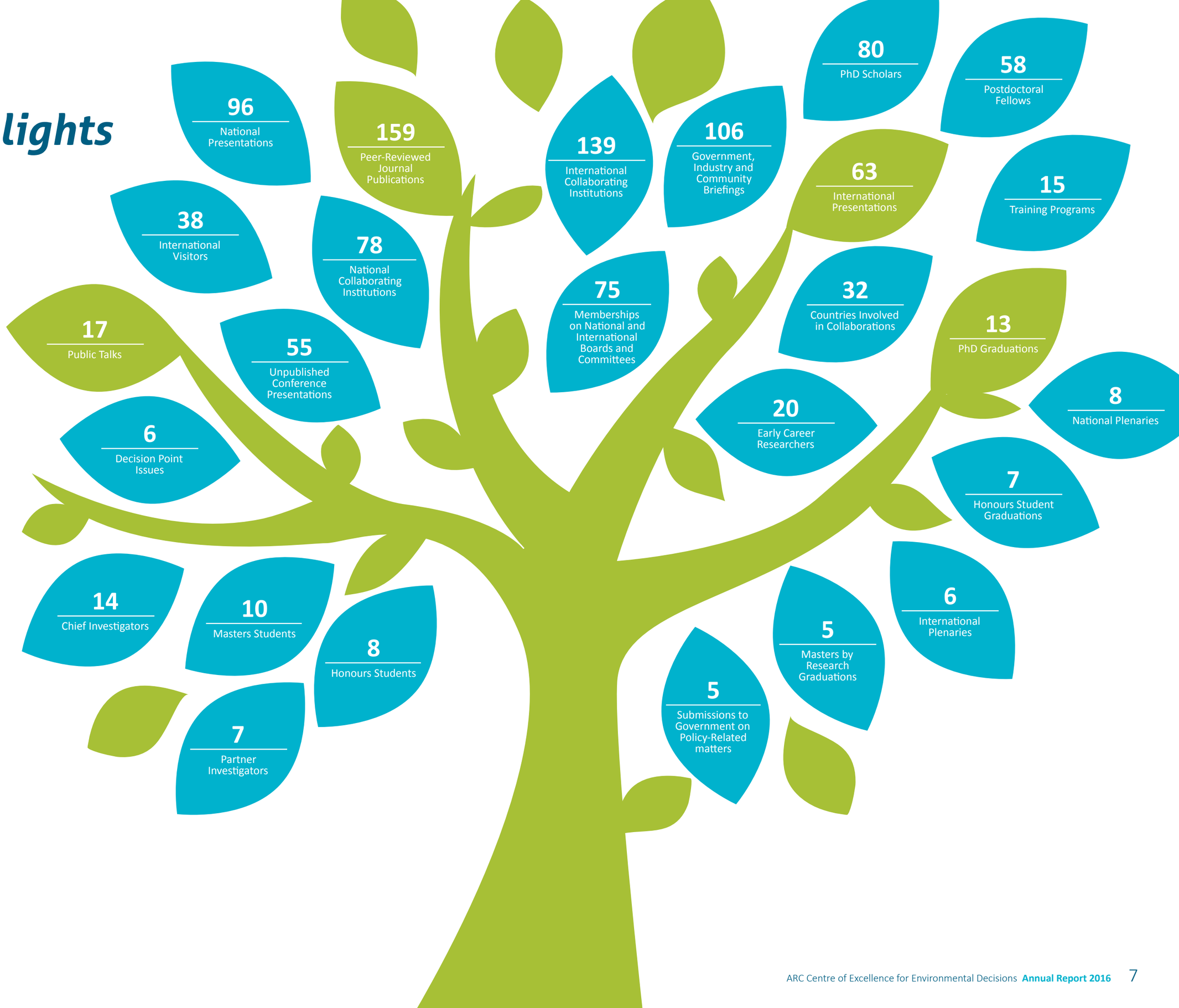
Kerrie, recipient of last year's Frank Fenner Prize for Life Scientist of the Year (one of the Prime Minister's Prizes for Science), has hit the ground running and has developed an exciting plan to guide CEED through its final few years delivering outcomes and impact at scale. I can already see the impact of Kerrie's organisational skill and energy and have complete confidence in her ability to capitalise on our success to date (ably assisted by Deputy Director Professor Michael McCarthy and CEED's Chief Investigators). New ideas already abound and I look forward to seeing how CEED evolves in the years ahead.

Prof Hugh Possingham
CEED Director

> *"I am struck by the number of topics covered in this annual report that were not typically discussed two decades ago: restoration, monitoring and multi-disciplinarity."*
> ***Prof Hugh Possingham***

2016 Highlights

The key achievements from CEED research are clearly demonstrated with standard performance metrics as well as its extensive interdisciplinary connectivity through significant national and international collaboration networks.



Strategy and Future Directions

Our new Strategic Plan 2016–18 will see CEED capitalise on its success through a more targeted focus on Our Research, Our Impact, Our People, Our Network and Our Outreach for the duration of operations.

The CEED Executive have defined an exciting agenda designed to draw on the expertise, enthusiasm and guidance of the CEED Advisory Board, International Scientific Advisory Panel, our extended network of Alumni and collaborating organisations as well as existing staff and students.

Key activities defined in the Strategic Plan include:

- Development of a CEED Alumni Network — to leverage the connectivity, reputation and strong collegial relationships through CEED membership
- A revised Early and Mid-Career Development Program — to ensure the employability and skill development of the next generation of conservation decision scientists
- Establishing the Environmental Decisions Alliance — a global consortium of conservation decision scientists
- A CEED School Engagement Program — designed to introduce young Australians to environmental decision-making and showcase science research careers
- A Benchmarking & Impact Exercise — to critically evaluate CEED performance and demonstrate the national and international significance and impact of CEED research
- A series of CEED Roadshow Events — to promote and disseminate our research findings to a broad range of stakeholders

Introducing the New CEED Director

Assoc Prof Kerrie Wilson

Associate Professor Kerrie Wilson commenced in the role of Centre Director in November 2016 having demonstrated significant research leadership and on the ground conservation and decision-making leadership.

Kerrie completed her PhD in Conservation Biology at The University of Melbourne in collaboration with the UNEP World Conservation Monitoring Centre in Cambridge. She then undertook post-doctoral research at The Ecology Centre before accepting the role of Director of Conservation with The Nature Conservancy Australia program. Kerrie returned to academia in 2008 on an ARC Fellowship and has taught into Conservation Biology and Climate Change courses at UQ, and lead an amazing team of research higher degree students.

Kerrie's own research is focussed on applied conservation resource allocation problems, such as where to invest limited resources to protect or restore biodiversity. Her research program elucidates the benefits that natural ecosystems provide then she can calculate the most effective way to protect and restore these ecosystems. Around the world she is helping governments to make smart investments in conservation. This has led to publications in journals such as *Nature*, *Science*, *PLOS Biology*, *Nature Climate Change*, and *Proceedings of the National Academy of Sciences* as well as a seminal review for the New York Academy of Sciences and a co-edited book published by Oxford University Press.

Kerrie has received numerous national awards, including two Australian Research Council Research Fellowships, an Australian Museum Eureka Prize for Outstanding Young Researcher in 2013, the 2014 HG Andrewartha Medal Royal Society of South Australia and the 2014 SCOPUS Young Researcher Award for the Life and Biological Sciences, the 2015 Women in Technology Life Sciences Research Award and in October 2016 the prestigious Frank Fenner Prize for Life Scientist of the Year.

Our Research

Our research is integrated across five key themes:

THEME A — Environmental policy and management evaluation

THEME B — Optimal monitoring

THEME C — Socio-ecological analysis and modelling for environmental decision-making

THEME D — Ecological theory and processes

THEME E — Quantitative tools and approaches

Our research, led by dedicated theme leaders with teams of senior, mid-career and early career researchers, is coordinated and integrated across these themes to achieve the overall objectives of the Centre.

THEME
A

Environmental policy and 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 (IPBES).

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.

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. The research undertaken by CEED focuses on identifying monitoring actions and strategies that provide the greatest environmental outcomes for the lowest cost.

This theme is currently focused on the following four exciting research areas for monitoring:

1. New technologies for enhancing the cost effectiveness of monitoring
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.

THEME
C

Socioecological analysis and modelling for environmental decision-making

Leader: Assoc. 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.

THEME
D

Ecological theory and 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.

THEME
E

Quantitative tools and approaches

Leader: Dr Michael Bode, 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 Red List of Ecosystems
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?

Planning for Better Environmental Outcomes

CEED collaborations between inter-disciplinary researchers, practitioners, policy makers and end-users help to deliver better conservation outcomes. Tackling the current conservation issues in this manner results in improved engagement and longer-term impact.

Using Telemetry to Improve Turtle Conservation Plans

Key Points

- *Spatial priorities for sea turtle conservation are sensitive to the type of information being used.*
- *Setting conservation targets for migration tracks altered the location of conservation priorities.*
- *Telemetry data needs to be better harnessed in conservation planning.*

Developing a conservation plan for a threatened migratory animal such as the loggerhead sea turtle is quite a challenge. The turtles' movements may be uncertain and variable, span vast distances, cross international borders and traverse land and sea habitats. The information available to conservation managers to create their plans is often thin, patchy and comes from various sources.

Filling in the information gaps can be expensive, time-consuming and have significant consequences for a threatened species.

A group of CEED researchers, led by PhD student Tessa Mazor, set out to determine the degree to which spatial information provides sufficient results for directing management actions. The team developed and evaluated an approach that incorporates habitat and movement information to advance the conservation of migratory species, then tested it using information on loggerhead sea turtles (*Caretta caretta*) in the Mediterranean.

Four approaches, each requiring increasing amounts of information, were used and compared to develop conservation plans for the loggerhead turtles.

Developing conservation plans for a threatened migratory animal like the loggerhead sea turtle presents multiple challenges. (Photo: Tessa Mazor)

The approaches involved:

1. Maps of the turtle's broad distribution
2. Maps showing multiple-habitat types used by the turtles (feeding, nesting and inter-nesting habitats)
3. Movement information based on mark–recapture studies (in which turtles were caught, tagged and later re-caught) and
4. Migration tracks derived from radio-tracked turtles.

The analysis revealed that spatial priorities for sea turtle conservation are sensitive to the type of information being used. Setting conservation targets to include migration tracks altered the location of conservation priorities, meaning that conservation plans designed without such data would miss important sea turtle habitats. This work highlights the wealth and value of connectivity information provided from telemetry research (satellite tracking) when planning the conservation of migratory species.

When there is only a short window of time to act for threatened species, it is critical decision-makers invest and intervene in those areas that will generate the best conservation outcomes.

The recommendations based on this analysis include directing future telemetry studies towards conservation prioritisation needs, meaning that spatially dispersed samples, rather than just large numbers, should be obtained.

The next challenge lies in improving the dialogue and understanding between the 'telemetry camp' and conservation planners. Recognition of the value that telemetry data can provide to conservation planning and determining how much of that data needs to be collected in the first place is critical for the cost-effective application of telemetry data. This information needs to be relayed to those undertaking telemetry studies, and collaborations need to be established before tracking projects commence.

Reference:

Mazor T, Beger M, McGowan J, Possingham HP, Kark S (2016) The value of migration information for conservation prioritization of sea turtles in the Mediterranean. *Global Ecology and Biogeography* 25(5):540–552.

Mapping the Distribution and Protection of Intertidal Habitats in Australia

Key Points

- *The distribution and conservation status of intertidal habitats across Australia is poorly understood.*
- *The first map of intertidal habitats across Australia estimates a minimum intertidal area of 9,856 km².*
- *About 39% of intertidal habitats are protected in Australia with some primarily within marine protected areas and others within terrestrial protected areas. Of this, 3% of the intertidal areas fall under the jurisdiction of both marine and terrestrial protected area designations.*

Intertidal habitats such as sandflats, mudflats and rocky reefs, lie between land and sea. These in-between places provide a wide range of valuable services including fisheries, recreation, buffers to a rise in sea-level and storm protection. Mapping the distribution of a repeatedly inundated habitat can be remarkably complex, even when using remote sensing. For example, creating a map using Landsat imagery requires images (which are taken only every 16 days) to coincide with the highest and lowest astronomical tides on a day without cloud. Finding suitable images at a national level is, therefore, difficult but not impossible.

It is for this reason that little is known about the distribution of these habitats and how well they are protected in reserves, below a 10 km resolution.

This CEED study combined 15 years of images to produce the first map of intertidal habitats for Australia at a 30 m resolution.

Five million shorebirds rely on intertidal habitats for feeding in Australia. Several of these species are considered nationally or globally threatened with extinction. (Photo: Rob Clemens)

Of the 9,856 km² of mapped habitat, large intertidal areas were discovered along embayed coastlines and river mouths, particularly in Western Australia, Queensland and South Australia. It was also discovered that 39% of mapped intertidal habitats fell under the jurisdiction of one protected area designation or another.

Interestingly, the levels of protection varied considerably among states ranging, from 80% in Victoria to 6% in the Northern Territory. It was surprising to discover that some states mainly protected intertidal habitats as part of their marine protected areas (e.g., Queensland), and others as part of terrestrial protected areas (e.g., Victoria). In some cases, 3% of intertidal habitats were protected both by marine and terrestrial protected areas (with 10% in South Australia).

Given the importance of intertidal habitats, there is a strong need to understand how these designations can affect the management of intertidal species. Intuitively, it might be expected that such designations would lead to improved collaboration between protected area managers, resulting in better management of both marine and terrestrial areas. However, there is also the potential for confusion, with neither organisation sure which should take responsibility.

By providing the most accurate map of intertidal habitats to date, this research provides the data needed to better align protected area boundaries with intertidal habitats. In turn, this can improve the protection afforded to the many amazing species these habitats support.

Reference:

Dhanjal-Adams KL, JO Hanson, NJ Murray, SR Phinn, VR Wingate, K Mustin, JR Lee, JR Allan, JL Oliver, CE Studds, RS Clemens, CM Roelfsema, RA Fuller (2016) Distribution and protection of intertidal habitats in Australia. *Emu* 116(2): 208–214

Connecting Pyrodiversity and Biodiversity

Key Points

- *The variation in fire regimes that will promote plant and animal conservation depends on the type of ecosystem.*
- *Combining extensive biodiversity and fire history data with a suite of ecological models and decisions tools will show how to achieve desirable levels of pyrodiversity.*
- *These new approaches are already being put to work across large parts of Victoria, such as in Murray Sunset National Park, to ensure that fire regimes benefit biodiversity.*

Researchers at CEED have identified ways that conservation managers and policy makers could pay more attention to the connection between fire and biodiversity conservation. In particular, they are working on improved ways for acknowledging that there are many different types of fire and fire impact across the landscape.

Variations in the time between fires, their severity, size and patchiness is called 'pyrodiversity'.

The dependence of plants and animals on resources that vary as a result of fire leads to an argument that pyrodiversity will produce a diversity of habitats that can support more species.

"Some studies demonstrate that more plants and animals live in areas with a high diversity of fire histories, while others show no such relationship. This challenges the generality of the hypothesis that 'pyrodiversity promotes biodiversity'," says Luke Kelly, a CEED ecologist from The University of Melbourne working with the Forest Sciences Centre of Catalonia, Spain.

Large bushfires occur in the mallee shrublands and woodlands of Victoria, NSW and South Australia. Policymakers need to pay more attention to the connection between fire and biodiversity conservation. (Photo: Lauren Brown)

Kelly and colleagues have identified that despite the inadequacy of the general pyrodiversity hypothesis, scientists and decision-makers can achieve desirable outcomes for animal conservation in fire-prone ecosystems by recognising the importance of context, differentiating among hypotheses, focusing on functional heterogeneity, and applying decision frameworks that consider uncertainty.

In a 'Hot Topic' article for the Ecological Society of Australia, also led by Kelly, the authors suggest that "natural ecosystems contain different species, have different fire regimes and present different fire risks to biodiversity and people. Fire management will be more effective when guided by local knowledge and based on the demonstrated requirements of plants and animals, as well as the habitats they depend on".

The relationship between pyrodiversity and biodiversity is much better understood following research during the past decade. However, fire-prone ecosystems continue to experience significant changes including more extreme fire weather, growing use of prescribed burning, and serious declines in some plant and animal communities.

"Now, more than ever, understanding of animal and plant responses to fire should be used to determine fire management objectives and actions," says Kelly.

Several CEED researchers — Luke Kelly, Kate Giljohann and Michael McCarthy — have also recently teamed up with scientists from La Trobe University and the Department of Environment, Land, Water and Planning for an exciting new research project on fire and biodiversity: the Spatial Solutions Fire Ecology Project.

References:

Kelly LT, L Brotons, MA McCarthy (in press) Putting pyrodiversity to work for animal conservation. *Conservation Biology* http://onlinelibrary.wiley.com/doi/10.1111/cobi.12861/full

Kelly LT, A Haslem, B Murphy (2016) Managing fire for plant and animal conservation. *Ecological Society of Australia* www.ecolsoc.org.au/hot-topics/managing-fire-plant-and-animal-conservation

Economists Enhance Ecological Restoration

Key Points

- *Economic principles, tools and instruments can be applied to a range of factors that affect the success of a restoration project.*
- *Addressing the following four key aspects of ecological restoration would enhance their success:*
  1. *assessing social/economic benefits,*
  2. *estimating overall costs,*
  3. *ensuring effective prioritisation, and*
  4. *providing long-term financing.*

What would an economist know about ecological restoration? Well, while he or she may not be up on the taxonomy or ecology of the plants and animals being targeted in a restoration effort, an economist brings considerable expertise when it comes to evaluating the costs of a project. That expertise adds an important dimension to the complex process of ecological restoration and its many ecological, technical, social, and economic challenges.

CEED researchers at the UWA Node show there are four key aspects of restoration in which economics can provide valuable assistance:

- Estimation of restoration benefits
- Estimation of the costs of restoration
- Selection and prioritisation of projects
- Securing long-term financial resources to support restoration.

The economic method applied for restoration benefit assessment depends on the type of value likely to be produced by the project.

Ecological restoration is complex and expensive. Economists can provide multiple insights into how to make it more effective. (Photo: Greening Australia)

Market-based methods are not applicable because most of the values generated through successful ecological restoration are not traded in formal markets (i.e., they have non-market values). Non-market values have either a use value (e.g., recreation) or a non-use value (e.g., preserving a threatened species for future generations).

Revealed-preference approaches are applied to measure use values, and stated-preference approaches are applied to non-use values. A benefit-transfer method could be applied when it is too expensive to conduct primary studies.

Cost information is important for ecological restoration planning because it informs decisions on whether to conserve or to restore, the choice of which projects to pursue, and which methods to use. The four main costs involved are acquisition, establishment, maintenance and transaction.

Different economic tools are used to estimate different types of costs. Establishment and maintenance costs are often the easiest to estimate because market prices are available for most of the items in these costs categories. Acquisition and opportunity costs are estimated using capitalised gross revenue, or the gross margin of the productive use of land, or using methods based on property or sales prices, such as hedonic pricing. Transaction costs can be estimated by conducting surveys among the participating landholders or agencies and reviewing documents.

Once the costs and benefits have been measured, the choice among projects requires an index or metric to help guide the decisions. A metric is a formula or a model that 'translates' the various parameters of a project such as cost, effectiveness and area into a single score that can be compared with the score of other projects. The use of a rigorously designed metric is even more important when combining multiple benefits, which can be complex and conflicting. Concessions may be required in the location, design, and complexity of restoration projects to achieve broader benefits.

The acceptability of such a trade-off is likely to vary between restoration projects and depends on factors such as project outcomes specified by regulatory or funding bodies, the threat status of the biodiversity asset, and the value of the biodiversity asset to the community.

Even when restoration benefits and costs have been assessed and prioritised, without adequate financial support failure is possible, particularly for long-term projects often lasting decades.

The Conservation Reserve Program in the United States, established over 30 years ago, is an example of a long-running environmental program; however, most environmental programs have short funding time frames. Finding innovative ways to secure long-term funding is considered one of the greatest hurdles to restoration. Long-term funding could be implemented by working within existing funding arrangements, developing synergy among existing programs, financing through property taxes, developing public-private partnerships and through volunteerism.

The science and practice of ecosystem restoration has for many years been based mostly on ecological considerations. Only recently have restoration scientists and practitioners begun to include economic aspects in the design of restoration projects. Failure to capture the full suite of benefits and costs involved in a restoration process comes with a risk of undervaluing the restoration and inviting poor investment decisions. So, bring an economist into the decision-making and planning process.

Reference:

Iftekhar MS, M Polyakov, D Ansell, F Gibson, G Kay (2016) How economics can further the success of ecological restoration. *Conservation Biology* doi:10.1111/cobi.12778

It is one thing to know the cost of a restoration activity (such as direct seed drilling, as pictured here), but to ensure the best outcomes in ecological restoration it is crucial to incorporate the full range of social, ecological and economic benefits into your planning. (Photo: Greening Australia)

‘Planning’ for Climate Change

Key Points

- *Almost 96% of studies on spatial prioritisation incorporate no aspect of climate change.*
- *Those that do recognise climate change mainly forecast changing distributions of species.*
- *There is a need to incorporate extreme events and human responses to climate change into conservation planning.*

Human-forced climate change affects biodiversity in myriad ways including range changes in many species, mass coral bleaching events, and changes in the timing of biological events such as breeding or fruiting seasons. Human responses to climate change are adding further threats to biodiversity through agricultural expansion, construction of seawalls and changes in fishing areas. The effects are considered likely to worsen, with climate change expected to become the main cause of extinctions during the coming century. So, what can conservation planners do?

A CEED literature review has examined the effects and time frames being incorporated into the different approaches to spatial conservation prioritisation that embrace climate change. The review indicates the vast majority (96%) of articles on spatial prioritisation do not incorporate any aspect of climate change. Of the papers that do incorporate climate change, most are about forecasting species distributions and aim to either protect future habitats or identify areas in which climate change will have the least effect.

It is a major concern that the human responses to climate change and extreme events are virtually ignored, yet are predicted to be as damaging to biodiversity as the direct effects of climate change.

Climate change presents a real and present danger to natural ecosystems, yet most studies on spatial conservation planning don’t even incorporate it in their analysis. Pictured here are the impacts of the 2016 bleaching event on the Great Barrier Reef. (Photo: Oregon State University, CC BY-SA 2.0)

On Pacific islands, for example, humans are being forced inland by rising sea levels. As humans move they clear forest for agriculture and housing, actions that are likely to have an even-more detrimental effect on biodiversity than the habitat lost directly from the rise in sea levels. Human responses to climate change can also impact existing protected areas as changing crop suitability and increasing food shortages compel people to exploit protected areas for food and fuel.

Overall, despite numerous mandates and calls for climate change to be incorporated into conservation planning, the methods available for conservation planners remain few, and those that are available ignore some of the most harmful aspects of climate change.

It is essential that future research develops planning approaches that not only strengthen current conservation efforts but also anticipate the predicted future conditions and provide responses to them.

Most actions that strengthen current conservation efforts (e.g., increasing the size and effectiveness of protected areas, reducing poaching) are still likely to be prudent even if climate change plays out differently to expectations. These would constitute ‘no-regret’ responses.

The anticipation of, and response to, future conditions is hampered by the uncertainty of climate predictions, but the effects of climate change will be of such magnitude that the only option is to accept the uncertainty and continue planning regardless. While identifying how various species will respond to climate change is important, the more crucial challenge lies with developing planning methods that incorporate the full range of climate impacts. Only by doing so will biodiversity be given a good shot at surviving rapid climate change.

Reference:

Jones KR, JEM Watson, HP Possingham and CJ Klein (2016) Incorporating climate change into spatial conservation prioritisation: A review. *Biological Conservation* DOI: 10.1016/j.biocon.2015.12.008

Restoration Planning for Wildlife Conservation in Farm Landscapes

Key points

- *Ensure that farms support a range of broad structural types of vegetation on a farm — remnant old growth woodland, regrowth woodland and replanted woodland.*
- *Ensure there are plantings of a range of ages on a farm.*
- *Adopt conservation planning strategies that allow for the efficient combinations of plantings and remnant woodland patches to maximize species richness and the persistence of species of conservation concern.*

Billions of dollars have been spent in Australia on restoring native vegetation on farms. Far more money has been spent worldwide on forest and woodland restoration in agricultural areas. Restoring native vegetation can be expensive and it is critical that it is done in a cost-effective and ecologically effective way. As part of CEED research, work has been investigating how to best restore temperate woodlands in the wheat-sheep belt of southern Australia. Specifically, the work has quantified how the bird species composition of restored areas changes as plantings age and how such temporal patterns are influenced by factors like planting size and width. The research has demonstrated that species richness changes little over time but the composition alters markedly, with many species dropping out over time but are replaced by others, including migratory bird species. This work suggests that to maximize the value of restored areas it is important to establish and then maintain plantings of different ages throughout a farmscape. This includes plantings that are many decades old and others only relatively recently established.

Planting on an agricultural landscape. (Photo: Chris MacGregor)

Importantly, older plantings are those where despotic hyper-aggressive species such as the Noisy Miner are least likely to occur – thereby enabling other less aggressive native species (usually smaller-bodied taxa) to occupy planted areas.

Other, complementary research studies, have shown how best to plan for complementary sets of planted areas alongside patches of existing remnant native woodland. Plantings, regrowth woodland and patches of remnant vegetation support different assemblages of species and form a portfolio of vegetation assets on a farm. This work is critical for determining how many species can be sustained by a minimum set of restored and remnant areas and which kinds of species respond best to different combinations of planted and remnant woodland areas. Importantly, strategies that lead to the maximum number of bird species being conserved also result in the conservation of many individual species of conservation concern.

This work has significant implications for how to best conduct farm planning to guide the integration of wildlife conservation with sustainable agriculture. In addition, insights from the work in areas of restored and remnant native vegetation in southern Australia has been used in more extended meta-analyses examining global responses patterns to restoration efforts.

Reference:

Ikin K, Tulloch, A., Gibbons, P., Ansell, D., Seddon, J., and Lindenmayer, D.B. (2016). Evaluating complementary networks of restoration plantings for landscape-scale occurrence of temporally dynamic species. *Conservation Biology*, 30, 1027–1037.

Lindenmayer, D.B., Lane, P.W., Barton, P.S., Crane, M., Ikin, K., Michael, D.R. and Okada, S. (2016). Long-term bird colonization and turnover in restored woodlands. *Biodiversity and Conservation*, 25, 1587–1603.

An Eastern yellow robin. (Photo: Dejan Stojanovic)

Informing Policy with Science

Underpinning policy development, implementation and long-term conservation planning with scientific knowledge brings multiple benefits. CEED research often reveals the unexpected gains of a collaborative and coordinated approach.

Balancing Development of Northern Australian Savannas

Key Points

- *Strategically considering potential biodiversity outputs when planning for agricultural development leads to zoning options that would have a significantly lower impact on biodiversity values and carbon farming.*
- *If agricultural development proceeded without consideration for biodiversity, suitable habitat for three species would disappear, and 40 species and vegetation communities could lose more than 50% of their current distributions.*

The northern Australian savannas occupy a vast area, approximately the size of France and Germany combined. The region possesses a relatively intact cover of native vegetation largely consisting of open eucalypt woodlands with a grass understorey, providing a home for a broad suite of native animals and plants, many of which are endemic.

The savannas support low-intensity rangeland grazing. In recent years, it has been recognised that savanna has considerable potential to contribute to climate change mitigation through the storage of carbon, depending on the manner in which fires are managed. There is also a focus on developing Australia's north, of doubling the agricultural output of this region and pouring billions of dollars into new infrastructure such as irrigation.

Irrigated agriculture in the Ord River Development. Developing the north will involve trade-offs with biodiversity. (Photo: Garry Cook)

Based on soil properties, a fifth of this region is also deemed highly suitable for agricultural intensification.

What are the consequences of enabling intensive agriculture in these places? Is it possible to develop the north and still retain these other values?

Spatial analysis undertaken by CEED researchers revealed that the impact of agricultural development in northern Australia depends on how and where it is done. It could have a profound impact on biodiversity or a relatively light impact. Given this, if managers and decision-makers want the sweeping northern savannas to serve multiple purposes, then strategic planning is essential.

The trade-offs between biodiversity, carbon storage, and agricultural intensification were analysed in northern Australia.

Maps of agricultural intensification potential were compared with the geographic distributions of 611 native species and 43 vegetation communities to compare the extent of the overlap. The distributions of areas with larger carbon storage potential that are suitable for carbon farming were also compared.

The northern savanna in its natural condition. (Photo: James Fitzsimons)

Using this information, five alternative scenarios were explored to examine different approaches to development and how each could impact the unique biodiversity values of the region.

One scenario evaluated what might happen if only agriculture was considered in the planning for agricultural expansion (agriculture-only); another evaluated what happened if biodiversity conservation was the only consideration (biodiversity-only); the third looked at carbon-farming as the only consideration (carbon-only); the fourth gave equal weighting to farming, biodiversity and carbon, seeking to balance the three goals (all-equal); and the final scenario looked at saving as much biodiversity as possible while still allowing for carbon farming and significant agricultural development (biodiversity-weighted).

The agriculture-only scenario revealed that if all suitable soils were converted to agriculture, the suitable habitat of three species would disappear, and 40 species and vegetation communities could lose more than 50% of their current distributions.

However, agricultural development need not have such a dramatically negative impact. Analysis showed that it is possible to zone the region so that agricultural development could still occur on over 56,000 km^2 with a significantly lower impact on biodiversity values and carbon farming. By expanding the protected area network to capture an additional 5% of northern Australia, the representation of the biodiversity features could be effectively doubled from 29% to 57% (i.e., nearly doubling the average proportion of currently suitable areas for species that could be protected).

The development of extensive areas of irrigated agriculture might also cause potentially negative impacts on other industries, such as tourism.

Our trade-off analysis could include other cultural, historical, social and economic considerations to identify development footprints that have the lowest possible impact on biodiversity while still providing strong economic opportunity.

The research also has application beyond northern Australia. The analysis provides a template for policymakers and planners to identify areas of conflict between competing land uses, places to protect in advance of impacts, and planning options that balance the needs of agriculture and conservation.

Reference:

Morán-Ordóñez A, AL Whitehead, GW Luck, GD Cook, R Maggini, JA Fitzsimons, BA Wintle (2016) Analysis of Trade-Offs Between Biodiversity, Carbon Farming and Agricultural Development in Northern Australia Reveals the Benefits of Strategic Planning. *Conservation Letters* 10(1):94–104

Conservation Covenants: Worth the Paper They're Written On?

Key Points

- *Conservation covenants are an important and enduring mechanism for conserving biodiversity on private land.*
- *Multi-party covenants offer greater permanence than single-party agreements.*
- *Ongoing monitoring and reporting is needed to assess the true contribution and value of these agreements.*

Conservation covenants are legally binding agreements that place 'permanent' restrictions on activities landholders can undertake on their land; for example, they often prevent the clearing of native vegetation. These agreements are registered on the title of the property, obligating the current and future owners to look after their property's ecological values.

Landowners voluntarily enter into these agreements because it helps them preserve the natural values of the land they love. Governments like these agreements because they help meet the obligation to conserve biodiversity.

Since the first conservation covenant in Australia — a New South Wales wildlife refuge established back in 1951 — the number of covenants has grown to around 7,500 across Australia. The majority of the agreements were established in the past 25 years.

From a conservation policy perspective, the permanence and security of these agreements with private landholders are central issues. In theory, most conservation covenants in Australia are permanent in that the conditions they impose are passed on to the new owners when the land is sold.

Conservation covenants are usually legally binding agreements that place restrictions on what activities can take place on land in order to protect its natural values. (Photo: James Fitzsimons)

They are designed to last forever. However, landholders can change frequently with potentially negative consequences for the protected land.

This study led by Matthew Hardy, an ECR at RMIT University, examined the permanence and security of covenants in Australia by asking the 13 major covenanting organisations to report on the status of the covenants they oversaw and whether the obligations they prescribed had been observed.

Of the 6,818 multi-party covenants created across Australia, only eight had been released (0.12%). Of the 673 single-party (NSW Wildlife Refuge) covenants formed, 130 had been released.

Detailed breach data was hard to obtain, making it difficult to accurately determine the number and types of breaches. It was also difficult to assess the impact the breaches were having on the natural values the covenants had been established to protect. Some organisations suggested that the turnover of conservation covenants to 'successor landholders' may be developing into a policy issue, requiring agencies to engage with the new landholders and ensure they are as committed to the terms of the covenant as the original owners.

The study showed that the agreements are, on the whole, relatively secure and enduring, but ongoing monitoring and reporting to assess the true contribution of the agreements is needed.

Knowing that the majority of existing covenants were created in the past 25 years, further increases in transfers to new owners is to be expected. Given this, coupled with a growing enthusiasm by governments to encourage new conservation covenants, the need for ongoing and effective monitoring has never been greater.

Reference:

Hardy MJ, JA Fitzsimons, SA Bekessy, A Gordon (2016) Exploring the permanence of conservation covenants. *Conservation Letters* DOI:10.1111/conl.12243

People are Willing to Pay for Carbon Farming

Key Points

- *Adopting carbon farming practices often leads to a loss in profit for farmers.*
- *The public's 'willingness-to-pay' for the co-benefits of carbon farming was estimated.*
- *Respondents were willing to pay $19.20 per year for every extra hectare of native vegetation, and $1.13 per year for every metric tonne of CO_2-e reduced.*

There has been a lot of scientific and political focus on reducing greenhouse-gas emissions from agricultural production. The research team looked at general community preferences for the potential benefits of carbon farming (see the box 'What is Carbon Farming').

Previous research by the team has shown that financial incentives offered by the government involving carbon-farming practices often lead to a loss in profit for farmers. This study investigated other ways to increase funds for farmers to adopt carbon farming. For example, some carbon farming practices can deliver co-benefits, such as biodiversity or landscape aesthetics, in addition to climate-change mitigation.

The CEED research team from UWA and UQ set out to estimate the public's 'willingness-to-pay' for the co-benefits of carbon farming. A choice-experiment survey of Australian residents in New South Wales (NSW), Queensland, Victoria and Western Australia asked respondents to choose their preferred alternative from three carbon-farming options. An econometric analysis of the respondents' choices revealed the relative weight that people put on the various impacts presented.

The model results demonstrate that people cared about costs, emission reduction, and protecting native vegetation, and that individual preferences varied significantly across the population. For example, people who believe that climate change is happening and is at least partly caused by humans, preferred the more-positive options for the benefits of carbon farming than other respondents.

Using the econometric model, people's individual willingness-to-pay to receive carbon-farming benefits was estimated. On average, respondents were willing to pay $19.20 per year for every extra hectare of native vegetation, and $1.13 per year for every metric tonne of CO_2-e reduced. These willingness-to-pay estimates varied for respondents with different opinions on climate change.

The results of this research have important implications for carbon-farming policies.

Given that the Australian community derives a positive value from carbon-farming benefits (e.g., carbon mitigation and biodiversity protection), there is a strong case to broaden policies to include co-benefits in the value calculations, rather than considering greenhouse-gas reductions alone. To increase the social welfare from carbon-farming policies, higher incentive payments should be offered to encourage changes in agricultural practices that generate environmental co-benefits.

Reference:

Kragt ME, FL Gibson, F Maseyk, KA Wilson (2016) Public willingness to pay for carbon farming and its co-benefits. *Ecological Economics* 126:125–131

What is 'Carbon Farming'?

A set of activities that increases carbon storage or avoids greenhouse-gas emissions. Storage activities can include:

- Re-introducing woody vegetation into landscapes
- Protecting native forests
- New farm-forestry plantations
- Increasing soil carbon by reducing soil disturbance (e.g., through no-till farming or increased stubble retention)
- Practices that can avoid greenhouse-gas emissions can include early savanna burning, changing manure handling practices, or changing livestock feed.

Two Australian policy programs, the Carbon Farming Initiative (2011–14) and the Emissions Reduction Fund (2014 onwards), have aimed to reduce carbon emissions by rural landholders. Both programs provide(d) financial rewards to farmers who adopted practices to reduce greenhouse-gas emissions or increase carbon storage in soils or vegetation.

Engaging Landholders in Biodiverse Carbon Plantings

Key Points

- *A Bayesian Belief Network can predict landholder participation rates for any type of carbon-farming scheme.*
- *Program characteristics are more influential at driving participation than financial incentives.*
- *Biodiversity co-benefits of carbon planting is another important factor.*

Biodiverse carbon plantings are considered by many to hold the key to sustainable land management. In addition to storing carbon, planting trees has the potential to preserve vital ecological processes and provide habitat for wildlife.

Like any private-land conservation scheme, the number of landholders participating in carbon and biodiversity related programs directly influences the amount of carbon stored and biodiversity protected. The rate of landholder participation depends on many social and environmental drivers.

A team led by CEED ECR Nooshin Torabi of RMIT University has focused on identifying these drivers. The literature reviewed the factors influencing landholder participation in agri-environment schemes, voluntary carbon plantings and private land conservation. Then researchers surveyed and interviewed 17 Victorian landholders, including commercial farmers, semi-commercial farmers, hobby farmers and lifestyle landholders, who had participated in a voluntary biodiverse carbon-planting program. Landholders' drivers and motivation for participation in the program was investigated in each step of adoption.

Biodiverse carbon plantings in an agricultural landscape in Victoria. (Photo: Nooshin Torabi)

The study also interviewed 14 science and policy stakeholders from universities, CSIRO, government organisations and NGOs working in the field of carbon and biodiversity conservation in Australia. Interviewees were asked about challenges and opportunities in bundling and stacking carbon, and biodiversity ecosystem services.

Bundling refers to paying a premium price for the biodiversity co-benefits of carbon plantings and stacking relates to selling carbon and biodiversity credits separately in their related markets.

Bundling and stacking could offer landholders more incentives for their participation in biodiverse carbon plantings.

A Bayesian Belief Network (BBN) was developed from the literature review, survey and interview results. The BBN is a probabilistic graphical model that predicts landholder participation rate for any type of carbon-farming scheme. The effects of three main factors on the participation rate: program design, landholders' values for co-benefits and financial incentives, were examined.

Program design was identified to be the most important factor, followed by the value of co-benefits, with financial incentives being the least important factor. The participation rate under scenarios with different combinations of incentives (bundling, stacking or carbon-only payments) and program permanence (100 years, 25 years and on-contract agreements) was tested. Results revealed that 'on-contract agreement' and stacking/bundling carbon and biodiversity credits could increase the landholder participation rate more than any other scenario.

These findings could help policymakers to design programs that are more flexible and appealing to a broader range of landholders. Such programs need to ensure that the landscape-specific co-benefits of participation are effectively communicated to landholders. This is because both conservation and productivity related co-benefits matter to landholders.

Reference:

Torabi N, L Mata, A Gordon, G Garrard, W Wescott, P Dettmann, S Bekessy (2016) The money or the trees: What drives landholders' participation in biodiverse carbon plantings? *Global Ecology and Conservation* 7: 1–11.

Supporting Management and Practice

Providing support, advice and improved on-ground decision making capabilities to conservation practitioners, managers and policy makers is a key directive for CEED researchers. This connectivity also provides excellence research and training opportunities for early career researchers and practitioners alike.

What's the Cost and Feasibility of a Cane Toad Barrier?

Key Points

- *There is great value in ecological modellers getting input from conservation practitioners.*
- *A refined model has produced a feasible and cost-effective solution of a waterless barrier to stop the cane toad invasion in Western Australia.*

When building models of ecological systems, there are many reasons to engage with practitioners who often have access to the most relevant data and a better understanding of the system being modelled.

Such information can improve the realism and accuracy of model predictions. Practitioners can also benefit from engagement through increased understanding and awareness of a model and its capabilities. This two-way dialogue can improve trust in a model and increase the chance it will be adopted to support decision-making.

Despite these advantages, the engagement between modellers and practitioners is often limited. Researchers from CEED have attempted to bridge this gap between theory and practice for one of the worst invasive species in Australia — the cane toad.

The researchers updated an existing theoretical model predicting cane toad spread through arid regions of Australia with local knowledge of weather and land use, to find the most cost-effective location for a 'waterless barrier' to contain the spread of toads.

The idea behind a waterless barrier is that cane toads need access to water every 3–4 days. Because of their inability to retain water, the toads simply can't survive without it. So, in very dry regions, their spread may be able to be halted by excluding them from permanent water sources.

In arid areas of Australia, artificial water points, such as pastoral dams and tanks, are the only permanent water sources at which toads can rehydrate and breed. If cane toads could be denied access, by replacing dams with leak-proof tanks, then their invasion could be halted.

While a number of NGOs and local management groups have expressed interest in a waterless barrier approach to halting the spread of cane toads, some practitioners had reservations. Why the doubt? Were they concerned with the data and assumptions underpinning the model? Or did they just misunderstand its limitations and capabilities?

To find out, CEED researchers decided to ask them. To do that, a workshop was run in Broome with local practitioners and experts in cane toad biology.

Attendees revealed that they were most concerned about the accuracy of input data going into the model, such as rainfall variability, the locations of dams, and other land uses in the corridor that might support toad populations.

In response to these concerns, the researchers updated the previous spread model to incorporate this information. They also drove the entire length of the corridor, verifying the locations of artificial and natural waterbodies on every property between Broome and Port Hedland.

In addition, a variety of other points were mapped that could potentially provide refuges for toads, such as dwellings, homesteads and roadhouses, as well as regions of irrigation and cropping. This fieldwork enabled the production of the most up-to-date map of permanent water and land use on pastoral land between Broome and Port Hedland.

With these updated maps, the researchers then investigated the most-cost effective location for a waterless barrier in the corridor. This involved simulating the spread of toads through the region in the absence of management and then testing barriers placed at 17 potential locations. An economic model estimating the upfront installation and ongoing maintenance costs of a barrier was developed to find the most-cost effective barrier location. The updated model was run with and without local knowledge of the landscape, to determine if this information affected the best barrier location.

The results of the analysis suggest that the toad invasion front could be contained by excluding toads from fewer than 100 waterbodies, at the cost of approximately $4.5 million over 50 years (that's less than $100,000 a year). This is considerably less than the amount spent on other invasive species management programs in Australia. For example, the Federal Government recently spent $19 million on feral camels in central Australia over four years, and $35 million on the fox eradication program in Tasmania over eight years.

Just as importantly in terms of the environmental decision science, our research demonstrates the importance of practitioner engagement during model development.

Local knowledge overlooked in the original incarnation of the model — specifically knowledge about irrigation and dwellings — influenced the best place for a barrier. Our new research suggests that the idea of a waterless barrier to halt the spread of cane toads is both feasible and cost-effective, and promises big conservation outcomes. This proposal is also a win–win situation for pastoralists and conservationists, because installing leak-proof tanks improves farm productivity, while simultaneously mitigating a key threatening process for biodiversity.

An example of a leaky trough system on a property between Broome and Port Hedland. Developing a waterless barrier would involve replacing this water point with a leak-proof tank so that toads cannot access the surface water in the dry season. (Photo: Darren Southwell)

Reference:

Southwell D, R Tingley, Ml Bode, E Nicholson, BL Phillips (2016) Cost and feasibility of a barrier to halt the spread of invasive cane toads in arid Australia: incorporating expert knowledge into model-based decision-making. *Journal of Applied Ecology* 54:216–224

The cane toad can't retain water. Consequently, its remorseless spread might be stopped if a waterless barrier was built. (Photo: Reid Tingley)

Structured Decision-making

While there are various ways to engage practitioners, to date there is little understanding of which approaches achieve and maintain collaboration.

For our waterless barrier-workshop, CEED researchers adopted a structured decision-making approach, which is being increasingly advocated in the conservation literature for explicitly acknowledging uncertainty, facilitating relationship building and revealing hidden agendas. There is no doubt that in this case, the engagement process, facilitated by structured decision-making, helped all parties agree on the problem and the objective while improving the practitioners' understanding of the model's capabilities and limitations, as well as the modellers' understanding of the landscape.

What do Dairy Farmers Think about Planting Riparian Margins?

Key Points

- *CEED researchers surveyed Taranaki dairy farmers on their perceptions of the value of riparian plantings.*
- *The farmers reported many different values with the plantings; some positive, some negative.*
- *Farmers who carried out riparian plantings reported improvement to both farm performance and the environment.*

Over two stormy days in 2015, a group of dairy farmers working on the Taranaki ring plain in New Zealand left their flooding paddocks to gather at the Stratford Multisports Centre. They had been invited to participate in an interactive CEED meeting to describe their experiences and views on the costs and benefits of planting riparian margins on their farms.

Following European settlement in the mid-1800s, the once-forested plains around Mt Taranaki (one of New Zealand's most iconic volcanoes) were rapidly converted into a pastoral landscape dominated by exotic pasture species.

This transformation made Taranaki a nationally important dairy region. In the process, native vegetation was reduced to less than 10% of its former cover. The benefit of food production had come at a considerable cost to native biodiversity and the provision of a range of other ecosystem services.

In 1993 the Taranaki Regional Council initiated a voluntary planting program to restore vegetation to riparian margins with the aim of maintaining water quality. Twenty years on, CEED researchers were interested in finding out how farmers perceived the costs and benefits of undertaking riparian planting.

Two groups of farmers participated in the meetings; Group A (17 farmers) who have or are implementing riparian planting and Group B (five farmers) who have fenced, but not planted their riparian margins (Figure 1).

Not surprisingly, the two groups of farmers had quite different perspectives, with Group A perceiving 21 positive aspects and 11 negative aspects associated with riparian margin plantings, and Group B perceiving only 15 aspects, all of which were negative. These pros and cons fell across production, environmental, and social values (Figure 2), and showed that the participant farmers were thinking about additional ecosystem services and benefits beyond water quality, as well as trade-offs.

Figure 1 ▶ Group A farmers opted for planted margins (image on the left shows multi-tier planted margins) whereas Group B farmers used fenced grass strip margins (as pictured on the right). (Image on the left by Fleur Maseyk; image on the right Taranaki Regional Council.)

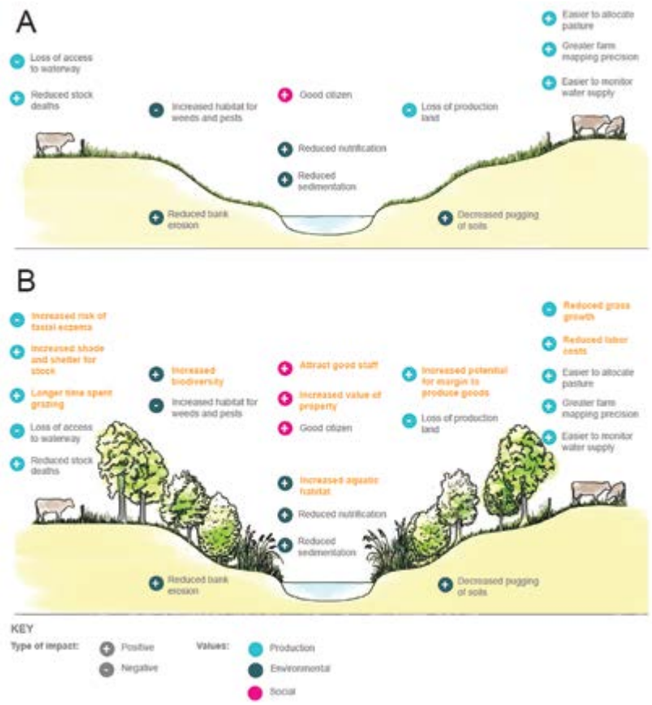


Figure 2 ▶ The pros and cons of fenced-only grass strip riparian margins (Panel A) and fenced and riparian margins (Panel B) as identified by Taranaki ring plain dairy farmers. Individual attributes of riparian margins can contribute values across the board; for example, a well-managed farm attracts better staff which is shown here as a social value, but also ultimately contributes to the productivity of the farm and "more milk in the vat".

From these structured discussions, Group A identified many benefits from planting riparian margins; they also shared some common ground with Group B in recognising associated costs and liabilities, such as the loss of production land, and increased weeds and pests. However, Group A suggested that many of these issues could be balanced by positive aspects of riparian margin plantings. For example, they observed that cows would graze longer in the shade provided by the riparian plantings (which meant more milk) and this could be enough to make up for the loss of production land.

In contrast to Group A, Group B farmers were disinclined to plant their riparian margins as they did not think there were any additional benefits to be gained that could not be achieved by fenced-only (grass strip) margins.

Indeed, both groups observed that fencing excluded livestock from waterways, and allowed for greater precision mapping of the farm, improved rotational grazing, and better allocation of feed.

The farmers observed that not only did fences prevent their livestock from falling into, or getting stuck in, the waterways, but they also saved them money (by avoiding livestock injury or loss, labour time to retrieve animals, and damage to farm equipment used in retrieval), and increased the safety of farm staff who were no longer retrieving animals from waterways.

Critically, Group B identified that neither grass strip nor planted multi-tier riparian margins could address sub-surface nutrient flows.

Consequently, this group of farmers felt the objective of the planting program — to protect water quality — was misguided, and this view obscured the recognition of all other potential values and benefits of planting riparian margins and prevented them from implementing planting on their farms. However, the CEED researchers found that farmers who had planted and fenced riparian margins, experienced increased benefits for both farm performance and environmental enhancement.

Reference:

Maseyk FJF, EJ Dominati, T White, AD Mackay (2017) Farmer perspectives of the on-farm and off-farm pros and cons of planted multifunctional riparian margins. *Land Use Policy* 61: 160–170

This study was a collaboration between CEED, AgResearch New Zealand, and Taranaki Regional Council.

Restoring Marine Coastal Ecosystems: Counting the Costs and Assessing the Feasibility

Key Points

- *CEED researchers examined the cost and feasibility of restoration in marine coastal ecosystems.*
- *The median price was around US$80,000 per hectare, the average price was up at US$1,600,000 per hectare.*
- *Feasibility ranged from 38% for seagrass, to 65% for coral reefs and saltmarshes.*

Coasts are popular areas for tourism, recreation, transportation, and development. Unfortunately, our love affair with coastal regions has resulted in significant damage to large areas of natural habitat. The result has been extensive and rapid rates of decline in a range of important ecosystems including seagrass, coral reefs, mangroves, saltmarsh, and oysters. And this decline is being witnessed worldwide. Along with the loss of habitat comes a decline of the services they provide (ecosystem services). These include the provision of habitat for threatened, iconic, or fished species; shoreline protection from waves and storm surges; water filtration; and carbon storage to help mitigate climate change.

There is now considerable interest in reversing trends in the decline of coastal ecosystems. This means restoration — the process of removing the factors that cause ecosystems to disappear, and/or establishing replacement plants or animals. Restoration is also an important element of biodiversity-offsetting projects — where losses of biodiversity from development at one site are 'offset' (replaced) by restoration at another (degraded) site.

There is one important catch — for restoration to achieve a particular goal, it must anticipate how likely the project is to succeed, and how much it will cost.

This study examined the cost and feasibility of restoration in marine coastal ecosystems, including seagrass, corals, mangroves, saltmarsh, and oyster reefs. Researchers from CEED accomplished this by reviewing the peer-reviewed literature and reports on this topic, and by filling in data gaps by talking to people who undertake restoration. This was important for oyster reefs, for which data was largely absent from the published literature.

The literature review quickly established there is a huge range of costs for different types of marine coastal restoration. The least-expensive projects, conducted by volunteers in 'inexpensive' developing countries, could be accomplished for less than $2,000 per hectare (all dollar values are in US dollars). But these were more the exception than the rule.

The median (middle) price for coastal restoration was typically around $80,000 per hectare. The average price, however, was up at $1,600,000 per hectare. The big difference between the median and average cost is due to some marine restoration projects being incredibly expensive, costing many millions of dollars per hectare. Examples would include the use of artificial structures to rebuild the ecosystems in 'expensive' countries like the USA and Australia.

As an aside, it was also observed that investment in restoration could be up to 30 times more cost-effective in developing countries than in developed countries. Many projects in developing nations go undocumented due to a lower-incentive to publish and report on restoration outcomes.

Information on the 'feasibility' of a restoration project succeeding (i.e., the likelihood of a project meeting objectives) was largely unavailable. Failed projects are often not reported. Instead, for project feasibility, success was only documented in terms of the percentage of restored organisms that survived over the reporting period. Project duration was typically one year or less. Only in a few instances were restoration projects monitored for more than a decade. Feasibility ranged from 38% for seagrass to 65% for coral reefs and saltmarshes.

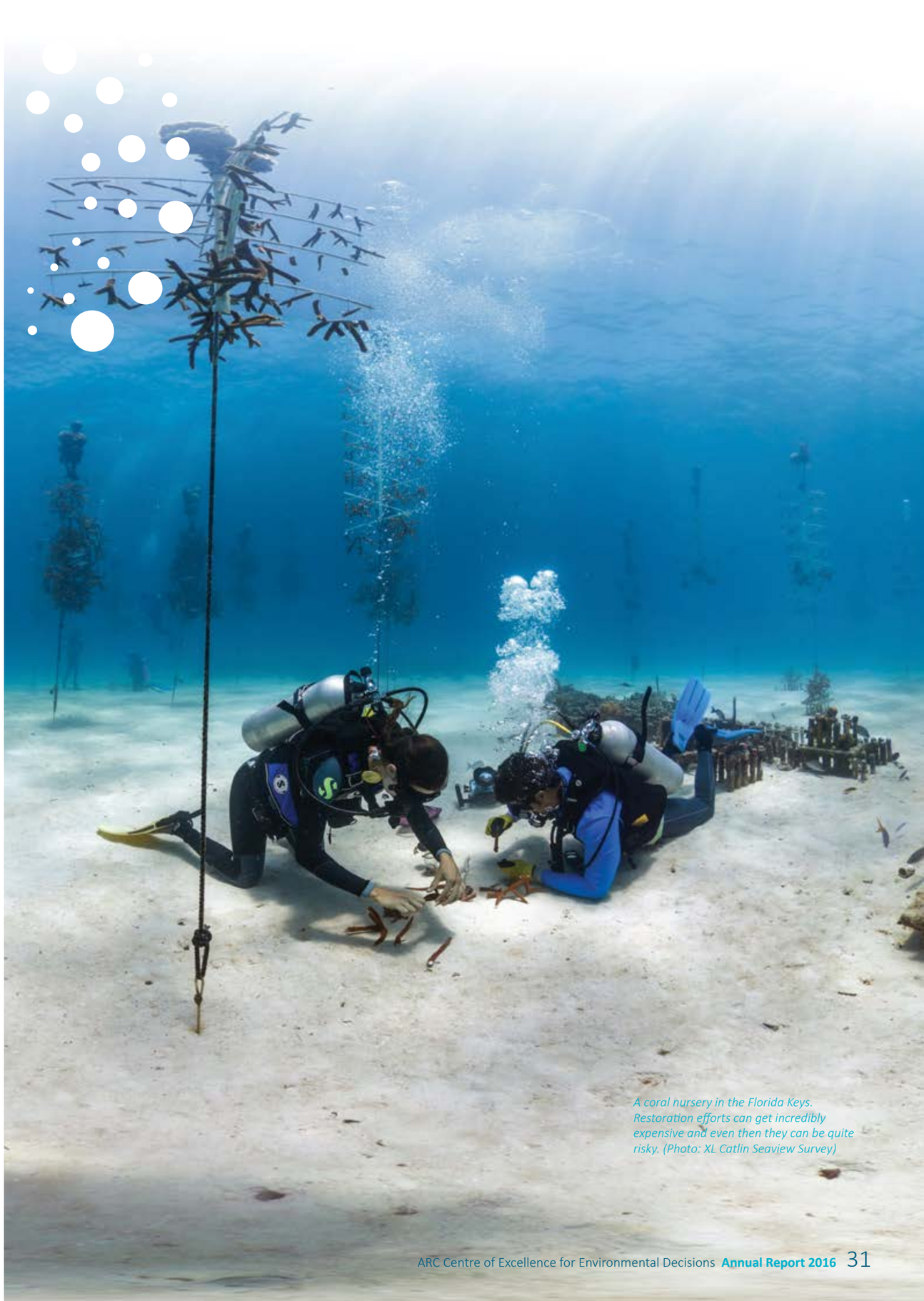
Researchers at CEED were surprised to find that project success was unrelated to the amount of money spent.

And restoration cost-per-unit effort did not decrease with increasing project areas (so there were no economies of scale). This suggests that marine restoration techniques still need work. Further studies will be required to achieve a transition from small-scale to a large-scale restoration of marine coastal ecosystems.

Restoration may be a critical tool used to secure a sustainable future in marine coastal ecosystems. If that's the case, a lot more effort needs to go into understanding how this can be achieved more effectively.

Reference:

Bayraktarov E, M Saunders, S Abdullah, M Mills, J Beher, HP Possingham, PJ Mumby, CE Lovelock (2016) The cost and feasibility of marine coastal restoration. *Ecological Applications* 26: 1055–1074



A coral nursery in the Florida Keys. Restoration efforts can get incredibly expensive and even then they can be quite risky. (Photo: XL Catlin Seaview Survey)

Promoting Social Benefits Improves Landholder Engagement

Key Points

- *To increase engagement the social and personal benefits of conservation need to be articulated.*
- *Focusing on environmentally-framed benefits misses engaging with community-minded landholders.*

A CEED study of how private-land conservation organisations frame the benefits of participation has found a bias for emphasising the environmental benefits while under-emphasising the benefits to landholders and the wider social benefits.

"The success of these conservation efforts is tied to the engagement of landholders, however, only a small proportion of landholders participate in conservation," says RMIT's Alex Kusmanoff, the lead author on the study.

This study analysed the websites of 20 most notable Australian private land conservation schemes and categorised how the benefits of participation were framed; whether framed as benefits to landholders, to society or the environment.

"To be as relevant and engaging to as broad a range of landholders as possible, all three kinds of benefits should be well represented," says Kusmanoff.

Emphasising the multiple benefits of land conservation to land holders, especially the social and personal benefits, increases the possibilities to reach more people. (Photo: Geoff Park).

"Yet, we found a predominance of environmentally-framed benefits. The lack of emphasis on social benefits, in particular, is a missed opportunity to engage community-minded landholders who don't necessarily identify with the conservation movement. By appealing to those people who are already receptive to conservation messages, we are only ever going to recruit from the same potential pool of landholders. But that pool can be increased beyond the conservation-minded, by emphasising both the social and personal benefits of conservation.

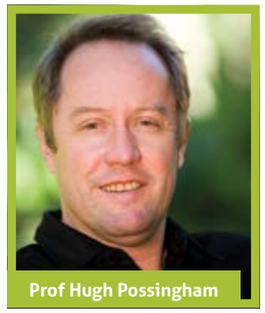
"We must think strategically about who we are trying to reach, what motivates them, and how to frame our messages to better engage them."

Reference:

Kusmanoff AM, MJ Hardy, F Fidler, G Maffey, C Raymond, MS Reed, JA Fitzsimons, SA Bekessy (2016) Framing the private land conservation conversation: Strategic framing of the benefits of conservation participation could increase landholder engagement. *Environmental Science & Policy* 61:124–128

Recognition of Research Excellence

In 2016 CEED researchers were finalists in, and the recipients of, some of the highest awards, prizes and professional association memberships on the national and international stage.



Prof Hugh Possingham

CEED Director Joins National Academy of Sciences

CEED Director Hugh Possingham received formal recognition for his contribution to original research, elected as a foreign associate of the National Academy of Sciences alongside a small cohort of distinguished researchers.

The National Academy of Sciences, a not-for-profit institution established under President Lincoln in 1863, recognises outstanding achievements in science by electing researchers to membership (US citizens) or foreign associate status (if a non-citizen). The Academy was established to provide science policy advice to the American Federal Government.

Professor Possingham was one of 21 scientists to be accepted as a foreign associate in the latest intake, and is the first Queensland-based academic to receive the honour.

"I am humbled to be recognised by such an illustrious institution. I would like to thank everyone I have worked with, and I hope I can use the election to further the cause of environmental science globally," Professor Possingham said.

Hugh is one of only 20 Australian scientists who are members of the Academy as a foreign associate.

Assoc Prof Kerrie Wilson

New CEED Director Receives Fenner Prize for Life Scientist of the Year 2016

CEED's Associate Professor Kerrie Wilson has been awarded one of Australia's most prestigious science awards — the Fenner Prize for Life Scientist of the Year (as part of the this year's Prime Minister's Prizes for Science). The award is open to all disciplines in the life sciences, from biomedical research through to ecology.

University of Queensland Vice-Chancellor Professor Peter Høj said Dr Wilson's research built connections between ecosystems, governments and people. "Kerrie is one of UQ's rising stars, and her work epitomises our focus at UQ — to create change in the world," says Professor Høj.

Kerrie and her team have generated an impressive series of more than 120 papers with about 7,000 citations. Her work with CEED is also connecting global leaders in environmental decision science.

"The award not only recognises CEED's significant contribution to Australia's goals by demonstrating scientific excellence but also our contribution to delivering innovative solutions to addressing the loss of biodiversity," says Associate Professor Wilson.


Assoc Prof Jane Elith

Associate Professor Jane Elith Receives Two Prestigious Awards

2016 Australian Academy of Science Fenner Medal & Australian Ecology Research Award (AERA)

Associate Professor Jane Elith specialises in developing and evaluating species distribution models, statistical models that describe relationships between the occurrence and abundance of species and the environment. These models are used to predict where species occur in the landscape, or where they might occur in the future.

Associate Professor Jane Elith has rapidly become one of the world's most influential researchers in applied ecology. In addition to her major academic impacts, her guides and novel tools for modelling species and ecological communities have been used by government and environmental management agencies in Australia and internationally. The interface between environmental management and science makes extensive use of her research to plan management of invasive species, improve conservation of biodiversity, and contribute to strategic land-use planning. In this way, Associate Professor Elith has substantially influenced academic research and also impacted environmental management nationally and internationally.

The Fenner Medal recognises outstanding contributions to science by the late Professor FJ Fenner, AC, CMG, MBE, MD, FAA, FRS. Its purpose is to recognise distinguished research in biology (excluding the biomedical sciences) by researchers up to 10 years post-PhD.

The AERA is conferred by the Ecological Society of Australia and recognises excellence in research in Australia ecology for a specific body of work by a mid-career researcher.


Dr Elizabeth Law

German Honour for Dr Elizabeth Law

Dr Elizabeth Law, a CEED associate researcher who is pioneering new methods to evaluate trade-offs in environmental policies, has been selected into the German Government's Green Talents program. Researchers selected for the program will visit Siemens AG, the Potsdam Institute for Climate Impact Research, the Max-Planck Institute for Plasma Physics, TU Hamburg, SASSCAL, and the Alfred Wegener Institute.

Dr Law received travel and living costs for a two-week tour of German research institutes in October 2016 and will also be sponsored for a three-month research stay at one German research institute in 2017.

Dr Law, who has been a conservation biology researcher at UQ since 2011, was awarded her PhD in 2015 for a study on land management strategies to enhance biodiversity and ecosystem services in production landscapes. She currently coordinates research across several teams associated with ARC Discovery and Woodspring Trust grants.

Her current research focuses on the complexities of sustainably managing agricultural production landscapes to both capitalise on and enhance their multifunctional capacity and to provide outcomes that are effective, efficient and equitable for all stakeholders. Dr Law tackles this problem from a collaborative, interdisciplinary approach, using case studies across Australia, Asia and Canada.


Ms Marie Dade

Marie Dade, CEED PhD Scholarship Holder Receives Outstanding Outreach Award

The NSW Office of Environment and Heritage and the Ecological Society of Australia have joined forces to award six early career researchers doing an exceptional job of communicating ecological research to the public, and inspiring other ecologists to get involved in outreach. The prizes were awarded at the 2016 Ecological Society of Australia Annual Conference in Fremantle, WA.

UQ based PhD student, Marie will establish a partnership with a school class to gather and analyse data as part of a year-long research project, with the aim of producing a publishable paper with the students. Marie is also developing a schools outreach program for CEED in collaboration with others, which will be launched during 2017.

Marie's PhD project questions how ecosystem services supply changes under different urban landscape scenarios. In 2015, she was named Young Student Ambassador with the Wonder of Science program, to promote science education within regional Queensland schools. Marie has also worked with the School of Distance Education, visiting remotely-based students on the Cape York Peninsula to talk about science careers and ecology research.

"I am passionate about developing ecology-related projects for school students and love being involved in scientific outreach. It's a great way to communicate new ideas and discoveries to a wider audience, and encourage scientific thinking in students," Marie says.


Ms Rebecca Runting

Rebecca Runting Receives 2016 Society of Conservation Biology Oceania Best Student Paper Award

Rebecca's research extended traditional conservation planning approaches to meet multiple competing public policy targets and achieve sustainable development across the three national jurisdictions on Borneo. This was the first time the value of cross-border collaboration for integrated land-use planning was assessed anywhere in the world. The work revealed the potential of collaborative, integrated planning to deliver large gains in both economic and environmental efficiency relative to the current land use plan and other proposed options.

The project involved wide-spread collaboration with external agencies including the Borneo Futures Project [E. Meijaard, funded by ARCUS (an NGO)], the Center for International Forestry Research (D. Gaveau), HUTAN (a local NGO, M. Ancrenaz), Pelangi Indonesia (a local NGO, F. Ardiansyah), the Wildlife Conservation Society (M. Gumal), the Sabah Wildlife Department (L. Ambu), and multiple universities (the University of Kent, Liverpool John Moores University, and The Australian National University).

CEED Alumni

CEED Researchers Named as Finalists

2016 Eureka Prize Finalists

Dr Eve McDonald-Madden
Finalist for Outstanding Early Career Researcher

Dr Eve McDonald-Madden applies quantitative methods, from fields such as economics and artificial intelligence; to solving complex conservation problems. Her research is frequently published in leading interdisciplinary journals and has influenced the way major conservation organisations make decisions. Presented annually by the Australian Museum, the Australian Museum Eureka Prizes reward excellence in research and innovation, leadership, science communication and school science.


Dr Eve McDonald-Madden

Dr Luke Kelly
Member of Mallee Fire and Biodiversity Team (La Trobe University)

Together with government agencies, private landowners and conservation organisations, the Mallee Fire and Biodiversity Team collected one of the world's largest datasets on fire. Their research has transformed the understanding of how fire affects biota, produced innovative new tools and significantly contributed to change in fire policy.


Dr Luke Kelly


Dr Georgia Garrard


Assoc Prof Sarah Bekessy

2016 Banksia Sustainable Cities Award Finalists

Dr Georgia Garrard and Associate Professor Sarah Bekessy
Interdisciplinary Conservation Science Research Group

The Biodiversity Sensitive Urban Design protocol developed by Dr Georgia Garrard and Associate Professor Sarah Bekessy of the Interdisciplinary Conservation Science Research Group from RMIT's Centre for Urban Research earned a nomination as a finalist for the 2016 Banksia Sustainable Cities Award. The research presents a re-visioning of the Fishermans Bend urban renewal area as a model for sustainable mid-rise development across Melbourne. The project aims to bridge the disconnect between the built and natural environments by linking urban design to measurable outcomes for native species and ecosystems.

Where Are They Now?


Prof Graeme Doole

Dr Graeme Doole

Graeme Doole was a Senior Researcher and CEED member from its inception in 2011. Graeme was employed at UWA full-time after completion of his PhD in 2006 with distinction; first as a teaching-and-research academic, and then in a research-only position. His research interests are in environmental economics, including farm management economics, fisheries economics, and natural resource management (NRM) economics.

Supported by CEED funding, he focused on economic analysis to inform decision-making regarding complex natural systems. This work involved farm, catchment, regional, and national studies. He worked concurrently at UWA and the University of Waikato, until mid-2015 when he was offered the position of Professor of Environmental Economics at the University of Waikato (New Zealand). Graeme remains a highly valued adjunct in the School of Agricultural and Resource Economics at UWA. To get to a full professor position in less than 10 years from his PhD is a testament to the remarkable quality and quantity of his work.

He won a substantial number of awards for his research excellence, including UWA's Excellence Award for highest quantity and quality of peer-reviewed publications by an early career researcher (2010), Young Agronomist of the Year (2010), and acknowledgement for the Best Article in a range of journals. Graeme has a rare and extremely valuable ability to convey his research to managers, policymakers and the broader community.

He was already having a major influence on policy related to water pollution in NZ during his time as a CEED member, and this continues to grow in his new position. His economic advice has been extensively used by the New Zealand Government in the development and implementation of policies for water pollution. In fact 75% of the funding for his current position as professor at the University of Waikato is provided by the Ministry for the Environment in New Zealand, reflecting the high value that they see in his advice.

Where Are They Now?

▶ Four CEED ECRs Spread Their Wings ... UK Bound

Maria Beger, a marine ecologist, Jane Catford, an invasion biologist, Morena Mills, a social scientist and Roberto Salguero-Gomez, a plant demographer, are all passionate about their science improving biodiversity conservation and have all accepted excellent roles in the United Kingdom in 2016.

All four researchers have strong international research reputations, and have played important roles at CEED.

The demand for our quantitatively-trained early career researchers is strong evidence that CEED's people — and their experience, skills and knowledge — are internationally sought after. It is also an indicator that knowledge created through CEED is being shared around the planet.

Their engagement in CEED has made a real contribution to conservation science and practice. Having networks such as CEED around will be important to attracting overseas talent and growing the network of environmental decision scientists.


Dr Maria Beger

Dr Maria Beger

Maria, after four years at CEED, commenced a five year Research Fellowship at the University of Leeds.

"To me, CEED is exceptional because it combines Australia's top conservation scientists and ecologists in a very open and transparent collaboration, with everyone committed to making a difference in conservation on the ground," says Maria.

"CEED has not only given me an exceptional quantitative tool kit in conservation science but I have also been spoilt with an extremely open research environment, and I learned about the importance of interdisciplinary work. I was given incredible freedom to pursue my interests and passions in marine conservation during my time at CEED, and this allowed me to build networks that have enabled me to make an important contribution towards the conservation of coral reefs and related ecosystems."


Dr Jane Catford

Dr Jane Catford

Jane started a lectureship in Community Ecology at the University of Southampton (in the Centre for Biological Sciences).

"Working at CEED was been a great experience," says Jane.

"It allowed me to work alongside some of the world's top environmental researchers and thinkers. And, because of CEED's strong international connections, I look forward to sustaining those relationships in my new position at the University of Southampton."


Dr Morena Mills

Dr Morena Mills

Morena commenced a lectureship at Imperial College London on Conservation Science.

"CEED was an incredible place to work," she says.

"It exposes you to a great array of scientists with different backgrounds, all focused on how to best improve environmental decisions.

Additionally, we were encouraged to work in collaboration with governments and NGOs around the world and help them tackle the most pressing conservation issues. I can't imagine a better place to work as a Post-Doctoral Researcher."


Dr Roberto Salguero-Gomez

Dr Roberto Salguero-Gomez

Robert joined the University of Sheffield as a Natural Environmental Research Council Independent Research Fellow.

"Despite the geographic distance between Australia and most other countries, CEED has successfully created a brand of quality research which, in my opinion, is internationally recognised," says Roberto.

"My three years at CEED have made me aware of the value of social sciences, economics, mathematical modelling and even my own specialty (of population ecology) in decision-making. I feel that the skills that I have acquired during my time at CEED, including leadership skills, have put me in a position where I now feel fully capable of running my own lab, interacting with researchers from various groups and disciplines to tackle complex, timely questions."

Workshops and Training

ECRs Attend the ICN Workshop at Oxford

In June CEED ECRs Angela Guerrero Gonzalez and Nicole Shumway were very fortunate to be hosted by the Interdisciplinary Centre for Conservation Science at the University of Oxford (led by E.J. Milner-Gulland, one of CEED's international PIs).

While there, they helped organise and participate in a workshop of the Interdisciplinary Conservation Network (ICN).

The workshop gave early-career researchers the opportunity to interact with other conservation scientists and to learn key career skills.

CEED ECRs attend an ICN meeting in Oxford.

Three research themes were run over the two-day event: the application of predictive approaches to conservation; the integration of inter-disciplinary approaches to help manage 'wicked' conservation conflicts; and the future for no-net-loss of biodiversity in the marine environment.

Nicole's PhD research focuses on the improved implementation of no-net-loss (NNL) policies aimed at protecting marine biodiversity, and so this theme was particularly relevant to her research program.

Given the lack of data in the marine environment, avoidance will be a key component of successful NNL. The NNL research theme was developed and organised by herself, Will Arlidge (an Oxford PhD student) and Prue Addison (an Oxford Postdoc and previous CEED ECR).

For the weeks leading up to the workshop, they had many discussions about the increasing use of biodiversity offsetting and the need to refocus the conversation on the achievement of NNL by using the entire mitigation hierarchy, rather than focusing primarily on offsetting.

The workshop brought together people from varied backgrounds to discuss the application of NNL in other industries and the factors that could be hindering a broader application of the mitigation hierarchy.

The mitigation hierarchy requires that all reasonable measures have been taken first to avoid and minimise the impact of a development project and then to restore biodiversity on-site before moving to 'offsets'. Overall, the ICN workshop was an important chance to get other perspectives on CEED research and a wonderful opportunity to network with fellow students and researchers working in biodiversity conservation from a range of interdisciplinary fields.

Social Networks in NRM

Jointly organised by researchers from UWA and UQ, this workshop explored the theory, methodology and strengths and weaknesses associated with the application of social network analysis in natural resource management (NRM).

Participants from the University of Queensland, University of Melbourne, James Cook University, University of Western Australia, RMIT University, University of Tasmania, CSIRO and the Stockholm Resilience Centre came together in Brisbane.

Social networks consist of people — such as land holders, managers, government officials and organisations — and the relationships and exchanges that tie these 'actors' together.

How the network is organised and functions has been identified as a key determinant of participation and performance in environmental programs. Social networks can be used in multiple ways, from simply describing a system and understanding the processes that drive the formation of a system through to informing analysis for improved decision-making.

Membership in both formal and informal networks has the potential to deliver positive outcomes for individuals and groups. However, not all networks are equally effective. Several network characteristics, such as the number of social ties, the density of the network, the presence of leaders and how individuals are positioned within the network, can influence performance. Further, a single type of network is unlikely to be effective in all situations. For instance, an analysis in Stockholm found that a network with a core group of heavily connected members surrounded by a periphery of sparsely connected members facilitated collective action on a local level while simultaneously preventing collaborative management at a regional level.

"Our discussions revealed the importance in considering the value of information obtained from social-network analysis relative to the costs associated with data collection and the risks associated with poor response rates," says UQ's Courtney Morgans, one of the workshop conveners and CEED PhD student.

"Reasonable justification also needs to be given to how the network of interest will be bound. For example, is it more appropriate to bind the network at an institutional level or a geographic region? Will it be feasible to obtain a comprehensive dataset at this level?"

In addition to these practical considerations, the workshop explored theoretical assumptions relating to the position of the social network on the causal pathway: does the social network shape management effectiveness or is it that social processes shape the social network? How social network analysis can be best used to inform practical recommendations for NRM will form the focus of several upcoming papers.

Soapbox Science Brisbane

CEED researchers were among 12 women who shared their passion for science at Australia's first Soapbox Science event on Saturday, 20 August.

The fun and interactive event with audience participation was the first Soapbox Science event to be held in the southern hemisphere.

Soapbox Science was founded in the UK in 2011 by female academics from the Zoological Society of London and the University of Bristol.

Dr Alienor Chauvenet, co-organiser of the event and CEED Post-Doctoral Research Fellow, says the aim was to promote the amazing work of these women; to challenge gender stereotypes, implicit bias and perceptions of what a scientist does and looks like; to bring science to the people direct from the experts; and to inspire new generations of scientists. The event showcased all career stages, from PhD students to lecturers and through to professors.

Soapbox Science Brisbane 2016 was supported by the Queensland Government's Advance Queensland initiative, the ARC Centre of Excellence for Environmental Decisions, and UQ's Global Change Institute.

The 2016 Theo Murphy High Flyer Think Tank

A critical aspect of environmental decision-making involves dealing with risk and uncertainty, and much of CEED's research revolves around incorporating these elements into decision frameworks. Given this, it is not surprising that CEED researchers played a leading role in the 2016 Theo Murphy High Flyer Think Tank.

Each year, the Australian Academy of Science hosts the Theo Murphy High Flyer Think Tank. It brings together a varied group of early- and mid-career researchers from a wide range of disciplines — rising high flyers in their respective disciplines — to focus on an emerging area of challenge and get them to solve a series of related problems. The 2016 event asked think tankers to formulate an interdisciplinary approach to 'living in a risky world'.

Director of CEED Hugh Possingham convened the event while CEED members Gwen Iacona, Alienor Chauvenet, Jonathan Rhodes and Lucy Bland took part as think tankers, joining around 60 other participants coming from a range of disciplines (from physicists to social scientists).

The assembled thinkers were set four challenges to explore:

1. risk in international security;
2. risk and resource allocation for the environment;
3. antimicrobial resistance in a connected world, and
4. uncertainty, ignorance and partial knowledge.

Jonathan Rhodes (bottom right), a CEED CI and UQ Node Leader, was one of CEED's high flyers at the think tank.

The CEED participants contributed primarily to the problem of risk and resource allocation for the environment. This group was composed of experts in environmental sciences, social sciences, economics, law, and history. Such a diversity of disciplines created a rich, if sometimes challenging, discussion. Invited experts and members of the Academy were also available for guidance and discussion (including CEED's Mark Burgman).

Each group came up with two to three recommendations associated with their topic, focusing on what major risks and uncertainties we should be aware of and their potential solutions.

"The format challenged us to work as a group and quickly and clearly identify and articulate the most important points for policymakers," says CEED's Gwen Iacona. "There was deep discussion, many interesting chats and a lot of hard work, but at the end of the workshop I think it's fair to say we also had a lot of fun."

CEED Director Hugh Possingham holds up a finished report from the 2016 Theo Murphy High Flyer Think Tank on living in a risky world.

Stakeholder Engagement

CEED and CSIRO Join Forces with ScenNet

In February 2016, CEED joined forces with CSIRO and the Belmont Forum project 'ScenNet' to explore ways in which scenarios and models could be better used in setting and implementing conservation policy at national and global scales.

ScenNet is a global collaboration of researchers working on scenarios and models to support conservation assessment and decisions.

Convened by Brendan Wintle (UM) and Simon Ferrier (CSIRO), the week-long workshop focused on how to increase the use and utility of biodiversity and ecosystem-service scenarios and models in decision-making and agenda-setting at geo-political scales.

The Lorne Workshop brought together 23 researchers and policymakers working in a variety of areas.

There were conservation biologists, economists, social scientists, human geographers, policy scientists and mathematicians from both Australia and overseas, with expertise in marine and terrestrial environments. The meeting included representatives from International Union for Conservation of Nature (IUCN), Convention on Biological Diversity (CBD), International Platform on Biodiversity and Ecosystem Services (IPBES) and the Wildlife Conservation Society (WCS), providing a strong global policy perspective.

Karel Mokany and Simon Ferrier (CSIRO) discuss the finer points of scenarios and models with ScenNet members Paul Leadley, Rob Alkemade, and Cornelia Krug. (Photo: Natasha Cadenhead)

A key premise of the workshop was that most decisions that impact on biodiversity and ecosystem services are not ostensibly 'environmental decisions', and often do not involve environmental professionals. A key outcome of the workshop was to develop a classification of the types of decisions made at the international level that have the most impact on biodiversity and the global institutions that mediate many of those decisions. Participants also developed case studies on how some of those big decisions could be better supported by scenarios and models.

A second key topic was an examination of the way scenarios and models can be used to set more meaningful international conservation targets, including the next round of CBD targets (the targets that will follow on from the Aichi Targets).

Bishan Park, a great example of innovative urban planning in Singapore. (Photo: National Parks Board, Singapore)

CEED Builds Bridges to Singapore

Singapore is an important regional centre for biodiversity and conservation sciences. In recent years there have been growing links between CEED and the National University of Singapore (NUS), collaborations that are proving mutually beneficial. Here are some examples:

Located one degree north of the Equator, Singapore seeks to become a 'City in a Garden'. More than 50 years of greening has given rise to a cityscape incorporating a network of nature reserves and nature parks nestled within a matrix of verdant streetscapes, urban parks and park connectors. The challenge of developing and sustaining such an ecosystem in a land-scarce city-state is enormous and requires scientific inputs from a wide range of disciplines. Researchers from CEED are working with NUS on multiple projects relating to urban and park biodiversity. Chong Kwek Yan has been visiting CEED's UQ node from October 2015 to 2017. He received the NUS Overseas Post-Doctoral Fellowship and is working on the optimal planning of urban greenspaces with CEED Chief Investigators Kerrie Wilson, Jonathan Rhodes and Hugh Possingham.

In May 2016, Roman Carrasco from NUS visited with his two graduate students, William Symes and Zhang Yuchen. Roman is collaborating on a new project with CEED on expanding conservation objectives to incorporate development objectives.

Kerrie Wilson also delivered talks on systematic conservation planning and structured decision-making at the NUS Biology Colloquium and at the Centre for Urban Greenery and Ecology's (CUGE) Professional Speakers Series in September 2016. The CUGE is part of the National Parks Board, the agency that handles matters relating to biodiversity and greenery in Singapore.

Nao Takashina also spent some time with Ryan Chisholm's lab in NUS, from September to November 2016. Nao is a Post-Doctoral Fellow visiting CEED from the University of the Ryukyus (Japan).

Yong Ding Li, a PhD student with David Lindenmayer at CEED's ANU node, coordinated the Arctic Migratory Birds Initiative-East Asian-Australasian Flyway Workshop in Singapore in January 2017.

The event was attended by a contingent of three graduate students from CEED: Stephanie Avery-Gomm, Eduardo Gallo-Cajiao and Micha Jackson.

NUS is ranked consistently among the top universities in the world. Its interactions with CEED will help deepen its research capacity and impact, as well as develop enduring collaborations with Australia. It's a relationship benefitting both countries, which can only grow in the years ahead.

CEED Director Kerrie Wilson sharing on conservation decision-making in social-ecological systems at NUS' Biology Colloquium. (Photo: Chong Kwek Yan)

CEED Plays a Leading Role in Science-Policy Platform

Many efforts are being made around the world to arrest and reverse the unfolding crisis of biodiversity decline.

Front and centre in recent years has been the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), an independent, intergovernmental body designed to synthesise and analyse biodiversity information for decision-making. As its name suggests, IPBES makes science and policy its central focus. Australia is making important contributions to IPBES via CEED — one of the world's leading institutions working in this space.

In February 2016 IPBES staged its Fourth Plenary Session in Malaysia at which it launched its first two products: a thematic assessment on pollinators, pollination, and food production; and the methodological assessment of scenarios and models of biodiversity and ecosystem services. Associate Professor Brendan Wintle, from CEED, was one of the coordinating lead authors on the scenarios and modelling assessment, having joint responsibility for putting together chapter two: 'Using scenarios and models to inform decision-making in policy design and implementation', one of the overarching chapters in the report. The chapter provides an overview of policy and decision-making contexts in which modelling and scenarios can be used. It sets the scene for subsequent chapters to identify the scenarios and models needed in these different contexts.

The eastern curlew is one of many species of migratory shorebird that are at risk of being lost. The work of institutions such as IPBES will prove critical to arrest declines in biodiversity. (Photo: Dean Ingwersen)

"This IPBES assessment found that while scenarios and models are commonly used to inform and support decisions at local scales, they are almost never used in any kind of structured way in big decisions at national scales and above," says Associate Professor Wintle.

"There is a lot of scientific literature on using modelling and scenarios in decision-making processes, but this work does not seem to have made its way into real world applications at national to global scales."

The assessment identified barriers to the use of decision support tools in environmental policy agenda setting, design and implementation. These range from a lack of appreciation among decision-makers about the potential benefits of using models and scenarios, to a lack of willingness on the part of some modellers to properly engage in real-world decision-making and undertake relevant analyses.

While CEED has played a pivotal role in this landmark report, the Centre has also contributed to many other aspects of IPBES including providing valuable input into its assessment processes. Several of our researchers have also been authors on IPBES reports and two of our early career researchers were selected as IPBES Young Fellows.

Marxan helps Brazil plan deep-sea protected areas around oil fields

Since its inception, CEED has played a strong supporting role in developing, promoting and extending the impact of the Marxan, the world's most widely used conservation-planning software.

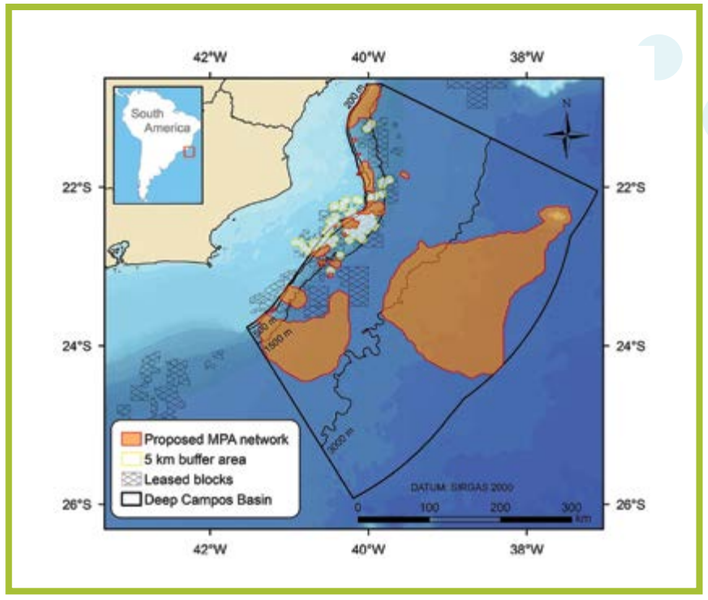
In 2016, Marxan once again demonstrated its power and widespread utility by assisting in the design of a network of deep-sea marine reserves in the Campos Basin, an important area for oil fields off the Brazilian coastline.

Gustavo Almada from Brazil's Ministry of Environment was tasked with designing the network of deep-sea reserves. At the end of 2015 he participated in a Marxan training course at Brazil's Mato Grosso do Sul Federal University being conducted by CEED's Morena Mills and Jennifer McGowan.

"The Campos Basin lies offshore of south-eastern Brazil," explains Almada.

"It contains many of the most productive oil and gas fields of Brazil, accounting for more the 60% of total annual production. Our aim was to propose a network of marine protected areas (MPAs) that would offer protection to areas of high natural value within current offshore fields, with minimal impact on existing production activities in order to provide a politically feasible outcome."

Over the last three decades, Brazil's main oil company, Petrobras, has been collecting a range of information about the Campos Basin comprising biological, geophysical, geochemical, hydrochemical, oceanographic and socioeconomic data.



The Campos Basin off the Brazilian coastline showing the location of a proposed MPA network. The plan was generated using Marxan.

Using this extensive database, Almada and colleagues developed a map of benthic habitats and then used Marxan to provide options of networks of MPAs that protected at least 30% of the area of each habitat.

"Our analysis provided options that we believe are politically feasible as they have little impact on the ongoing oil industries activities," says Almada.

"But our results have wider potential because we believe our approach can be applied to other deep sea provinces along the Brazilian margin and serve as a model for other regions seeking to protect deep-sea biodiversity on and around deep-sea oil fields, mining prospects or fishing areas."

"The Marxan workshop was critical to our research. It allowed me to use the Marxan software properly, to develop the input files with confidence, to completely understand the mechanics of Marxan's underlying algorithm (and its limitations and premises) and to appropriately interpret the software's outputs."

And the result is a conservation plan that all parties can work with.

Our People — Our Legacy

The Centre supports 58 Post-Doctoral Researchers, 80 PhD scholars, 10 Masters and 8 Honours students working on a diverse range of projects.

Women in Science Leadership Expedition to Antarctica

Two scientists from CEED have taken part in the inaugural program of Homeward Bound, a pioneering leadership, strategy and science initiative for women, set against the backdrop of Antarctica. Homeward Bound acknowledges the effects climate change and anthropogenic alterations have on the Earth. The initiative aims to heighten the influence and impact of women with a science background in directing policy and decision-making as it shapes our planet's future. Launching in 2016, Homeward Bound gathered the first 76 of a targeted 1000 women from around the world, all with science backgrounds. The women undertook a year-long state-of-the-art program for developing leadership and strategic capabilities to enhance scientific expertise. The program culminated in the largest-ever female expedition to Antarctica in December 2016.

The science program was led by UQ CEED researcher Dr Justine Shaw and Dr Mary-Anne Lea from the Institute of Marine & Antarctic Studies, UTAS. Another CEED researcher, Dr Nancy Auerbach, was also on the expedition, selected from a field of over 270 applications to participate.

CEED researcher Dr Justine Shaw in preparation for her Homeward Bound expedition to the Antarctic in December 2016.

The Antarctic trip involved an intense schedule of leadership, strategy execution and global change science. The expeditioners presented their own research in a symposium while at sea in Antarctica. They were encouraged to explore opportunities for collaborations and to show how their work could have greater impact and reach.

Dr Shaw said: "It's incredibly exciting when you look at the group of women (who went), the range of backgrounds and experiences, their scientific disciplines and career stages. This isn't simply a trip to Antarctica, it's about bringing women scientists together and exploring leadership and strategy and how we can make a change. We can't wait to see what comes out of this voyage, the future collaborations and what it all means for science."

The women set sail from Ushuaia, in Argentina, for the 20-day expedition.

Women in Science Leadership Expedition to Antarctica *continued...*


Dr Justine Shaw

Dr Justine Shaw

Research Fellow Dr Justine Shaw, from CEED, was the Science Program Coordinator and on-board science faculty for Homeward Bound. Justine's research focus is the conservation of Antarctic and sub-Antarctic terrestrial ecosystems and invasive species establishment in these areas of low human-pressure. Justine is interested in understanding the way in which species interact with each other and their role in ecosystem function. Her research examines the role of environmental factors in influencing species abundance, distribution and occurrence. She is currently examining the risks posed by non-native species to the Antarctic protected areas and the role of climatic change in conservation planning for Antarctica. She is also quantifying human movements within Antarctica and investigating how sub-Antarctic island ecosystems respond to pest eradications to inform conservation decision-making. Justine has a wide global research network, having worked in Australia, South Africa, sub-Antarctic/Antarctic and the Arctic. She has been "going south" for 19 years and is passionate about expedition science, having spent many hours in the snow, wind and rain with a pack on her back. She is subject editor for several journals and a co-founder of the Women in Polar Science Network. Through her research, she hopes to further the conservation of these last true wilderness areas.


Dr Nancy Auerbach

Dr Nancy Auerbach

Dr Nancy Auerbach earned a PhD for her CEED research into prioritising management actions for the conservation of threatened flora and fauna. She is the senior project officer in database support for the NSW Office of Environment and Heritage Saving Our Species program and an Adjunct Fellow at the UQ Centre for Biodiversity and Conservation Science. She is also the managing editor of eBird Australia. Her passion for the natural world had already led her to work in alpine, Arctic, rainforest and desert ecosystems and her connections to the living world and interactions with the increasingly distressed biosphere have inspired her commitment to biodiversity conservation. She was compelled to participate in Homeward Bound to join other women scientists in creating an alternative future and advocates a holistic stewardship of nature and the environment over economic growth.

2016 PhD Scholars

Student	University	Country of Origin	Thesis Title	Supervisors
James Allan	UQ	Australia	Cumulative threat mapping and conservation planning	James Watson, Hugh Possingham
Carla Archibald	UQ	Australia	How to utilise privately protected areas in conservation planning to reach local and international conservation targets	Jonathan Rhodes
Stephanie Avery-Gomm	UQ	Australia	Global spatial threats analysis and conservation of marine migratory species	Hugh Possingham, Richard Fuller
Christopher Baker	UM	Australia	Optimising invasive species management	Michael Bode, Michael McCarthy, Steve Carnie
Payal Bal	UQ	India	Biodiversity indices for monitoring and managing ecosystems	Jonathan Rhodes, Eve McDonald-Madden, Ayesha Tulloch
Sana Bau	UM	New Zealand	Reconciling value judgements and evidence-based decision making theory in conservation	Michael McCarthy, Terry Walshe
Richard Beggs	ANU	Australia	Impact of noisy miner removal from small fragment of native vegetation on presence and behaviour of small passerines	David Lindenmayer, Jennifer Pierson, Ayesha Tulloch
Donna Belder	ANU	Australia	Survival and persistence of woodland birds in restoration plantings	David Lindenmayer, Jennifer Pierson, Ayesha Tulloch
Laurence Berry	ANU	Australia	The ecology of fire refugia in the Victorian Central Highlands	David Lindenmayer, Sam Banks, Don Driscoll
Louise Blackmore	UWA	Australia	Collaborative conservation: getting landholders to work together to achieve biodiversity outcomes	Steven Schilizzi, Sayed Iftekhar, Marit Kragt, Kerrie Wilson, Abbie Rogers
Sugeng Budiharta	UQ	Indonesia	Systematic planning for the rehabilitation of degraded tropical forests: Scenarios for optimum allocation of REDD+ in Indonesia	Kerrie Wilson, Hugh Possingham, Peter Erskine, Erik Meijaard
Abbey Camaclang	UQ	Canada	Critical habitat definition and identification for threatened and endangered species	Hugh Possingham, Tara Martin, Martine Maron
Hernan Caceres Escobar	UQ	Chile	Prioritisation of management actions for invasive mammals and threatened species in Southeastern Queensland Islands	Salit Kark, Eve McDonald-Madden, Hugh Possingham
Xyomara Carretero-Pinzón	UQ	Colombia	Conservation planning of primates in rapidly transformed landscapes	Jonathan Rhodes, Thomas Defler, Clive McAlpine
Colleen Corrigan	UQ	USA	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	Marc Hockings, Catherine Robinson, Stephen Garnett, Hugh Possingham
Marie Dade	UQ	Australia	Identifying and managing ecosystem service relationships in dynamic landscapes	Jonathan Rhodes

2016 PhD Scholars *continued...*

Student	University	Country of Origin	Thesis Title	Supervisors
Brendan Dillon	UQ	Australia	Share or spare? A quantitative framework for optimising investment between restoration of human dominated landscapes and pristine ecosystems	Hugh Possingham, Margie Mayfield
John Evans	ANU	Australia	The long-term and large-scale effects of the establishment of an exotic plantation on species of native forest beetles and butterflies	Sam Banks, Don Driscoll, Katrina Davies
Dini Fardila	UM	Indonesia	Relating landscape metrics to ecological processes for spatial planning and management of birds in fragmented habitat	Michael McCarthy, Luke Kelly
Claire Foster	ANU	Australia	Ecological impacts of highly abundant macropods	David Lindenmayer, Phil Barton, Chloe Sato
Hannah Fraser	UM	Australia	Of woodlands and birds: how terminology effects our inferences	Michael McCarthy
Rachel Friedman	UQ	USA	A multi-level governance networks — participating in social forestry in Indonesia	Kerrie Wilson
Eduardo Gallo-Cajiao	UQ	Columbia	How effective is the international regime for the conservation of migratory shorebirds in the East Asian Australasian flyway	Richard Fuller, Salit Kark
Veronica Gama	UQ	Brazil	Are migratory birds more threatened than non-migrants?	Hugh Possingham, Richard Fuller, Morena Mills, Simon Blomberg
Katherine Giljohann	UM	Australia	Optimal fire management for biodiversity conservation in fire-prone landscapes	Michael McCarthy, Tracey Regan
Valerie Hagger	UQ	Australia	The costs and success of ecological restoration in Australia and the potential for achieving multiple outcomes for biodiversity and carbon	Kerrie Wilson, John Dwyer, Jacqui England
Yi Han	UQ	China	Modelling the effects of invasive species eradication on other interacting species in an ecosystem context	Eve McDonald-Madden, Yvonne Buckley, Justine Shaw, Hugh Possingham
Nicole Hansen	ANU	Australia	Movement of reptiles through fragmented agricultural landscapes	David Lindenmayer, Damian Michael, Don Driscoll, Milton Lewis
Jeffrey Hanson	UQ	Australia	Designing reserve networks that are resistant to environmental change	Richard Fuller, Jonathan Rhodes
Mat Hardy	RMIT	Australia	The use of decision theoretic approaches to improve private land conservation	Sarah Bekessy, Ascelin Gordon, James Fitzsimons
Brett Howland	ANU	Australia	Managing kangaroo grazing in the conservation of grassland and grassy woodland fauna	David Lindenmayer, Adrian Manning
David Johnson	ANU	Australia	Restoring floristic diversity of the ground layer in modified ecosystems	Phil Gibbons, Don Driscoll, Jane Catford
Kendall Jones	UQ	Australia	Planning for the impacts of land uses on coral reef fisheries under different climate scenarios	James Watson, Hugh Possingham
Geoffrey Kay	ANU	Australia	Conserving endangered ecosystems through environmental stewardship	David Lindenmayer, Blanchard, Don Driscoll, Saul Cunningham
Claire Keely	UM	Australia	Conservation genetics of the growling grass frog in an urbanising landscape	Kirsten Parris, Geoff Heard
Alex Kusmanoff	RMIT	Australia	How message framing influences environmental decisions	Sarah Bekessy, Ascelin Gordon, Fiona Fidler
Juliana Lazzari	ANU	Australia	The interaction of fire and fragmentation: Can fire in fragmented landscapes cause regional declines of fire-specialist (reptile) species	Geoff Cary, David Lindenmayer, Don Driscoll
Darren Le Roux	ANU	South Africa	Maintaining and perpetuating resources associated with mature trees for wildlife in modified landscapes	Phil Gibbons, Adrian Manning, David Lindenmayer
Hsien-Yung Lin	UQ	Taiwan	Conserving migratory species under human impacts and climate change	Hugh Possingham, Richard Fuller
Sophia Lopez-Cubillos	UQ	Columbia	Using ecosystem services for spatial planning in tropical agricultural landscapes	Eve McDonald-Madden
Bonnie Mappin	UQ	Australia	Priorities for the restoration and protection of habitat to conserve global terrestrial biodiversity	Hugh Possingham, James Watson, Carissa Klein
Maria Martinez-Harms	UQ	Chile	Conservation planning for ecosystem services in the system of natural protected areas of Chile	Kerrie Wilson, Brett Bryan, Jonathan Rhodes, Hugh Possingham
Fleur Maseyk	UQ	New Zealand	Applying the ecosystem services concept to natural resource management and conservation decision making	Hugh Possingham, Alec Mackay, Yvonne Buckley, Marit Kragt
Sean Maxwell	UQ	Australia	Ecological, social and economic factors for conservation decision making: what should we learn about and when	James Watson, Jonathan Rhodes, Eve McDonald-Madden
Jennifer McGowan	UQ	USA	Benchmarking reef health of spatial conversation	Hugh Possingham, Carissa Klein, Maria Beger
Matthew McKinney	UQ	USA	Modelling invasion success: Natural and human-related factors for spatial systematic planning and prioritization of actions to confront invasive species	Salit Kark, Jonathan Rhodes, Hugh Possingham
Courtney Morgans	UQ	Australia	Conservation Strategy Evaluation	Kerrie Wilson, Erik Meijaard and Kelly Fielding

2016 PhD Scholars *continued...*

Student	University	Country of Origin	Thesis Title	Supervisors
Will Morris	UM	Australia	The value of information for vegetation management	Peter Vesk
Laura Mumaw	RMIT	Australia	Biodiversity decision making and stewardship in urban neighbourhoods	Sarah Bekessy, Cecily Maller
Thayse Nery	UWA	Brazil	Optimal land-use change to increase water quality, quantity and biodiversity outcomes	Morteza Chalak, Ben White, Rohan Sandler, Maksym Polyakov
Katherina Ng	ANU	Australia	Movement of ground arthropods in fragmented agricultural landscapes	David Lindenmayer, Don Driscoll, Milton Lewis
Christy Nguyen	UWA	Vietnam	Factors influencing calculation of capacity value of wind power: a case study of the Australian National Electricity Market	Morteza Chalak. Atakelty Hailu, Chubo Ma
Junior Novera	UQ	Papua New Guinea	Incorporating Biological and Cultural Diversity into Conservation Prioritisation: the Mammals of Bougainville, East Melanesia Biodiversity Hotspot as a case study	Salit Kark
Estibaliz Palma	UM	Spain	Plant invasion ecology: seeking for generalisation through species traits	Jane Catford, Peter Vesk
Michaela Plein	UM	Germany	Assessing and managing interacting species at risk of co-extinction	Peter Vesk, Melinda Moir, Michael Bode, Michael McCarthy
Tal Polak	UQ	Israel	Using fine and coarse conservation targets to maximize cost-effectiveness of road mitigation and protected areas	Hugh Possingham
Stephanie Pulsford	ANU	Australia	Exploring methods for improving connectivity of terrestrial native fauna in South East Australian grazing landscapes	David Lindenmayer, Don Driscoll, Alessio Mortelliti
Keren Raiter	UWA	Australia	Mitigating mining's enigmatic ecological impacts in Australia's Great Western Woodlands	Richard Hobbs, Hugh Possingham, Suzanne Prober, Leonie Valentine
Andrew Rogers	UQ	USA	Avian community response to invasion by non native species	Salit Kark, Berndt Van Rensburg
Cristina Romero De Diego	UQ	Spain	Evaluating interventions to manage conservation conflicts	James Watson, Morena Mills
Rebecca Runting	UQ	Australia	Managing natural capital assets and ecosystem services under global change	Jonathan Rhodes, Hugh Possingham
Gerard Ryan	UM	Australia	Birds in the sky, fish in the sea, money in the bank: quantitative methods for more effective conservation	Michael McCarthy, Emily Nicholson
Matthew Selinske	RMIT	USA	Predicting human behaviour for better environmental policy decision making	Sarah Bekessy
Nicole Shumway	UQ	Australia	Human-predator conflict and conservation policy	Martine Maron, James Watson
Blake Simmons	UQ	USA	Disentangling the political, cultural, and socioeconomic dimensions of tree clearing to inform environmental policy	Kerrie Wilson, Clive McAlpine, Elizabeth Law and Raymundo Marcos Martinez
Ingrid Stirnemann	ANU	New Zealand	Habitat heterogeneity: how it is generated and drives spatial patterns in mammals and birds	David Lindenmayer, Wade Blanchard, Phil Gibbons
Freya Thomas	UM	Australia	The generation and generalisation of plant functional traits in fire-prone communities	Peter Vesk
Nooshin Torabi	RMIT	Australia	Understanding landholder participation in biodiverse carbon plantings	Sarah Bekessy and Kathryn Hegarty
Vivitskaia Tulloch	UQ	Australia	Managing threats to land and sea ecosystems to balance multiple objectives	Hugh Possingham, Chris Brown, Carissa Klein, Eva Plaganyi
Els Van Burm	UM	Belgium	Optimal monitoring for environmental management	Michael McCarthy, Gurutzeta Guillera-Arroita, Brendan Wintle
Ruben Venegas	UQ	Costa Rica	Marine conservation prioritization in a rapidly changing world	Salit Kark, Noam Levin and Hugh Possingham
Nelida Villasenor	ANU	Chile	Biodiversity conservation in urbanising forested landscapes	David Lindenmayer, Don Driscoll, Phil Gibbons
Casey Visintin	UM	USA	Wildlife collisions with linear infrastructure: Modelling, management and mitigation	Michael McCarthy, Rodney van der Ree (ARCUE)
Matt West	UM	Australia	Evaluating the response to frogs to multiple threats	Michael McCarthy
David Wilkinson	UM	Australia	Evaluation of, and Extensions to, the Joint Species Distribution Modeling Framework	Michael McCarthy, Reid Tingley; Gurutzeta Guillera-Arroita; Nick Golding
Steve Wilson	UQ	Australia	Factors affecting the conservation of the critically endangered Javan Rhinoceros	Salit Kark, Duan Biggs and Anne Goldizen
Michael Wysong	UWA	USA	Understanding the mechanisms between feral cat and wild dog interactions in the arid rangelands of Western Australia	Richard Hobbs, Leonie Valentine, Neil Burrows, Euan Ritchie
Hui Xiao	UQ	China	Conservation based on ecosystem complexity using network theory	Eve McDonald Madden
Ding Li Yong	ANU	Singapore	Cross-taxonomic surrogates of biodiversity in a woodland setting in Australia	David Lindenmayer, Phil Barton, Saul Cunningham
Johanna Zimmerhackel	UWA	Germany	Interactions of diving tourism and fisheries in marine protected areas: market values and new approaches to deter illegal fishing in the Maldives Shark Sanctuary	David Pannell, Mark Meekan, Marit Kragt, Abbie Rogers

Communication and Outreach

The Centre maintained its focus on the importance of effective communication during 2016 building on the communications strategy developed in late 2015.

Consultation with CEED staff revealed a desire to reach a wider range of audiences; better coordinate Centre communication products; and make more effective use of our internal talent. Evaluation of our previous media strategy indicated that using online and social media sources were more effective than standard media releases.

Media Coverage

CEED's media coverage included an emphasis on telling our stories with 69 news items posted, often repurposed from media releases. Across print, TV, radio and web based media 1,260 stories were published. This translated into 1,623 total stories being aired or printed through syndication e.g. a radio interview being broadcast to smaller radio stations; see Table 1. The quality of media coverage was exceptional, with a potential audience reach of 8,035,872 people for all our media stories.

Table 1 ▶ Media coverage

Media Type	Number
Magazines	11
Newspapers	52
Online News	1,189
Radio	246
TV	125

The potential reach of our most significant stories are listed in Table 2. Their significance lies not only in their quality, measured by the circulation and number of stories, but in the number of early career researchers who led these stories.

Decision Point Magazine

In 2016 five English and one Spanish issues of *Decision Point* were produced and made available to its readership of over 6000 subscribers.

The quality of stories and diversity of topics covered aims to connect conservation policymakers, researchers and practitioners.

The magazine's audience covers a wide spectrum from universities and research institutions, government agencies, and the private sector.

The second year of our online version at http://decision-point.com.au/ gave download access to any story from the 98 editions produced over the years. The June issue of *Decision Point* (#96) focused on marine conservation in celebration of the 'decade of marine conservation' and coinciding with the Society for Conservation Biology Oceania Brisbane 2016 conference.

The August issue (#97) introduced a new design to freshen the brand and coincided with the release of a second issue of a Spanish version (en Espanol) of *Decision Point*.

The most popular 2016 stories included:

Feb-16	Beyond threat maps
Aug-16	The permanency of conservation covenants
Apr-16	Restoring marine coastal ecosystems
Feb-16	What's in a [species common] name?

Decision Point Magazine.

Table 2 ▶ Significant CEED media stories

CEED researcher	Topic	Media	Circulation
Brendan Wintle (UM)	Tightening of land clearing laws	ABC News (syndicated)	251,701
Danielle Shanahan (ECR - UQ)	How 30 minutes of outdoor activity can improve people's health	126 articles in Radio & Print media	305,147
Darren Southwell (ECR – UM)	Creating a dry barrier to stop the spread of Cane toads	40 articles, ABC News, 24 ABC TV	541,969
David Lindenmayer (ANU)	Various commentaries on approaches to conservation practice and policy	329 articles All media	1,906,592
David Lindenmayer (ANU)	"Devastating" long-term prognosis for ancient Gondwanan ecosystem after bushfires	Various print, web, TV and radio media	372,970
David Lindenmayer (ANU)	Comment on Australia's short sighted to cut environmental posts (at CSIRO)	WEB NATURE	840,703
David Pannell (UWA)	Benefits of planting trees in rural areas	The Saturday Age newspaper	241,029
Duan Biggs (ECR – UQ)	Discussion regarding building private tourism facilities within National Parks around the world	Radio National	170,000
Hugh Possingham (UQ)	Various	419 articles various news media	1,903,675
Hugh Possingham (UQ)	Discusses the value of local urban areas, like Sherwood Arboretum, for preserving biodiversity and encouraging citizen science	Brisbane News (magazine)	239,502
Hugh Possingham (UQ)	Discussing the best way to save endangered animals in Australia	ABC Radio Sydney	149,200
Hugh Possingham (UQ)	Native animals at risk of extinction could be leased to landowners	Sun-Herald (Sydney)	196,060
Hugh Possingham (UQ)	Concerns about clearing native vegetation if new NSW legislation is successful	ABC Radio, Web WA Today, Web Brisbane Times & Web Melbourne Age	431,899
Jonathan Rhodes (UQ)	Articles regarding Koala conservation and land clearing	179 articles Various, print, web, TV and radio media	1,552,534
Kerrie Wilson (UQ)	Award of the Fenner Prize for Life Science (a Prime Ministers Prize for Science)	Various print, web, and radio media	124,497
Sarah Bekessy (RMIT)	Melbourne's urban biodiversity and feral cats	Various print and web media outlets	133,724
Sean Maxwell (PhD Student – UQ)	Guns, Nets and Bulldozers: ¾ of the world's threatened species are imperilled from agriculture, land conversion and over-harvesting	Various web news outlets, Radio Adelaide (syndicated)	88,273
Skipton Woolley (PhD Student – UM)	Work to create a map which describes deep sea biodiversity around the globe	ABC Radio Melbourne	124,000

Online Communications

The social media strategy during 2016 focused largely on Facebook and Twitter platforms, including a move to management by in-house volunteers. Overall, the average reach increased 37% for Facebook and 210% for Twitter impressions — the number of times the tweet is seen.

An additional 650 new followers have been added on Twitter, for a total of 1655 at the end of 2016 (Figure 3).

The actual number of impressions tripled (from 109,000 in 2015 to 338,291 in 2016), and engagement — clicks and retweets — more than doubled (from almost 2000 in 2015 to 5334 in 2016) (Figure 4).

Spikes in engagement occurred around the Society for Conservation Biology Oceania (SCBO) conference in July, the IUCN World Conservation Congress in August, and the Ecological Society of Australia meeting in November, which was associated with elevated activity on Twitter and interactions with conference attendees (Table 3). Twitter is ideal for this type of outreach, because it is fast-moving and reactive.

In 2016 the number of Facebook page followers increased 25% to 170. The number of posts shared has been stable, at an average of 12 posts per month (with a total of 153 in 2016). Collectively, these posts generated a significant amount of engagement (>1,400 Likes) and shares. Posts with photos and links were most popular. The content predominantly involved announcement of new publications, illustrating the scientific impact ARC CEED has in the conservation sphere.

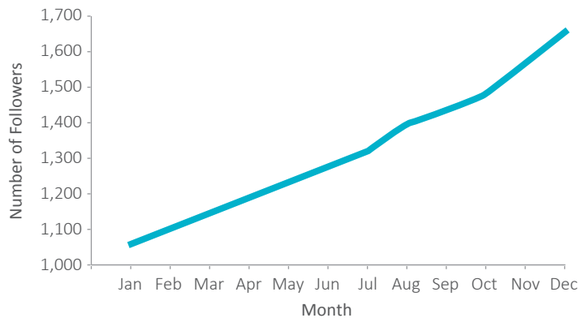


Figure 3 ▶ Twitter Follower Growth — 2016

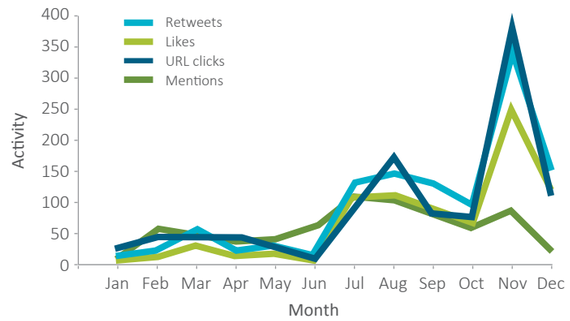


Figure 4 ▶ Twitter Activity — 2016

Table 3 ▶ International Distribution of Twitter Followers and Audience

Country	Followers (%)	Audience Reached (%)
Australia	50	33
USA	12	18
UK	11	15
Canada	4	5
New Zealand	3	3
Spain	2	2
Germany	1	2
Switzerland	1	1
India	1	1
South Africa	1	1
Other	14	19

Publications

In 2016 CEED again excelled in publishing our scientific findings in peer-reviewed, high ranking scientific journals, empowering our Early Career Researchers and collaborating widely.

In 2016 CEED researchers produced 161 publications comprised of 159 journal articles and 2 book chapters. CEED publications appeared in 75 different journals in 2016, 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 30% of the 159 journal articles being published in journals with an Impact Factor (IF) greater than five (see Figure 5). These include 10 journal articles published in some of the most prestigious journals including *Nature*, *Science*, *Nature Climate Change*, *TREE*, and *Ecology Letters* (all IF > 10).

CEED has continued to demonstrate exemplary collaboration with 95% of publications involving cross-institutional collaboration, and 57% involving international collaboration.

The strong development of our ECRs resulted in the number of publications involving an ECR increased from 39% in 2015 to 74% in 2016. Remarkably 53% of publications involving an ECR had them listed as the first author.

Evidence of CEED's research impact and quality reputation is apparent in the 443 Google Scholar citations overall for 2016 papers accumulated by February 2017 with 38% having two or more citations. An extraordinary 10 publications (6%) had 10 or more citations, with one journal article published in 2016 already receiving 18 citations.

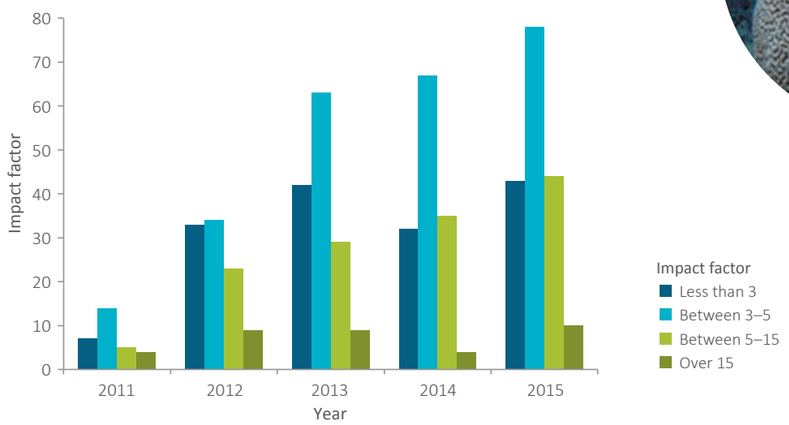


Figure 5 ▶ Impact factor categories for journal publications

CEED 2016 Publications — 1 January–31 December 2016

Book Chapter

1 Polyakov M and DJ Pannell (2016) Accounting for private benefits in ecological restoration planning. In (Eds) Ansell D, F Gibson and D Salt, Learning from Agri- Environment Schemes in Australia. ANU Press, Canberra, Australia.

2 Renwick A and N Schellhorn (2016) Ch 9: A perspective on land sparing versus land sharing. In Ansell D, F Gibson, D Salt (Eds) Learning from Agri-Environment Schemes in Australia: Investing in Biodiversity and Other Ecosystem Services on Farms ANU Press

Journal Article

1 Abram NK, DC MacMillan, P Xofis, M Ancrenaz, J Tzanopoulos, R Ong, B Goossens, LP Koh, C Del Valle, L Peter, AC Morel, I Lackman, R Chung, H Kler, L Ambu, W Baya, AT Knight (2016) Identifying Where REDD plus Financially Out-Competes Oil Palm in Floodplain Landscapes Using a Fine-Scale Approach. *PLoS One* 11(6) ~ IF: 3.057

2 Adams-Hosking C, MF McBride, G Baxter, M Burgman, D de Villiers, R Kavanagh, I Lawler, D Lunney, A Melzer, P Menkhorst, R Molsher, BD Moore, D Phalen, JR Rhodes, C Todd, D Whisson, CA McAlpine (2016) Use of expert knowledge to elicit population trends for the koala (*Phascolarctos cinereus*). *Diversity and Distributions* 22(3):249-262 ~ IF: 4.566

3 Arnold S, S Attinger, K Frank, P Baxter, HP Possingham, A Hildebrandt (2016) Ecosystem Management Along Ephemeral Rivers: Trading Off Socio-Economic Water Supply and Vegetation Conservation under Flood Regime Uncertainty. *River Research and Applications* 32(3):219-233 ~ IF: 1.980

4 Atkinson SC, SD Jupiter, VM Adams, JC Ingram, S Narayan, CJ Klein, HP Possingham (2016) Prioritising Mangrove Ecosystem Services Results in Spatially Variable Management Priorities. *PLoS One* 11(3) ~ IF: 3.057

5 Barnes MD, ID Craigie, LB Harrison, J Geldmann, B Collen, S Whitmee, A Balmford, NG Burgess, T Brooks, M Hockings, S Woodle (2016) Wildlife population trends in protected areas predicted by national socio-economic metrics and body size. *Nature Communications* 7(12747) ~ IF: 11.329

6 Beher J, HP Possingham, S Hoobin, C Dougall, C Klein (2016) Prioritising catchment management projects to improve marine water quality. *Environmental Science & Policy* 59:35-43 ~ IF: 2.972

7 Bennett JR and B Gilbert (2016) Contrasting beta diversity among regions: how do classical and multivariate approaches compare? *Global Ecology and Biogeography* 25(3):368-377 ~ IF: 5.840

8 Beyer HL, E Gurarie, L Borger, M Panzacchi, M Basille, I Herfindal, B Van Moorter, SR Lele, J Matthiopoulos (2016) 'You shall not pass!': quantifying barrier permeability and proximity avoidance by animals. *Journal of Animal Ecology* 85(1):43-53 ~ IF: 4.827 Citations:12

9 Beyer HL, Y Dujardin, ME Watts, HP Possingham (2016) Solving conservation planning problems with integer linear programming. *Ecological Modelling* 328:14-22 ~ IF: 2.275

10 Biggs D, F Amar, A Valdebenito, S Gelcich (2016) Potential Synergies between Nature-Based Tourism and Sustainable Use of Mari Resources: Insights from Dive Tourism in Territorial User Rights for Fisheries in Chile. *PLoS One* 11(3) ~ IF: 3.057

11 Biggs D, MH Holden, AR Braczkowski, HP Possingham (2016) Track the impact of Kenya's ivory burn. *Nature* 534(7606):179-179 ~ IF: 38.138

12 Bland LM and M Bohm (2016) Overcoming data deficiency in reptiles. *Biological Conservation* 204:16-22 ~ IF: 3.985

13 Bode M, DH Williamson, R Weeks, GP Jones, GR Almany, HB Harrison, JK Hopf, RL Pressey (2016) Planning Marine Reserve Networks for Both Feature Representation and Demographic Persistence Using Connectivity Patterns. *PLoS One* 11(5) ~ IF: 3.057

14 Bode M, JN Sanchirico, PR Armsworth (2016) Returns from matching management resolution to ecological variation in a coral reef fishery. *Proceedings of The Royal Society B-Biological Sciences* 283(1826) ~ IF: 4.823

15 Bodin O, G Robins, RRJ McAllister, AM Guerrero, B Crona, M Tengo, M Lubell (2016) Theorizing benefits and constraints in collaborative environmental governance: a transdisciplinary social-ecological network approach for empirical investigations. *Ecology and Society* 21(1) ~ IF: 2.305

16 Boettiger C, M Bode, JN Sanchirico, J LaRiviere, A Hastings, PR Armsworth (2016) Optimal management of a stochastically varying population when policy adjustment is costly. *Ecological Applications* 26(3):808-817 ~ IF: 4.252

17 Bohm M, R Williams, HR Bramhall, KM McMillan, AD Davidson, A Garcia, LM Bland, K Bielby, B Collen (2016) Correlates of extinction risk in squamate reptiles: the relative importance of biology, geography, threat and range size. *Global Ecology and Biogeography* 25 (4):391-405 ~ IF: 5.840 Citations:12

18 Boon PY and M Beger (2016) The effect of contrasting threat mitigation objectives on spatial conservation priorities. *Marine Policy* 68:23-29 ~ IF: 2.453

19 Bowman DMJS, GJ Williamson, LD Prior, BP Murphy (2016) The relative importance of intrinsic and extrinsic factors in the decline of obligate seeder forests. *Global Ecology and Biogeography* 25(10):1166-1172 ~ IF: 5.840

CEED 2016 Publications *continued...*

20 Briscoe NJ, MR Kearney, CA Taylor, BA Wintle (2016) Unpacking the mechanisms captured by a correlative species distribution model to improve predictions of climate refugia. *Global Change Biology* 22(7):2425-2439 ~ IF: 8.444

21 Buckley YM and J Catford (2016) Does the biogeographic origin of species matter? Ecological effects of native and non-native species and the use of origin to guide management. *Journal of Ecology* 104(1):4-17 ~ IF: 6.180 Citations:18

22 Budiharta S, E Meijaard, JA Wells, NK Abram, KA Wilson (2016) Enhancing feasibility: Incorporating a socio-ecological systems framework into restoration planning. *Environmental Science & Policy* 64:83-92 ~ IF: 2.972

23 Bull JW, A Gordon, JEM Watson, M Maron (2016) Seeking convergence on the key concepts in "no net loss' policy. *Journal of Applied Ecology* 53(6):1686-1693 ~ IF: 5.196

24 Butt N, HP Possingham, C De Los Rios, R Maggini, RA Fuller, SL Maxwell, JEM Watson (2016) Challenges in assessing the vulnerability of species, to climate change to inform conservation actions. *Biological Conservation* 199:10-15 ~ IF: 3.985

25 Callister KE, PA Griffioen, SC Avitabile, A Haslem, LT Kelly, SA Kenny, DG Nimmo, LM Farnsworth, RS Taylor, SJ Watson, AF Bennett, MF Clarke (2016) Historical Maps from Modern Images: Using Remote Sensing to Model and Map Century-Long Vegetation Change in a Fire-Prone Region. *PLoS One* 11(3) ~ IF: 3.057

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Governance and Management

The Centre's governance structure reflects the emphasis on strategy, research, and communication and outreach in planning and implementing the work programs. Figure 6 illustrates the governance and operating structure of the Centre.

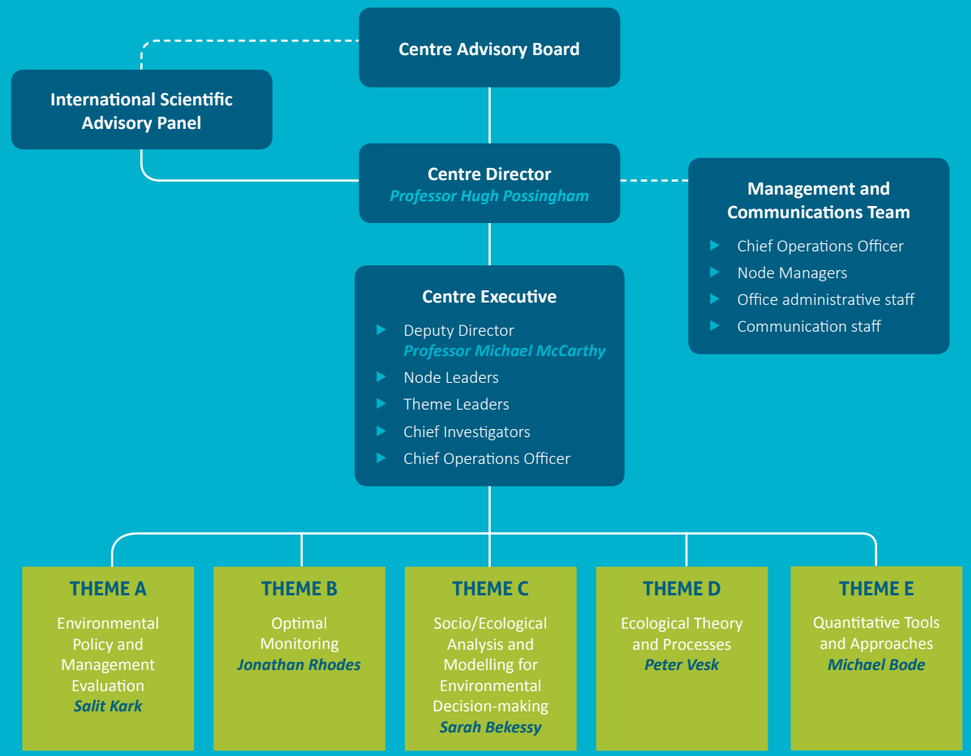

Figure 6 ▶ CEED's Governance Structure

Centre Advisory Board

A Centre Advisory Board oversees the work of CEED. It comprises members drawn from the across the research, industry, policy and philanthropic sectors.

The Board provides strategic advice to the Centre's executive leadership team with a particular focus on governance, communication, impact, outreach and research management.

The Board held its annual meeting in April 2016 in Brisbane, with discussions focusing on progress against the strategic plan, implementation of early and mid-career researcher development activities, increasing CEED's external engagement and outreach efforts, and increasing the impact of our research.

Members:

- **Professor Stephen Walker** (Chair), University of Queensland
- **Professor Andrew Cockburn** (FAA), Australian National University
- **Professor Alistar Robertson,** University of Western Australia (ret)
- **Professor Charlie Zammit,** Commonwealth Department of the Environment (ret)
- **Dr Margaret Byrne,** Western Australian Department of Parks and Wildlife
- **Mr David Shelmerdine,** Myer Foundation

Ex Officio Members

- **Professor Hugh Possingham** (Director), University of Queensland
- **Professor Michael McCarthy** (Deputy Director), University of Melbourne

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 in 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 Peter Kareiva** (FNAS), Chief Scientist and Director of Science, The Nature Conservancy
- **Professor Claire Kremen**, University of California, Berkeley
- **Professor Bill Murdoch** (FNAS), University of California, Santa Barbara
- **Professor Bill Sutherland,** Miriam Rothschild Professor of Conservation Biology, Cambridge University

Our Partnerships

The collaborative partnerships within CEED ensure the research is of a consistently high quality and pushes the frontiers of environmental decision science. The partners are core to CEED's operating structure and include:

Collaborating organisations

- The University of Queensland (UQ)
- The University of Melbourne (UM)
- The Australian National University (ANU)
- RMIT University (RMIT)
- The University of Western Australia (UWA)

Partner organisations

- CSIRO
- Trinity College Dublin (TCD)
- Imperial College London (ICL)
- Hebrew University of Jerusalem, Israel (HUJI)
- US Geological Survey (USGS)

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 Hugh Possingham, and Deputy Director, Professor Michael McCarthy, provide the overarching guidance and day-to-day leadership of the Centre and its research.

The Executive meets monthly via teleconferences or face-to-face at events to discuss Centre management, research, operations and policy.

Executive members:

- **Prof Hugh Possingham** (Director), UQ
- **Prof Michael McCarthy** (Deputy Director), UM
- **Prof David Lindenmayer,** ANU
- **Prof David Pannell,** UWA
- **Assoc Prof Jonathan Rhodes,** UQ
- **Assoc Prof Kerrie Wilson,** UQ
- **Assoc Prof Sarah Bekessy,** RMIT
- **Assoc Prof Brendan Wintle,** UM
- **Dr Michael Bode,** UM
- **Prof Richard Hobbs,** UWA
- **Assoc Prof Salit Kark,** UQ
- **Dr Eve McDonald-Madden,** UQ
- **Dr Anthony Richardson,** UQ
- **Assoc Prof Peter Vesk,** UM
- **Ms Melanie King** (Chief Operations Officer), UQ

Centre Management and Communications Team

The Centre continues to deliver high-quality outputs and is supported by a team of professional staff across the five collaborating partner nodes: Chief Operations Officer, Melanie King (UQ); Node Managers — Dolla Boutros (UM), Claire Shepherd (ANU), Heather Gordon, Caroline Mitchell / Tammie Harold (UWA); Administrative and support staff — Heather Christensen (UQ), Pauline Byron (UM), Tabitha Boyer (ANU), Jane Campbell (UQ), Barbara Whittaker (UQ), Michelle Baker (UQ) and Dominique Pomfret (UQ); and Communication and Engagement staff — Gabrielle Sheehan (Currie Communications), Karen Gillow (UQ), David Salt (ANU).

The team plays an important role in supporting the Centre's core functions of research, research training and mentoring, events, communication and outreach.

Our People

Our Members

Director

Prof Hugh Possingham (Jan – Nov)	UQ
Prof Kerrie Wilson (Nov – Dec)	UQ

Deputy Director

Prof Mick McCarthy	UM

Executive

Prof David Lindenmayer	ANU
Prof Mick McCarthy	UM
Prof David Pannell	UWA
Prof Hugh Possingham	UQ
Assoc. Prof Kerrie Wilson	UQ
Assoc. Prof Brendan Wintle	UM
Ms Melanie King	UQ

Theme Leaders

Assoc. Prof Salit Kark (Theme A)	UQ
Assoc. Prof Jonathan Rhodes (Theme B)	UQ
Assoc. Prof Sarah Bekessy (Theme C)	RMIT
Assoc. Prof Peter Vesk (Theme D)	UM
Dr Michael Bode (Theme E)	UM

Chief Investigators

Assoc. Prof Sarah Bekessy	RMIT
Dr Michael Bode	UM
Prof Richard Hobbs	UWA
Assoc. Prof Salit Kark	UQ
Prof David Lindenmayer	ANU
Prof Michael McCarthy	UM
Dr Eve McDonald-Madden	UQ
Prof David Pannell	UWA
Prof Hugh Possingham	UQ
Assoc. Prof Jonathan Rhodes	UQ
Dr Anthony Richardson	UQ
Assoc. Prof Peter Vesk	UM
Assoc. Prof Kerrie Wilson	UQ
Assoc. Prof Brendan Wintle	UM

Partner Investigators

Prof Yvonne Buckley	TCD
Dr Iadine Chadès	CSIRO
Assoc. Prof Noam Levin	HUJI
Dr Tara Martin	CSIRO
Prof E.J. Milner-Gulland	ICL
Dr James D. (Jim) Nichols	USGS
Dr Michael Runge	USGS

Post-Doctoral Fellows

Dr Vanessa Adams	UQ
Dr Chris Baker	UQ/UM
Dr Maria Beger	UQ
Dr Hawthorne Beyer	UQ
Dr Duan Biggs	UQ
Dr Lucie Bland	UM
Dr Nathalie Butt	UQ
Dr Jane Catford	UM
Dr Alienor Chauvenet	UQ
Dr Shaun Coutts	UQ
Dr Mike Craig	UWA
Dr Katrina Davis	UQ
Dr Martina Di Fonzo	UQ
Dr Moreno Di Marco	UQ
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 Cindy Hauser	UM
Dr Geoff Heard	UM
Dr Matt Holden	UQ
Dr Gwen Iacona	UQ
Dr Sayed Iftekhar	UWA
Dr Karen Ikin	ANU
Dr Luke Kelly	UM
Dr Carissa Klein	UQ
Dr Marit Kragt	UWA
Dr Nadiah Kristensen	UQ
Dr Heini Kujala	UM
Dr Jose Lahoz-Monfort	UM
Dr Elizabeth Law	UQ
Dr Pia Lentini	UM
Dr Luis Mata	UM
Dr Maina Mbui	UQ
Dr Morena Mills	UQ
Dr Melinda Moir	UWA
Dr Alana Moore	UM
Dr Ram Pandit	UWA
Dr Maksym Polyakov	UWA
Dr Tracey Regan	UM
Dr Anna Renwick	UQ
Dr Abbie Rogers	UWA
Dr Tracy Rout	UQ
Dr Libby Rumpff	UM
Dr Rob Salguero-Gomez	UQ
Dr Truly Santika	UQ
Dr Danielle Shanahan	UQ
Dr Justine Shaw	UQ
Dr Luke Shoo	UQ
Dr Martin Stringer	UQ
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Dr Ayesha Tulloch	ANU
Dr Leonie Valentine	UWA
Dr Oscar Venter	JCU
Dr Jessie Wells	UQ
Dr Jian Yen	UM

PhD Students

Mr James Allan	UQ
Ms Carla Archibald	UQ
Ms Stephanie Avery-Gomm	UQ
Ms Payal Bal	UQ
Ms Sana Bau	UM
Mr Richard Beggs	ANU
Ms Donna Belder	ANU
Mr Laurence Berry	ANU
Ms Louise Blackmore	UWA
Ms Elle Bowd	ANU
Mr Sugeng Budiharta	UQ
Mr Hernan Caceres Escobar	UQ
Ms Colleen Corrigan	UQ
Ms Marie Dade	UQ
Mr Brendan Dillon	UQ
Ms Megan Evans	ANU
Ms Dini Fardila	UM
Ms Hannah Fraser	UM
Ms Rachel Friedman	UQ
Mr Eduardo Gallo-Cajiao	UQ
Ms Veronica Gama	UQ
Ms Katherine Giljohann	UM
Ms Valerie Hagger	UQ
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Mr David Johnson	ANU
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Ms Juliana Lazzari	ANU
Mr Hsien-Yung Lin	UQ
Ms Sophia Lopez-Cubillos	UQ
Ms Bonnie Mappin	UQ
Ms Maria Martinez-Harms	UQ
Ms Fleur Maseyk	UQ
Mr Sean Maxwell	UQ
Ms Jennifer McGowan	UQ
Mr Matthew McKinney	UQ
Ms Courtney Morgans	UQ
Mr Will Morris	UM
Ms Laura Mumaw	RMIT
Ms Wendy Neilan	ANU
Mr Thayse Nery	UWA
Ms Katherina Ng	ANU
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Ms Michaela Plein	UQ
Ms Stephanie Pulsford	ANU
Ms Keren Raiter	UWA
Mr Andrew Rogers	UQ
Ms Cristina Romero De Diego	UQ
Ms Rebecca Runting	UQ
Mr Gerard Ryan	UM
Mr Matthew Selinske	RMIT
Ms Nicole Shumway	UQ
Mr Blake Simmons	UQ
Mr Darren Southwell	UM
Ms Madeline Stigner	UQ
Ms Ingrid Stirnemann	ANU
Ms Freya Thomas	UM
Mrs Nooshin Torabi	RMIT
Mr Arthur Tuda	UQ
Ms Vivitskaia Tulloch	UQ
Ms Els Van Burm	UM
Mr Ruben Venegas Li	UQ
Ms Nelida Villasenor	ANU
Mr Casey Visintin	UM
Mr Matthew West	UM
Mr David Wilkinson	UM
Mr Steve Wilson	UQ
Mr Skipton Woolley	UM
Ms Melissa Wynn	ANU
Mr Michael Wysong	UWA
Ms Hui Xiao	UQ
Mr Ding Li Yong	ANU
Ms Johanna Zimmerhackel	UWA

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Ms Renae Boyd	UWA
Ms Kate Cranney	UM
Mr Gunther de Vos	UWA
Mr Russell McKenna	UQ
Ms Sonia Mennen	UWA
Ms Sachiko Okada	ANU
Ms Alina Pung	UM
Mr Thomas Stephens	UM
Ms Krishnani Vasundhara (Tanvi)	UQ

Honours Students

Ms Sharna Bourke	ANU-UQ
Ms Helena Bowler	UWA
Ms Georgina Hockings	UQ
Ms Emma Lee	UQ
Ms Carly Martin	UQ
Ms Samantha Richardson	UQ
Ms Rachelle Todd	UQ
Ms Brooke Williams	UQ

Research Assistant

Ms Jutta Beher	UQ
Mr Joshua Volkman	UQ

Operations Staff

Ms Dolla Boutros	UM
Ms Pauline Byron	UM
Mrs Jane Campbell	UQ
Miss Heather Christensen	UQ
Ms Carol Fawcett	UQ
Mrs Sarah Gillow	UQ
Ms Heather Gordon	UWA
Ms Tammie Harold	UWA
Ms Caroline Mitchell	UWA
Ms Dominique Pomfret	UQ
Ms Claire Shepherd	ANU
Ms Barbara Whittaker	UQ

Science Communications

Ms Gabrielle Sheehan	Currie Communications
Mr David Salt	ANU
Ms Karen Gillow	UQ
Ms Michelle Baker	UQ

International Collaborators

1 AgResearch, New Zealand
2 City of Annapolis, MD
3 Ben Gurion University of the Negev, Israel
4 BirdLife International, UK
5 Cambridge University, UK
6 Carleton University, Canada
7 Cary Institute of Ecosystem Studies, USA
8 Center for Ecological Research and Forestry Applications, Spain
9 Center for International Forestry Research, Indonesia
10 Center for Large Landscape Conservation, USA
11 Centre for Ecosystems, Society and Biosecurity, Forest Research, Forestry Commission, UK
12 Colombian Primatological Association, Columbia
13 Colorado State University, USA
14 Conservation International, USA
15 Cornell University, USA
16 Department of Conservation, New Zealand Government, New Zealand
17 Durham University, UK
18 Earthwatch, Brazil
19 EcoHealth Alliance, USA
20 Finnish Environment Institute, Finland
21 Forest Sciences Center of Catalonia, Spain
22 Fundacion Proyecto Titi, Columbia
23 Georgia Institute of Technology, USA
24 Ghent University, Belgium
25 Hebrew University of Jerusalem, Israel
26 Hungarian Natural History Museum, Hungary
27 Hutan — Kinabatangan Orangutan Conservation Programme, Malaysia
28 Imperial College London, UK
29 Indiana University, USA
30 Indonesian Institute of Sciences, Indonesia
31 French Research Institute for Development, France
32 Institute of Ecology and Biodiversity, Chile
33 International Long Term Ecological Research
34 International Union for Conservation of Nature, Switzerland
35 Israel Academy of Sciences and Humanities, Israel
36 Israel Institute of Technology, Israel
37 Israel Ministry of Environmental Protection, Israel
38 Israel Nature and Parks Authority, Israel
39 Israel Oceanographic and Limnological Research, Israel
40 Israel Society of Ecology and Environmental Sciences, Israel
41 Venezuelan Institute for Scientific Research, Venezuela
42 Johns Hopkins University, USA
43 Land Development Authority, Israel Government, Israel
44 Landcare Research, New Zealand
45 Leibniz Institute of Agriculture Development in Transition Economies, Germany
46 Living Landscape Alliance, UK
47 Marche Polytechnic University, Italy
48 Massey University, New Zealand
49 Max-Planck Institute for Demographic Research, Germany
50 Mediterranean Center for Marine and Environmental Research, Spanish National Research Council, Spain
51 Michigan State University, USA
52 Misgurnus Association, Romania
53 Missouri Botanical Garden, USA
54 Montpellier Supagro, France
55 National Autonomous University of Mexico, Mexico
56 National Center for Scientific Research, France
57 National Marine Park of Zakynthos, Ministry of Environment and Energy, Greece
58 National Park Service, USA
59 National Socio-Environmental Synthesis Center, USA
60 National Wildlife Institute, Italy
61 Naturalis Biodiversity Center, Leiden, Netherlands
62 New Zealand Forest Research Institute, New Zealand
63 Nice Sophia Antipolis University, France
64 PBL Netherlands Environmental Assessment Agency, Neherlands
65 Pennsylvania State University, USA
66 People and Nature Consulting International, Indonesia
67 Pontifical Catholic University of Chile, Chile
68 Princeton University, USA
69 Provita, Venezuela
70 Radboud University, Netherlands
71 Rutgers University, USA
72 Sabah Wildlife Department, Indonesia
73 Santa Clara University, USA
74 Sapienza University of Rome, Italy
75 Smithsonian Institute, USA
76 South African Environmental Observation Network, South Africa
77 South African National Biodiversity Institute, South Africa
78 Stanford University, USA
79 Stellenbosch University, South Africa
80 Stockholm University, Sweden
81 Taranaki Regional Council, New Zealand
82 Tel Aviv University, Israel
83 Tel Hai College, Israel
84 The Biodiversity Consultancy Ltd, UK
85 The Nature Conservancy, USA
86 UN Global Compact Cities Programme
87 UNEP World Conservation Monitoring Centre, UK
88 UNEP Great Apes Survival Partnership, Kenya
89 United Nations University, Japan
90 University College of London, UK
91 University of Alberta, Canada
92 University of Auckland, New Zealand
93 University of British Columbia, Canada
94 University of California, USA
95 University of Cape Town, South Africa
96 University of Chile
97 University of Copenhagen, Denmark
98 University of Exter, UK
99 University of Haifa-Oranim, Israel
100 University of Hamburg, Germany
101 University of Hawaii, USA
102 University of Helsinki, Finland
103 University of Illinois, USA
104 University of Kent, UK
105 University of Kiel, Germany
106 University of Lausanne, Switzerland
107 University of Lisbon, Portugal
108 University of Maine, USA
109 University of Manchester, UK
110 University of Minnesota, USA
111 University of Montpellier, France
112 University of Montreal, Canada
113 University of New Hampshire, USA
114 University of Northern British Columbia, Canada
115 University of Nottingham, UK
116 University of Otago, New Zealand
117 University of Oxford, UK
118 University of Paris-Sud, France
119 University of Porto, Portugal
120 University of Salento, Italy
121 University of Sao Paulo, Brazil
122 University of Stirling, UK
123 University of Tennessee, USA
124 University of the Aegean, Greece
125 University of the Witwatersrand, South Africa
126 University of Turku, Finland
127 University of Washington, USA
128 University of Wisconsin-Madison, USA
129 US Geological Survey, USA
130 Utah State University, USA
131 Wageningen University, Netherlands
132 Weizmann Institute of Science, Israel
133 Wildlife Conservation Society, USA
134 World Agroforestry Centre, Indonesia
135 Wuhan University, China
136 World Wildlife Fund, Cambodia
137 World Wildlife Fund, Switzerland
138 World Wildlife Fund, Vietnam
139 Zoological Society of London, UK

National Collaborators

1 Aboriginal Carbon Fund, Australia
2 Alcoa of Australia, Australia
3 Allens Australia Pty Ltd, Australia
4 Alluvium, Australia
5 Arthur Rylah Institute for Environmental Research, Australia
6 ARUP Consulting, Australia
7 Australian Antarctic Division, Australia
8 Australian Bureau of Statistics, Australia
9 Australian Conservation Foundation, Australia
10 Australian Institute of Marine Science, Australia
11 Australian Labor Party, Australia
12 Australian Research Centre for Urban Ecology, Victoria, Australia
13 Biosecurity, South Australia, Australia

National Collaborators *continued...*

14 Birdlife Australia, Australia
15 Brisbane City Council, Queensland, Australia
16 Bush Heritage Australia, Australia
17 Central Tablelands Local Land Services, NSW, Australia
18 Charles Sturt University, Australia
19 City of Ballarat, Victoria, Australia
20 City of Gold Coast, Queensland, Australia
21 City of Joondalup, Western Australia, Australia
22 City of Melbourne, Victoria, Australia
23 Committee for Economic Development of Australia, Australia
24 Common Cause Australia, Australia
25 Commonwealth Scientific and Industrial Research Organisation, Australia
26 Deakin University, Australia
27 Dennis Family Homes, Australia
28 Department of Agriculture and Food, Western Australia, Australia
29 Department of Defence, Australian Government, Australia
30 Department of Environment and Primary Industries, Victoria, Australia
31 Department of Environment, Land Water and Planning, Victoria, Australia
32 Department of Parks and Wildlife, Western Australia, Australia
33 Department of Primary Industries, Parks, Water and Environment, Tasmania, Australia
34 Department of the Environment and Energy, Australian Government, Australia
35 Earthwatch Institute, Australia
36 Environment Division, Environment and Planning Directorate, ACT Government, Australia
37 Gary Goucher and Associates, Australia
38 Gondwana Link Ltd, Australia
39 Greenfleet Australia, Australia
40 Griffith University, Australia
41 Growth Areas Authority, Victoria, Australia
42 Indigenous Architecture and Design Victoria, Australia
43 James Cook University, Australia
44 Kids Teaching Kids, Australia
45 La Trobe University, Australia
46 Lake Cowal Conservation Centre, Lake Cowal Foundation, Australia
47 Macquarie University, Australia
48 Melbourne Water, Victoria, Australia
49 Melbourne Zoo, Victoria, Australia
50 Mineral Policy Institute, Australia
51 Monash University, Australia
52 Moreton Bay Council, Queensland, Australia
53 Murdoch University, Australia
54 Murray LLS, Australia
55 National Climate Change Adaptation Research Facility, Australia
56 Natural Decisions Pty Ltd, Australia
57 Norman Wettenhall Foundation, Australia
58 Office of Environment and Heritage, NSW, Australia
59 Parks Australia, Department of the Environment and Energy, Australian Government, Australia
60 Pew Charitable Trust, Australia
61 Queensland Herbarium, Department of Science, Information, Technology, Innovation and the Arts, Queensland, Australia
62 Queensland University of Technology, Australia
63 Stockland, Australia
64 Sustainability Victoria, Australia
65 Sydney Coastal Councils Association, Australia
66 Terrestrial Ecosystems Research Network, Australia
67 Tiwi Land Council, Australia
68 Trust for Nature, Australia
69 University of Canberra, Australia
70 University of Sydney, Australia
71 University of Tasmania, Australia
72 Urban Design Forum, Australia
73 VicRoads, Victoria, Australia
74 Waterwatch, Australia
75 Wentworth Group of Concerned Scientists, Australia
76 Western Australian Museum, Western Australia, Australia
77 World Wildlife Fund, Australia
78 Yarra City Council, Victoria, Australia

International Visitors in 2016

Dr Marc Ancrenaz
Hutan Kinabatangan Orang-utan Conservation Programme, Malaysia

Dr Rob Alkemade
PBL Netherlands Environmental Assessment Agency, Netherlands

Mr Ryan Blanchard (PhD student)
Stellenbosch University, South Africa

Dr Tom Brooks
International Union for Conservation of Nature, Switzerland

Associate Professor Orjan Bodin
Stockholm Resilience Institute, Sweden

Dr Daan Bos
Altenburg & Wymenga, Netherlands

Professor Peter Boxall
University of Alberta, Canada

Mr Antoine Camus (student)
AgroParisTech, France

Dr Stefeno Canessa
Institute of Zoology, Zoological Society of London, UK

Assistant Professor Román Carrasco
National University of Singapore, Singapore

Dr Kwek Chong
NUS Overseas Postdoctoral Fellowship, National University of Singapore, Singapore

Dr Sarah Converse
US Geological Society, USA

Professor Carsten Dormann
University of Freiburg, Germany

Ms Constance Fastre (student)
University or Antwerp, Netherlands

Mr Sebastian Fiedler
Free University of Berlin, Germany

Professor Ben Halpern
University of California, USA

Professor Rob Johnston
Clark University, USA

Professor Andrew Knight
Imperial College London, UK

Professor Charles Krebs
University of British Columbia, Canada

Dr Cornelia Krug
Paris-Sud University, France

Professor Uwe Latacz-Lohmann
University of Kiel, Germany

Professor Paul Leadley
Paris-Sud University, France

Professor Jounghun Lee
Kyushu University, Japan

Dr Erin McCreless
University of California, USA

Dr Erik Meijaard
PT Habitat Hutan Alam Indonesia, Indonesia

Professor Jean Paul Metzger
The Institute of Biosciences, University of Sao Paulo, Brazil

Dr David L Miller
Integrated Statistics, Woods Hole, USA, and Centre for Research into Ecological and Environmental Modelling, University of St Andrews, Scotland, UK

Dr Michael Perring
Ghent University, Belgium

Dr Marc Rius
National Oceanography Centre Southampton, University of Southampton, UK

Ms Leslie Roberson
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Dr Osamu Saito
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Ms Monica Shandal (student)
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Dr Gopi Sundar
SarusScape Program, International Crane Foundation, India

Professor John Terry
University of Exeter, UK

Ms Haiyan Tian (PhD student)
College of the Environment & Ecology, Xiamen University, China

Dr Simon Thorn
University of Würzburg, Germany

Professor Katja Tielbörger
University of Tübingen, Germany

Ms Ellen Waddle (student)
University of Colorado, USA

Performance Measures

Key Result Area

Key Result Area	Performance Measure	Target 2016	Outcome 2016
Research Findings	Number of research outputs:		
	• Peer reviewed publications	80	161
	Quality of research outputs		
	• 50% of papers with IF in top 25% of ecology journals	50%	84%
	Number of invited talks / papers / keynote lectures given at major international meetings:		
	• Plenary talks at international conferences	9	6
	• Invitations to international workshops and conferences not covered above	30	40
Research training and professional education	Number of attended professional training courses for staff and students	20	15
	Number of Centre attendees at all professional training courses	40	84
	Number of new postgraduate students working on core Centre research and supervised by Centre staff (including PhD, Masters by research and coursework)	10	11
	Number of new postdoctoral researchers recruited to the Centre working on core Centre research	6	2
	Number of new Honours students working on core Centre research and supervised by Centre staff	10	6
	Number of postgraduate completions and completion times, by students working on core Centre research and supervised by Centre staff:	11	18
	• PhD: 3–4 years		(13)
	• Masters by research: 2 years		(5)
	Number of Early Career Researchers (within five years of completing PhD) working on core Centre research	15	20
	Number of students mentored	50	90
	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	14
	• For less than 10 days	20	34
	Number of national and international workshops held / organised by the Centre	2	3
	Number of visits to overseas laboratories and facilities		
	• For 10 days or more	15	13
	• For less than 10 days	30	44
End-user links	Number of government, industry and business community briefings	20	106
	Number and nature of public awareness programs	10	TBC
	Number of website hits	50,000	52,650^
	Number of public talks given by Centre staff	80	17

Key Result Area	Performance Measure	Target 2016	Outcome 2016
Organisational Support	Annual cash contributions from Collaborating Organisations		
	• The University of Queensland	386,439	386,439
	• The University of Melbourne	131,675	132.192
	• The University of Western Australia	203,184	203,184
	• The 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
	• The University of Melbourne	189,333	232,217
	• The University of Western Australia	203,627	281,264
	• The Australian National University	138,936	150,070
	• RMIT University	25,859	25,859
	Annual cash contributions from Partner Organisations	0	0
	Annual in-kind contributions from Partner Organisations		
	• Hebrew University of Jerusalem	15,000	15,000
	• CSIRO	26,857	26,857
	• Imperial College	24,114	24,114
	• US Geological Survey	12,000	12,000
	Number of new organisations collaborating with, or involved in, the Centre	1	>10
National Benefit	Contribution to the National Research Priorities and the National Innovation Priorities		
	• Briefings to government, business and interest groups		106
	• Cross-institutional publications		152
	• Submissions to government on policy matters		5
Centre-specific Performance Indicators	End-user Links		
	• Internally produced Magazine, issues	10	6
	• Separate media stories (releases)	10	1623
	• Media outputs, articles, radio	100	1259
	• Memberships of national and international boards and advisory committees	20	75

^ Technical issues due to website upgrades hindered Google analytics tracking of hits after September 2016

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 2016, the ARC CEED received **$1,986,040** in income from the ARC. 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 totalled $833,903. This was composed of:

Organisation	Amount ($)
UQ	386, 439
UM	132,192
ANU	55,458
RMIT	56,630
UWA	203,184

In-Kind Contributions

In-kind support totalled $1,148,282 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 2016 the Centre's partner organisations contributed $77,971 in-kind towards CEED with this primarily to support the partner investigator's time.

Expenditure

Expenditure for CEED totalled $2,910,874 in 2016. 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 $2,374,355 (82%). Travel was also a priority for the Centre with $185,768 (6%) expended to ensure researchers undertook fieldwork, visited other nodes, presented at conferences and attended research workshops and made linkages and collaborations nationally and internationally.

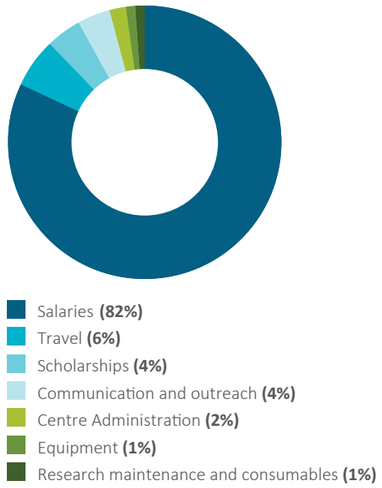


Figure 7 ▶ Summary of CEED expenditure

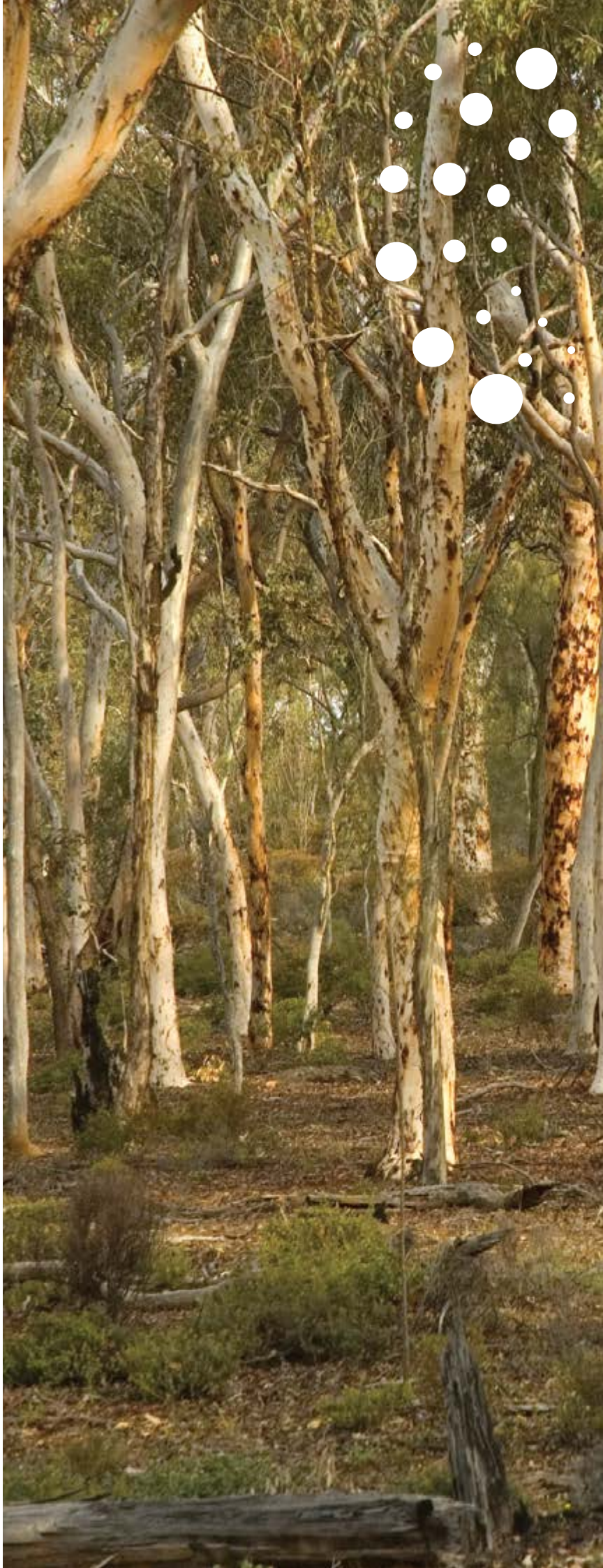
Statement of Operating Income and Expenditure for Year Ended 31 December 2016

Income	2016 ($)
ARC Centre Grant	$1,986,040
Host Institutions cash support	$833,901
Total Income	$2,819,943

Expenditure	2016 ($)
Salaries	$2,374,355
Equipment	$35,933
Travel	$185,768
Research maintenance and consumables	$31,770
Scholarships	$121,348
Centre Administration	$43,656
Communication and outreach	$118,044
Total Expenditure	$2,910,874

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
CSIRO	Commonwealth Scientific and Research Organisation
CUGE	Centre for Urban Greenery and Ecology
ECR	Early Career Researcher
HUJI	The Hebrew University of Jerusalem
ICL	Imperial College London
ICN	Interdisciplinary Conservation Network
ISAP	International Scientific Advisory Panel
IPBES	International Platform on Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature
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
RMIT	RMIT University
TCD	Trinity College Dublin
TNC	The Nature Conservancy
UM	The University of Melbourne
UQ	The University of Queensland
USGS	US Geological Survey
UWA	The University of Western Australia
WCS	The Wildlife Conservation Society



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
USGS
The Hebrew University of Jerusalem

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